



Australian Government
Department of the Environment



National Pollutant Inventory
Emission estimation technique manual
for

Malt Manufacturing

Version 1.1

October 2014

ISBN: 978-0-642-55386-7

© Commonwealth of Australia 2014

This manual may be reproduced in whole or part for study or training purposes subject to the inclusion of an acknowledgment of the source. It may be reproduced in whole or part by those involved in estimating the emissions of substances for the purpose of National Pollutant Inventory (NPI) reporting. The manual may be updated at any time. Reproduction for other purposes requires the written permission of the Department of the Environment, GPO Box 787, Canberra, ACT 2601, e-mail: npi@environment.gov.au, web: www.npi.gov.au.

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 Australian Government does not accept responsibility for the accuracy or completeness of the contents and shall not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance on, the contents of this manual.

Table of Contents

1	INTRODUCTION	1
2	PROCESS DESCRIPTION	2
3	EMISSIONS OF NPI SUBSTANCES.....	3
3.1	EMISSIONS TO AIR.....	3
3.1.1	<i>Emissions of Particulate Matter (PM_{2.5}) and Particulate Matter (PM₁₀)</i>	<i>4</i>
3.1.2	<i>Total VOC emissions</i>	<i>4</i>
3.1.3	<i>Emissions from the burning of fuel</i>	<i>5</i>
3.2	EMISSIONS TO WATER	5
3.2.1	<i>Emissions of Total Nitrogen and Total Phosphorus</i>	<i>6</i>
3.3	EMISSIONS TO LAND	6
4	TRANSFERS OF NPI SUBSTANCES.....	7
5	NEXT STEPS FOR REPORTING	8
6	REFERENCES	9
	APPENDIX A: DEFINITIONS AND ABBREVIATIONS.....	10
	APPENDIX B: ERRATUM TO THE MALT MANUFACTURING MANUAL	12

List of Figures, Tables and Equations

FIGURES

FIGURE 1 MALT MANUFACTURING FACILITY PROCESS DIAGRAM	2
--	---

TABLES

TABLE 1: LIKELY EMISSIONS TO AIR FOR MALT MANUFACTURING.	3
TABLE 2: PARTICULATE EMISSION FACTORS FOR BARLEY MALTING GRAIN RECEIVING	4
TABLE 3: PM10 EMISSION FACTORS FOR MALT MANUFACTURING	4
TABLE 4: TOTAL VOC EMISSION FACTORS FROM MALT MANUFACTURING	5

EQUATIONS

EQUATION 1	5
------------------	---

1 Introduction

National Pollutant Inventory (NPI) Emission Estimation Technique (EET) manuals provide guidance to assist facility reporters to report emissions and transfers of NPI substances to the NPI. This manual describes the procedures and recommended approaches to estimating emissions and transfers from malt manufacturing.

NPI substances are those that, when emitted at certain levels, have the potential to be harmful to human health or the environment. Australian state and territory governments have legislated that industry will report these emissions on an annual basis. Reportable NPI substances are listed in the *NPI Guide* and are classified into six categories, with different reporting thresholds. If your facility trips a threshold in a reporting year for an NPI substance, all emissions of that substance to air, water and land from your facility must be reported. Transfers of NPI substances must also be reported for each substance tripped in Categories 1, 1b and 3. Reporting of transfers depends on whether the NPI substance is transferred to a mandatory or voluntary reporting transfer destination. For more information on the NPI program, please consult the *NPI Guide*, which is available from the NPI website at www.npi.gov.au.

The ANZSIC code and ANZSIC code descriptions that apply to this Manual are as follows:

EET MANUAL
2006 ANZSIC code and
description

Malt Manufacturing
1161 Grain Mill and Cereal Product Manufacturing

2 Process description

The malt manufacturing activities covered in this manual apply to facilities primarily engaged in the manufacture of malt from barley used as a feed source for the beer brewing industry. Malt, primarily manufactured from barley, is a main constituent in beer manufacturing.

