National Pollutant Inventory

Emission Estimation Technique Manual

for

Wine and Spirits Manufacturing

28 February 2003
Version 1.1

First published in August 1999
Version 1.1 - 28 February 2003

Disclaimer

The manual was prepared in conjunction with Australian States and Territories according to the National Environment Protection (National Pollutant Inventory) Measure.

While reasonable efforts have been made to ensure the contents of this manual are factually correct, the Commonwealth does not accept responsibility for the accuracy or completeness of the contents and shall not be liable for any loss or damage that maybe occasioned directly or indirectly through the use of, or reliance on, the contents of this manual.

Erratum for Wine and Spirit Making Emission Estimation Technique (EET) Manual (Version 1.1 – 28 February 2003)

Page	Outline of alteration
10	Corrected example 1 on the third last line where the fuel flow is 2,000 kg/hr not 2000 kg/yr.
13	Corrected description and equation for determining the ethanol reporting thresholds for the NPI.

EMISSION ESTIMATION TECHNIQUES
FOR
WINE AND SPIRITS MANUFACTURING

TABLE OF CONTENTS

WINE AND SPIRITS MANUFACTURING

LIST OF FIGURES, TABLES AND EXAMPLES

1.0   Introduction

The purpose of all Emission Estimation Technique (EET) Manuals in this series 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 from facilities engaged in wine and spirits manufacturing.

The wine manufacturing activities covered by this manual consists of facilities engaged in the manufacturing or blending of wine, fermented cider or wine vinegar, or other alcoholic beverages.

EET MANUAL:	Wine and Spirits Manufacturing
HANDBOOK:	Wine and Spirits Manufacturing
ANZSIC CODES :	2183 & 2184

This Manual was drafted by the NPI Unit of the Queensland Department of Environment and Heritage on behalf of the Commonwealth Government. It has been developed through a process of national consultation involving State and Territory environmental authorities and key industry stakeholders.

2.0   Processes and Emissions

The following section presents a brief description of the wine and spirits manufacturing industry and identifies likely sources of emissions.

2.1   Process Description

Wine is an alcoholic beverage produced by the fermentation of sugars in grape juice. Wines may be classified as table wines and dessert wines. Table wines may further be divided into sparkling and still varieties.

The basic steps in wine production include:

- Harvesting;
- Crushing;
- Pressing;
- Fermentation;
- Clarification;
- Ageing;
- Blending;
- Finishing; and
- Packaging.

The distilled spirits industry includes the production of whisky, gin, vodka, rum, and brandy. Distilled spirits production also may include the secondary products such as distillers dried grains used for livestock feed and other feed/food components.

Distilled spirits can be produced by a variety of processes. Typically, in whisky production, grains are mashed and fermented to produce an alcohol/water solution, which is distilled to concentrate the alcohol. For whiskies, the distilled product is aged to provide flavour, colour and aroma.

A typical whisky production consists of grain handling and preparation, grain mashing, fermentation, distillation, grain and liquid stillage, warehousing/ageing, and blending/bottling.

Brandy is an alcoholic distillate or mixture of distillates obtained from the fermented juice, mash, or wine from fermented grapes and "fruit brandy" is made from other fruit, such as apples, apricots or peaches.

In brandy production the grapes are pressed immediately after crushing. There are major differences in the fermentation process between wine and spirits production.

