SNAP CODES:	**040606** **040607** **040608**
SOURCE ACTIVITY TITLES:	**PROCESSES IN WOOD, PAPER PULP, FOOD, DRINK AND OTHER INDUSTRIES** ***Wine*** ***Beer*** ***Spirits***
NOSE CODE:	**105.03.03** **105.03.04** **105.03.05**
NFR CODE:	**2 D 2**

1 ACTIVITIES INCLUDED

Emissions are included from the production of alcoholic beverages, specifically wine, beer and spirits. Emissions from the production of other alcoholic drinks are not covered in this edition.

Emissions from the distribution of alcoholic beverages should be included, but in this edition are not considered.

2 CONTRIBUTION TO TOTAL EMISSIONS

The contribution to total national emissions of NMVOC emissions from the production of alcoholic beverages lies in the range 0 to 2% (based on information given in Passant et al., 1993). In general, spirit production tends to be the largest source and this may be considered very country specific.

3 GENERAL

3.1 Description

When making any alcoholic beverage, sugar is converted into ethanol by yeast. This is fermentation. The sugar comes from fruit, cereals or other vegetables. These materials may need to be processed before fermentation. For example, in the manufacture of beer, cereals are allowed to germinate, then roasted and boiled before fermentation. To make spirits, the fermented liquid is then distilled. Alcoholic beverages, particularly spirits and wine, may be stored for a number of years before consumption.

3.2 Definitions

beverage	drink
cask	container in which drinks are stored to mature.

to decant	to pour from one container into another. This verb is often used to imply that only part of the contents of the first container are poured into the second.
distillate	product of distillation; the more volatile substances.

3.3 Techniques

3.3.1 Preparation of feedstock

Cereals used in the production of beer and some spirits are usually allowed to germinate before use. This process is called malting, and results in the conversion of starch into sugars.

Germinated cereals may then be roasted. The length of roasting varies depending on the type of grain and the type of beverage to be produced.

Before fermentation, cereals are often boiled in water to produce wort, which is then filtered to separate out the solid residues.

Grapes and other fruit used to make alcoholic beverages, are pressed to recover their juice, which is filtered to remove solid residues. Red wine is fermented with the grape skins remaining in the vat for the initial fermentation. The liquid wine is run off when the required colour and tannin have been obtained, and the remainder of the liquid is obtained by pressing.

The solid residues may be further processed into food for animals.

3.3.2 Fermentation

Fermentation occurs in large fermenting vessels and typically lasts for from one to three days. Some vessels are sealed, recirculating the carbon dioxide. Others, normally in smaller plants, vent to atmosphere via a water trap.

The yeast strain used for fermentation depends on the beverage.

The specific gravity of the fermenting mixture is measured regularly as an indication of the sugar content and thereby the degree of fermentation. Temperature controls may need to be used as most fermentation will only take place at 5-30^{o}C.

3.3.3 Distillation

After separating solids from the fermented product, distillation may be used to recover the alcohol and other volatile organic species. Additional flavourings may be added either before or after distillation. More than one stage of distillation may be used. The final distillate can now either be diluted to give a standard alcohol content and bottled, or, in the case of whisky, brandy, some gins and other spirits, undergo a period of storage (maturation) during which the flavour develops.

3.3.4 Maturation

Wine is transferred to wooden casks after fermentation. Every 3 months the wine is decanted ("racked") from one cask to another to remove the sediment which collects during maturation. After maturation, which may take from a few weeks to several years, the wine is bottled (Burroughs and Bezzant, 1980).

Some spirits are transferred to wooden casks after distillation. Whisky and brandy are stored for a minimum of three years (usually longer). Some other spirits, such as gin, may occasionally be stored for shorter periods before sale. The final product is diluted to the appropriate alcohol strength and bottled.

3.4 Emissions/Controls

Emissions may occur during any of the four stages which may be needed in the production of an alcoholic beverage.

During preparation of the feedstock, the most important emissions appear to occur during the roasting of cereals and the drying of solid residues. Techniques for controlling emissions during the drying of residues exist and may involve condensers or bio-filters.