Barley is shipped by railcar or truck to malting facilities. A screw conveyor or bucket elevator typically transports barley to storage silos or to the cleaning and sizing operations. The barley is cleaned, separated by size (using screens) and transferred to a malthouse where it is rinsed in steeping tanks (steeped) and allowed to germinate. Following steeping and germination, “green” malt is dried, typically in an indirect, natural gas-fired malt kiln. Malt kilns commonly include multiple levels, called beds or layers. For a two-level kiln, green malt, with a moisture content of about 45 percent, enters the upper deck of the kiln and is dried, over a 24-hour period, to between 15 and 20 percent. The barley is then transferred to the lower deck of the kiln, where it is dried to about 4 percent over a second 24-hour period. Some facilities burn sulfur in a sulfur stove and exhaust the stove into the kiln at selected times during the kiln cycle. The sulfur dioxide serves as a fungicide, bactericide, and preservative. Malting barley is then transferred by screw conveyor to a storage elevator until it is shipped. Malt is transported by truck or rail to a brewery and is conveyed to storage silos.

The first step in estimating emissions and transfers of NPI substances from a facility is to create a facility process diagram, highlighting points in the process where emissions and transfers may occur. Figure 1 illustrates a typical malting facility process diagram, showing likely emissions and transfer sources.

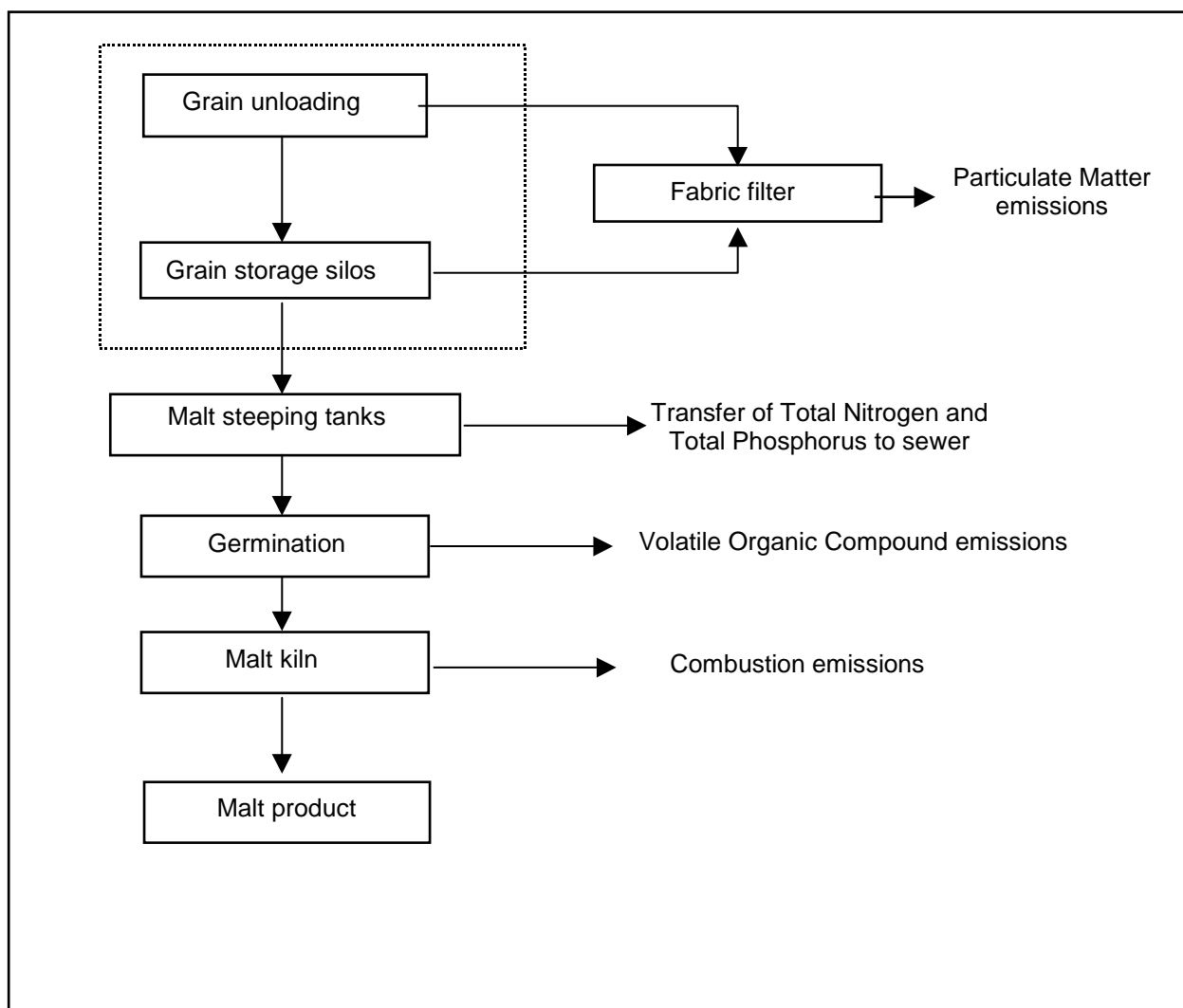


Figure 1: Malt manufacturing facility process diagram

3 Emissions of NPI substances

General information regarding emission sources can be located in the *NPI Guide*. Emissions from malt manufacturing will generally be directed through an air stack due to fuel combustion being the main source of emissions. Fugitive volatile organic compound (VOCs) emissions may occur from the germination process.

Table 1: Likely emissions to air from malt manufacturing

Activity	Constituent	NPI category	Emission factor
Germination	Volatile Organic Compounds (VOCs)	1a	Use emission factor in Table 4
Fuel burning kiln	Carbon monoxide Fluoride compounds Hydrochloric acid Particulate Matter (PM _{2.5}) Particulate Matter (PM ₁₀) Polycyclic Aromatic Hydrocarbons (PAHs) Sulfur dioxide Total Volatile Organic Compounds (VOCs)	2a	For estimating emissions of Particulate Matter (PM ₁₀) from fuel burning use emission factor in Table 3. See <i>Combustion in Boilers Emission Estimation Technique</i> manual) for estimating emissions for other Category 2a and 2b substances.