Figure 1 illustrates the basic steps in the production of still table wine.
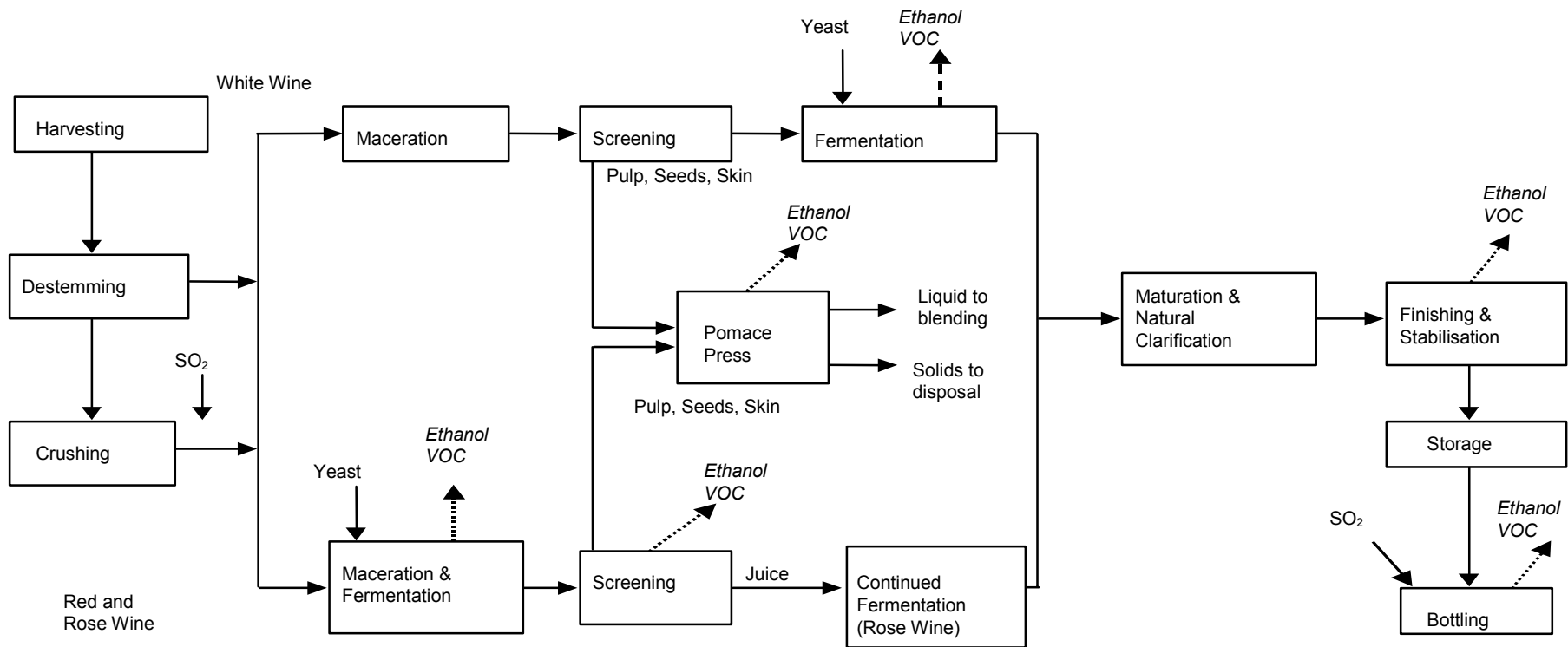
Figure 1 - Production of Still Table Wine
Source: USEPA, AP-42, Section 9.12.2, 1995.

2.2 Emission Sources and Control Technologies

2.2.1 Emissions to Air

Air emissions may be categorised as:

Fugitive Emissions

These are emissions that are not released through a vent or stack. Examples of fugitive emissions include evaporation of wastewater, dust from stockpiles, volatilisation of vapour from vats, open vessels, or spills and materials handling. Emissions emanating from ridgeline roof-vents, louvres, and open doors of a building as well as equipment leaks, and leaks from valves and flanges are also examples of fugitive emissions. Emission factors are the usual method for determining losses through fugitive emissions. Possible air emissions from the wine manufacturing industry are listed in Table 1 and include activities such as pressing, ageing and packaging (bottling).

Point Source Emissions

These emissions are exhausted into a vent (excluding roof vent) or stack and emitted through a single point source into the atmosphere.

Table 1 - Likely Emissions of NPI-listed Substances from Wine and Spirits Manufacturing

Process Stage	Possible Emissions
Fermentation	• Ethanol (largest emission by volume) • Acetaldehyde • Methanol • Hydrogen Sulfide • Total Volatile Organic Compounds (VOCs) • Ethyl Acetate
Fugitive Emissions - Screening of red wine - Pressing - Ageing in oak cooperage - Bottling process - Preservation agents	• Ethanol • Sulfur dioxide
Combustion Emission	• Carbon Monoxide (CO) • Sulfur dioxide (SO_2) • Volatile organic compounds (VOCs) • Particulate matter (PM_{10}) • Oxides of Nitrogen (NO_x)

Source: Adapted from USEPA, AP-42, Section 9.12.2. 1995

Emission controls are generally not used during the production of wines or spirits in Australia, however, five potential control systems have been considered. These include:

- carbon absorption;
- water scrubbers;
- catalytic incineration;
- condensation; and
- temperature control.