During fermentation, alcohol and other NMVOCs are carried out with the carbon dioxide as it escapes to atmosphere. In some cases, the carbon dioxide may be recovered, reducing the emission of NMVOC as a result.

During the distillation of fermentation products emissions are to be expected, but very little data is available. Losses occur as a result of poor maintenance and the use of old plant.

During maturation NMVOCs evaporate from the stored beverage. The mass of emission will be proportional to the length of the maturation period. Few if any control technologies are known.

Some losses of spirit are to be expected during transfer of spirit to barrels for storage. The UK Customs & Excise allow for a maximum loss of 0.1% of alcohol production (Passant, 1993).

4 SIMPLER METHODOLOGY

The simpler methodology involves combining readily available national data on the production of wine, beer and spirits with default emission factors based on all the currently available information. The default emission factors are designed to ensure that the resulting emission is not underestimated.

The annual production in hectolitre is multiplied by the relevant 'emission factor' to give the annual emission:

Emission Factor (kg/hl) x Annual Consumption (hl/a) = Annual Emission (kg/yr)

kg/yr = kilogram per year
kg/hl = kilogram per hectolitre
hl/yr = hectolitre per year

Emission factors for a variety of alcoholic beverages are given in paragraph 8.3.

5 DETAILED METHODOLOGY

The detailed methodology involves the acquisition of more detailed data on the production of red and white wine, and the types of spirit produced. These data are combined with default emission factors as described in the simpler methodology.

6 RELEVANT ACTIVITY STATISTICS

6.1 Simpler Methodology

Total production of wine
Total production of beer and cider
Total production of spirits

International statistics for these activities are given in World Drink Trends, 1993. NTC Publications Ltd, ISBN 1 870562 63 1, price £25.

6.2 Detailed Methodology

Total production of red wine
Total production of white wine
Total production of beer
Total production of whisky and the typical maturation period
Total production of brandy and the typical maturation period
Total production of other spirits and the typical maturation period

The principle information source will be the country's national statistics of production.

7 POINT SOURCE CRITERIA

The criterion proposed for consideration as a point source is an emission of 1.5 kt NMVOC per year.This is equivalent to a point source producing 19 000 000 hl of wine, 43 000 000 hl of beer, 100 000 hl(alcohol) of whisky, 430 000 hl(alcohol) of brandy, or 4 000 000 hl(alcohol) of other spirits. Hence it would be unusual for an individual production unit to create such a significant emission

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Background Data

The following emission factors were used to derive default emission factors for the simpler and detailed methodologies.

Process	Emission factor	Quality code	Reference
Barley malting	550 g/t (barley)	E	Passant, 1993
Hop processing	0.0055-0.011 kg/t(beer)	C	UBA, 1981
Fermentation	2 kg/t (alcohol)	D	Passant, 1993
Casking	0.5 kg/t (alcohol)	D	Passant, 1993
Maturation	20 kg/a/t (alcohol)	C	Passant, 1993
Grain drying	1310 g/t (grain)	E	USEPA, 1985
Wine	200 g/tonne	D	Rentz et al, 1991
Red Wine	0.1-1.2 kg/m^3	E	Jourdan et al, 1990
White Wine	0.1-0.3 kg/m^3	E	Jourdan et al, 1990
Red Wine	0.81 g/kg	D	Veldt,1991
White Wine	0.34 g/kg	D	Veldt, 1991

0.15 tonne of grain is required to produce 1 tonne of beer (Passant, 1993).

Malt whiskies are typically matured for ten years. Grain whiskies are typically matured for six years. It is assumed that brandy is matured for three years and that other spirits are not matured.

Beer is considered to be typically 4% alcohol by volume and to weigh 1 tonne per cubic metre.

If no better data is available, assume spirits are 40% alcohol by volume.