	Arsenic & compounds Beryllium & compounds Cadmium & compounds Chromium (III) & compounds Chromium (VI) & compounds Copper & compounds Lead & compounds Magnesium oxide fume Manganese & compounds Mercury & compounds Nickel & compounds Nickel carbonyl Nickel subsulfide Polychlorinated dioxins & furans PLUS all Category 2a substances (above)	2b	
Barley malting grain receiving	Particulate Matter (PM ₁₀)	2a	Use emission factor in Table 2

3.1 Emissions to air

Fugitive emissions at a malt manufacturing facility may occur from:

- germination
- equipment leaks
- emissions from barley and malt transfer operations
- windblown dust
- vehicle use
- fuel storage

Point source emissions may include:

- emissions from fuel combustion processes from stationary equipment (e.g. kilns)
- VOCs such as aldehydes and carboxylic acids

3.1.1 Emissions of Particulate Matter (PM_{2.5}) and Particulate Matter (PM₁₀)

Particulate Matter (PM_{2.5}) and Particulate Matter (PM₁₀) are category 2a and 2b substances and therefore are only reportable when a facility trips a fuel burning threshold. Where category 2a or 2b has been tripped, the facility is required to estimate emissions of PM_{2.5} and PM₁₀ from fuel burning as well as emissions of PM₁₀ from other sources such as barley transfer operations and silo filling. Emission factors for PM₁₀ from barley malting grain receiving are given in Table 2.

With regard to controls for PM₁₀ emissions 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 no other control efficiencies are available from literature or other sources.

Emission factors for PM₁₀ from malt manufacturing are given in Table 3.

Table 2: Particulate emission factors for barley malting grain receiving

Type of facility/ emission source	Type of control	Filterable ^a			
		PM	Emission factor rating	PM10 ^b	Emission factor rating
Grain receiving (SCC 3-02-007-08)	Fabric filter	0.0145 ^c	E (poor)	(d)	

a Weight of total filterable PM, regardless of size, per unit weight of grain throughput.

b Weight of PM ≤10µm in aerodynamic diameter per unit weight of grain throughput.

c Reference H. J. Beaulieu

d PM ≤10 µm test data are not available. PM ≤10 µm emission factors can be estimated by taking 100 percent of the filterable PM emission factor.