All of these systems have disadvantages in either low control efficiency, cost effectiveness, or overall applicability to the wide varieties of wineries.

Where such emission abatement equipment has been installed elsewhere, and where emission factors from uncontrolled sources have been used in emission estimation, the collection efficiency of the abatement equipment needs to be considered. Guidance on applying collection efficiencies to emission factor equations is provided later in Section 3.4.

With regards to emission controls for PM_{10} emissions (particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less ie. $\leq 10\mu m$) in the absence of measured data, or knowledge of the collection efficiency, for a particular piece of equipment, an efficiency of 90% should be used in the emission factor equation to calculate actual mass emissions. This default should only be used if there is no other available control efficiency.

2.2.2 Emissions to Water

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

- Surface waters (eg. lakes, rivers, dams, and estuaries);
- Coastal or marine waters; and
- Stormwater.

Because of the significant environmental hazards posed by emitting toxic substances to water, most facilities emitting NPI-listed substances to waterways are required by their relevant State or Territory environment agency to closely monitor and measure these emissions. This existing sampling data can be used to calculate annual emissions.

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

The discharge of listed substances to a sewer or tailings dam does not require you to report to the NPI. However, leakage and other emissions (including dust) from a tailings storage facility are reportable. (See also Section Three of *the NPI Guide*.)

2.2.3   Emissions to Land

Emissions of substances to land on-site include solid wastes, slurries, sediments, spills and leaks, storage and distribution of liquids that may contain listed substances. These emission sources can be broadly categorised as:

- surface impoundment of liquids and slurries; and
- unintentional leaks and spills.

Irrigation of wastewater is a common source of emissions of NPI-listed substances to land.

3.0 Emission Estimation Techniques

Estimates of emissions of NPI-listed substances to air, water and land should be reported for each substance that triggers a threshold. The reporting list and detailed information on thresholds are contained in *The NPI Guide* on the web (http://www.npi.gov.au/).

In general, there are four types of emission estimation techniques (EETs) that may be used to estimate emissions from your facility. The four types described in the *NPI Guide* are:

- sampling or direct measurement;
- mass balance;
- fuel analysis or other engineering calculations; and
- emission factors.

Select the EET (or mix of EETs) that is most appropriate for your purposes. For example, you might choose to use a mass balance to best 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.

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 emission estimation techniques 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 techniques for the NPI substances relevant to this industry. However, 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 relevant environmental authority. For example, if your company has developed site-specific emission factors, you may use these if approved by your relevant environmental authority.**

In general, direct measurement is the most accurate method for characterising emissions and, where available, such data should be used in preference to other EETs presented in this Manual. However, additional direct measurement is not required under the NPI Measure. Direct monitoring may be undertaken as an element of other EETs.

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 (eg. 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, ie. the quantity of the NPI reportable substance spilled, less the quantity recovered or consumed during clean up operations.

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 VOCs) reporting threshold is exceeded. If the threshold is exceeded, **emissions** of these Category 1 and 1a substances must be reported for all operations/processes relating to the facility, even if the actual emissions of the substances are very low or zero.

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

3.1   Direct Measurement

You may wish to undertake direct measurement in order to report to the NPI, particularly if you already do so in order to meet other regulatory requirements. However, the NPI does not require you to undertake additional sampling and measurement. For the sampling data to be adequate and able to be used for NPI reporting purposes, it would need to be collected over a period of time, and to be representative of operations for the whole year.

3.1.1   Sampling Data

Stack sampling test reports often provide emissions data in terms of kg/hr or g/m^3 (dry). Annual emissions for NPI reporting can be calculated from this data. Stack tests for NPI reporting should be performed under representative (ie. normal) operating conditions. You should be aware that some tests undertaken for a State or Territory license condition may require the test be taken under maximum emissions rating, where emissions are likely to be higher than when operating under normal operating conditions.

3.1.2   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.

3.2   Mass Balance

A mass balance identifies the quantity of 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.

3.3 Engineering Calculations

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

3.3.1 Fuel Analysis

Fuel analysis is an example of an engineering calculation and can be used to predict SO_2, metals and other emissions based on application of conservation laws, if fuel rate is measured. The presence of certain elements in fuels may be used to predict their presence in emission streams. This includes elements such as sulfur that may be converted into other compounds during the combustion process.