Alcohol (ethanol) has a density of 789 kg/m^3

8.2 Default Emission Factors

Beverage	Emission Factor		Quality
	Simple	Detailed	
Wine (unspecified colour)	0.08 kg/hl(wine)		E
Red Wine		0.08 kg/hl(wine)	D
White Wine		0.035 kg/hl(wine)	D
Beer (including de-alcoholized)	0.035 kg/hl(beer)		D
Spirits (unspecified sort)	15 kg/hl(alcohol)		E
Malt Whisky		15 kg/hl(alcohol)	C
Grain Whisky		7.5kg/hl(alcohol)	C
Brandy		3.5 kg/hl(alcohol)	D
Other Spirits		0.4 kg/hl(alcohol)	D

9 SPECIES PROFILES

Emissions from most processes in the manufacture of alcoholic beverages are likely to consist almost entirely of ethanol.

Emissions from the processing of cereals is known to involve a range of NMVOC including alcohols, ethers, aldehydes, aromatics, aliphatics, dimethyl sulphide and carboxylic acids (Rapport et al., 1983; Gibson et al., 1994; Buckee et al., 1982; Lukes et al., 1988; Seaton et al., 1982)

Methanol and dichloromethane may be used in the extraction of hops for the flavouring of beer. However, emissions from this process contribute very little to the total.

Little is known of actual emissions during the fermentation of wine, however 98% of all NMVOC in must (fermenting grapes and grape skins) is ethanol, so the primary species emitted from fermentation is likely to be ethanol, with the remaining species primarily alcohols, aldehydes and esters (Passant et al., 1993; Jourdan et al., 1990; Lichine, 1975)

Emissions from the fermentation of beer are >90% ethanol, with the remaining 10% are made up of hexanal, benzaldehyde, ethers, esters, acetates, acids.

Emissions from distillation and maturation are expected to be entirely ethanol.

Unless better information is available, the composition of emissions from the production of wine and spirits is assumed to be 100% ethanol.

The following default emission profile for beer production may be used, with a data quality of E:

Compound	**% contribution to total emission**
Ethanol	59%
Propanol	10%
Hexanal	10%
Dimethyl Sulphide	10%
Acetic Acid	10%
Dichloromethane	1%

10 UNCERTAINTY ESTIMATES

The uncertainty in emissions from the production of wine and beer is expected to be greater than a factor of 2.

The uncertainty in emissions from spirits will also be greater than a factor of 2 unless the type of spirit produced is identified. If this is the case, then the uncertainty in emissions from spirits will be less than a factor of 2.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspect of the methodology is the accuracy of the emission factors. Which factor should receive most attention depends on the relative proportions of wines, beers and spirits in a country's production. Hence, for example, in the United Kingdom, where a large volume of spirits (matured for several years) is manufactured, uncertainty in the emission factor for maturation is the largest source of uncertainty. In Germany, where more beer and a smaller volume of spirits (matured for less time) are made, the emission factors for cereal processing are also important. More accurate emission factors may be obtained through a programme of measurements from a range of selected plant.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

The manufacture of most beverages is associated with particular regions of a country. The lowest level of accuracy is obtained by disaggregating the net emission according to population density. Greater accuracy is achieved by identifying regions where particular beverages are produced and confining the distribution of emissions to those regions.

13 TEMPORAL DISAGGREGATION CRITERIA

The lowest accuracy assumes that emissions do not vary temporally.

Greater accuracy is achieved if it is assumed that the processing of feedstock and fermentation occur primarily in three months of the year, namely August, September and October. Distillation and maturation occur during all months of the year.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

World Drink Trends, 1993. NTC Publications Ltd, ISBN 1 870562 63 1, price £25.

16 VERIFICATION PROCEDURES

Verification procedures involve the measurement of emissions from specific plant and in particular emissions during the processing of cereals and fermentation.

17 REFERENCES

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18 BIBLIOGRAPHY

19 RELEASE VERSION, DATE AND SOURCE

Version : 2.1

Date : March 1995

Source : M A Emmott, S J Richardson.
AEA Technology Environment

20 POINT OF ENQUIRY

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