The basic equation used in fuel analysis emission calculations is the following:

Equation 1

$$E_{kpy, i} = Q_f * (\text{concentration of pollutant } i/100) * (MW_p/EW_f) * OpHrs$$

where:

$E_{kpy, i}$ = hourly emissions in kg per hour of pollutant i, kg/yr
Q_f = fuel use, kg/hr
MW_p = molecular weight of pollutant emitted, kg/kg-mole
EW_f = elemental weight of element in fuel, kg/kg-mole
$OpHrs$ = operating hours, hr/yr
Concentration of pollutant i in fuel expressed as weight percent, %

For instance, SO_2 emissions from oil combustion can be calculated based on the concentration of sulfur in the oil. This approach assumes complete conversion of sulfur to SO_2. Therefore, for every kilogram of sulfur (elemental weight, EW = 32) burned, two kilograms of SO_2 (MW = 64) are emitted. The application of this EET is shown in Example 1. Further assistance in estimating emissions from fuel combustion processes is available from the *Combustion in Boilers* and *Combustion Engines* EET Manuals.

<div style="border: 1px solid black; padding: 10px;">

Example 1 - Using Fuel Analysis Data

This example illustrates how SO_2 emissions can be calculated from oil combustion based on fuel analysis results and the fuel flow information. The facility is assumed to operate 1500 hours per year.

$E_{kpy, SO2}$ = may be calculated using Equation 1.

Fuel flow (Q_f) = 2000 kg/hr
Weight percent sulfur in fuel = 1.17%
OpHrs = 1500 hr/yr

$E_{kpy, SO2}$ = Q_f * (concentration of pollutant i/100) * (MW_p/EW_f) * OpHrs
= (2000 kg/hr) * (1.17 / 100) * (64 / 32) * 1500 hr/yr
= 46.8 kg/hr * 1500 hr/yr
= 70 200 kg/yr

</div>

3.4   Emission Factors

An emission factor is a tool that is used to estimate emissions to the environment. In this Manual, it relates the quantity of substances emitted from a source to some common activity associated with those emissions. Emission factors are obtained from US, European and Australian sources and are usually expressed as the weight of a substance emitted divided by the unit weight, volume, distance, or duration of the activity emitting the substance (eg. kilograms of Volatile Organic Compounds emitted per litre of white wine produced).

Emission factors are used to estimate a facility's emissions by the general equation:

Equation 2

$E_{kpy, i}$ = [A * OpHrs] * EF_i * [1 - (CE_i/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 of pollutant i, kg/t
CE_i = overall control efficiency for pollutant i, %.

Emission factors developed from measurements for a specific process may sometimes be used to estimate emissions at other sites. Should a company have several processes of similar operation and size, and emissions are measured from one process source, an emission factor can be developed and applied to similar sources. You are required to have

the emission factor reviewed and approved by State or Territory environment agencies prior to its use for NPI estimations.

3.4.1 Industry-Wide Emission Factors

The following emission factors may be used to estimate emissions from wine manufacturing processes.

Table 2 - Emission Factors for Uncontrolled Fugitive Ethanol Emissions Produced During Handling Operations[a]

Process	Units	Wine Type	
		Red	White
Pomace Screening	(kg/m^3) [b]	0.06	ND
Pomace Pressing	(kg/tonne) [c]	0.0082	N/A
Bottling	(kg/m^3) [b]	ND	0.012

Source: USEPA, AP-42, Section 9.12.2, 1995
[a] Emission Factor Rating: E. (See Section 4.4)
[b] Units are kg of pollutant emitted per cubic metre of fermented juice produced.
[c] Units are kg of pollutant per tonne of pomace.
 ND = no data available.
 N/A = not applicable

Table 3 - Emission Factor for Distilled Spirits[a]

Source	Ethanol	Ethyl Acetate	Isoamyl Alcohol	Isobutyl Alcohol	Total VOCs
Grain Mashing	NA	NA	NA	NA	NA
Fermentation vats	6.45 [b]	0.021[b]	$5.91 * 10^{-3}$, [b]	$1.82 * 10^{-3,}$ [b]	6.48 [b]
Distillation	ND	ND	ND	ND	ND
Ageing - evaporation loss [c]	3.13[d] (0.016)[e]	ND	ND	ND	3.13[d] (0.016)[e]
Blending/bottling	ND	ND	ND	ND	ND
Dryer house operations	ND	ND	ND	ND	ND

Source: USEPA, AP-42, Section 9.12.3
[a] Factors represents uncontrolled emissions. ND = no data available. NA = not applicable.
[b] In units of kg/1000 bushels of grain input. Where 1 bu (bushel) = 27.2 kg of wheat, = 25.4 kg of corn, = 14.5 kg or oats.
[c] Evaporation loss during whisky ageing does not include losses due to soakage.
[d] In units of kg/bbl/yr; where bbl is defined as barrels. Barrels have a capacity of approximately 200 litres.
[e] Since litres are commonly used in Australia instead of barrels, this emission factor is expressed in kg/L. eg. 1 bbl of whisky = 1 barrel of whisky = 190 L

Table 4 - Emission Factors for Wine Fermentation[a]

Wine Type	Control Type	Ethanol (kg/m³)[b]	Methanol (kg/m³)[b]	Acetaldehyde (kg/m³)[b]	Hydrogen Sulfide (kg/m³)[b]	Volatile Organic Compounds (VOCs) (kg/m³)[b]
Red	None	0.55	0.0003	0.00032	0.0002	0.552
	Carbon Adsorption	0.02	ND	ND	ND	ND
	Catalytic Incineration	0.13	ND	ND	ND	ND
	Wet Scrubber	0.0067	ND	ND	ND	ND
White	None	0.22	$7.7 * 10^{-5}$	$8.6 * 10^{-6}$	0.00016	0.22
	Carbon Adsorption	0.011	ND	ND	ND	ND
	Catalytic Incineration	0.018	ND	ND	ND	ND
	Wet Scrubber	0.01	ND	ND	ND	ND

Source: USEPA, AP-42, Section 9.12.2, 1995
[a] Emission Factor Rating: E (see Section 4.4).
[b] Units are kg of pollutant emitted per cubic metre of fermented juice produced.
 ND = no data available.

Example 2 - Using Emission Factors

Table 4 shows that during the fermentation process for red wine, with no control technology in place, 0.55 kg of ethanol is emitted per cubic metre of fermented juice produced. It is assumed that the winery produces 1.5 ML of fermented juice per year.

Emission control efficiency for ethanol is zero, with all ethanol produced emitted to air.
Variables have been expressed in more relevant units to industry, ie. Activity rate = ML/yr,
EF_i = kg/m³

CE_i	=	0
Emission Factor ($EF_{ethanol}$)	=	0.55 kg/m³ (= 0.55 * 10³ kg/ML)
Fermented juice produced (A)	=	1.5 ML/yr

As per Equation 2, activity rate is expressed as t/hr, which is multiplied by OpHrs (hr/yr) to obtain annual activity rate (t/yr). However, in this example, we are given annual activity rate. Therefore using a variation of Equation 2, the following can be calculated:

$$E_{kpy, ethanol} = A * EF_{ethanol} * [1 - (CE_i/100)]$$
$$= 1.5 \text{ ML/yr} * 0.55 * 10^3 \text{ kg/ML} * (1 - 0/100)$$
$$= 825 \text{ kg/year}$$

NB: Ethanol is produced coincidentally by the fermentation process but is also typically added to wine to raise the alcohol content to the desired level. Both the amount produced by fermentation and the amount purchased need to be considered for threshold determination and it is not appropriate to draw threshold conclusions only from the volume generated from fermentation.

3.4.2 Determining if Ethanol needs to be reported to the NPI

For the purposes of NPI reporting, a winery is required to report ethanol emissions arising from the fermentation reactions where ethanol use exceeds 10 tonnes per year. The amount of ethanol "used" in winemaking equals the amount purchased plus the amount co-incidentally produced. 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 wine produced, using Equation 3:

Equation 3

$$U_{ethanol} = P_{wine} * (A/100) * 0.79 / 1000$$

where:

$U_{ethanol}$	=	usage of ethanol in reporting period, tonnes/year
P_{wine}	=	annual wine production in litres/year
A	=	alcohol (ethanol), content, % by volume
0.79	=	density of ethanol, kg/litre
1 000	=	conversion factor, kg to tonnes

If the facility produces different types of wines with varying alcohol contents, the $U_{ethanol}$ for each type of wine 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 3 illustrates the application of Equation 3.

Example 3 - Determining Ethanol Use for Wine Making

A winery produces 1 million litres of wine per year with an alcohol content of 10 % by volume.

P_{wine} = 1,000,000 litres/year
A = 10 % by volume

Using Equation 3:

$U_{ethanol}$ = P_{wine} * (A/100) * 0.79 / 1000
= 1,000,000 * (10/100) * 0.79/1000
= 79 tonnes/year

As this is greater than 10 tonnes, the facility exceeds the ethanol usage threshold and is required to report estimated emissions of ethanol to the NPI.

3.4.3 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.

4.0 Emission Estimation Techniques: Acceptable Reliability and Uncertainty

This section is intended to give a general overview of some of the inaccuracies associated with each of the techniques. Although the National Pollutant Inventory does not favour one emission estimation technique over another, this section does attempt to evaluate the available emission estimation techniques with regards to accuracy.

Several techniques are available for calculating emissions from wine or spirits manufacturing facilities. The technique chosen is dependent on available data, available resources, and the degree of accuracy sought by the facility in undertaking the estimate. In general, site-specific data that is representative of normal operations is more accurate than industry-averaged data, such as the emission factors presented in Section 3.4 of this Manual.

4.1 Direct Measurement

Use of stack and/or workplace health and safety sampling data is likely to be a relatively accurate method of estimating air emissions from wine or spirits manufacturing facilities. However, collection and analysis of samples from facilities can be very expensive and especially complicated where a variety of NPI-listed substances are emitted and where most of these emissions are fugitive in nature. Sampling data from a specific process may not be representative of the entire manufacturing operation and may provide only one example of the facility's emissions. This is particularly relevant to the wine and spirits manufacturing industry, due to the large amount of fugitive emissions that occur.

To be representative, sampling data used for NPI reporting purposes needs to be collected over a period of time, and to cover all aspects of production.

In the case of CEMS, instrument calibration drift can be problematic and uncaptured data can create long-term incomplete data sets. However, it may be misleading to assert that a snapshot (stack sampling) can better predict long-term emission characteristics. It is the responsibility of the facility operator to properly calibrate and maintain monitoring equipment and the corresponding emissions data.

4.2   Mass Balance

Calculating emissions from a wine or spirits manufacturing facility using mass balance appears to be a straightforward approach to emission estimations. However, it is likely that few Australian facilities consistently track material usage and waste generation with the overall accuracy needed for application of this method. Inaccuracies associated with individual material tracking or other activities inherent in each material handling stage can often result in large deviations of total facility emissions. Because emissions from specific materials are typically below 2 percent of gross consumption, an error of only ± 5 percent in any one step of the operation can significantly skew emission estimations.

4.3   Engineering Calculations

Theoretical and complex equations or *models* can be used for estimating emissions from wine or spirits manufacturing processes.

Use of emission equations to estimate emissions is a more complex and time-consuming process than the use of emission factors. Emission equations require more detailed inputs than the use of emission factors, but they do provide an emission estimate that is based on facility-specific conditions.

4.4   Emission Factors

Every emission factor has an associated emission factor rating (EFR) code. This rating system is common to EETs for all industries and sectors and therefore, to all Industry Handbooks. They are based on rating systems developed by the United States Environmental Protection Agency (USEPA), and by the European Environment Agency (EEA). Consequently, the ratings may not be directly relevant to Australian industry. Sources for all emission factors cited can be found in Section 5.0 of this Manual. The emission factor ratings will not form part of the public NPI database.

When using emission factors, you should be aware of the associated EFR code and what that rating implies. An A or B rating indicates a greater degree of certainty than a D or E rating. The less certainty, the more likely that a given emission factor for a specific source or category is not representative of the source type. These ratings notwithstanding, the main criterion affecting the uncertainty of an emission factor remains the degree of similarity between the equipment/process selected in applying the factor, and the target equipment/process from which the factor was derived.

The EFR system is as follows:

A	-	Excellent
B	-	Above Average
C	-	Average
D	-	Below Average

E   -   Poor
U   -   Unrated

5.0   References

USEPA. October 1995. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*, *fifth edition, AP-42. Section 9.12.2 Wines and Brandy.* United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42.html

USEPA. March 1997. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*, *fifth edition, AP-42. Section 9.12.3 Distilled Spirits.* United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.

The following EET Manuals are available at the NPI Homepage (*http://www.npi.gov.au*) and from your local Environmental Protection Authority:

- Emission Estimation Technique Manual for Combustion in Boilers;
- Emission Estimation Technique Manual for Combustion Engines; and
- Emission Estimation Technique Manual for Sewage and Wastewater Treatment.