Source: USEPA AP-42 Chapter 9.9.1

Note: for more information on emission factor ratings, see the *NPI Guide*.

Table 3: Particulate emission factors for malt manufacturing

Substance	Emission factor (kg/t)	Emission factor rating
Particulate (PM ₁₀) emissions from gas-fired malt kiln	0.085 kg particulate matter emitted/tonne barley ^a	E (Poor)
Particulate (PM ₁₀) emissions from fabric filter	0.008 kg particulate matter emitted/tonne barley ^a	E (Poor)

a Source: Passant, Richardson, Swannell, Gibson & Woodfield, 1993
US EPA, 1998

Note: for more information on emission factor ratings, see the *NPI Guide*.

For guidance on the estimation of emissions from natural gas combustion processes, refer to the latest version of the *Combustion in Boilers Emission Estimation Technique* manual.

3.1.2 Total VOC emissions

A study in Europe (Passant, Richardson, Swannell, Gibson, Woodfield, 1993) indicates that extremely low concentration VOCs are released during malt manufacturing. It is expected that most malt manufacturers will have emissions that are below the Category 1a Total VOC threshold (25 tonnes). However, should the Category 2a fuel burning threshold be exceeded (thus tripping Total VOCs), Total VOC emissions from other aspects of malt manufacturing, (such as germination) will also need to be included in NPI reporting.

The methodology for calculating VOC emissions from malt manufacturing is quite straightforward. By multiplying the annual barley (or other input grain) tonnage by the emission factor, one will arrive at the estimated VOC emissions for malt manufacturing. Please note however that Passant et.al. (1993 p.2559)

suggests this is most likely an overestimation of VOC emissions and hence will illustrate the worst case scenario.

Table 4 provides an emission factor for Total VOCs from malt manufacturing.

Table 4: Total VOC emission factors from malt manufacturing

Substance	Emission factor	Emission factor rating
Total Volatile Organic Compounds	0.6 kg emitted/ tonne barley ^a	E (Poor)

a Source: Passant, Richardson, Swannell, Gibson & Woodfield, 1993
US EPA, 1998

Note: for more information on emission factor ratings, see the *NPI Guide*.

Equation 1

$$E_{\text{VOC}} = A_{\text{in}} * EF$$

where:

E_{VOC}	=	total emissions of VOCs from malt manufacturing, kg/yr
A_{in}	=	total tonnage of grain used (t/yr)
EF	=	emission factor (0.6kg VOCs/t grain)

Example 1 illustrates the use of Equation 1:

Example 1: Calculating Total VOC emissions using an emission factor

30 000 tonnes of barley are processed in a malt manufacturing facility over the reporting year.

Using Equation 1, emissions of Total VOC compounds can be calculated as follows:

$$E_{\text{VOC}} = A_{\text{in}} * EF$$

$$\begin{aligned} E_{\text{VOC}} &= 30\,000 \text{ t/yr} * 0.6 \text{ kg VOC emitted /tonne} \\ &= 18\,000 \text{ kg VOCs/yr} \end{aligned}$$

Since 18 000kg of Total VOCs is below the threshold value of 25 tonnes (25 000kg), this facility is not required to report Total VOCs under Category 1a, but may be required to report Total VOC emissions under the Category 2a threshold.

3.1.3 Emissions from the burning of fuel

All fuels emit substances when combusted, many of which are NPI substances. It is expected that malt manufacturing will trip the NPI threshold(s) for fuel burning. Emission estimation first involves identifying the type and amount of fuel(s) burnt onsite and the equipment used. All fuels burnt onsite need to be considered.

3.2 Emissions to water

For malt manufacturing, it is expected that process liquid effluent and wastewater will be either:

- sent to sewer;
- sent offsite for treatment, recycling or recovery; or
- recycled and reused in the process.

Emissions to water are not expected from malt manufacturing, as malting facilities usually discharge NPI substances to sewer. NPI substances in wastewater sent to sewer are regarded as transfers. Transfers are reportable to the NPI and more information on how to report transfers from malt manufacturing can be found in Section 5 of this manual. Section 4 of the *NPI Guide* also provides more detailed information on transfers.

3.2.1 Emissions of Total Nitrogen and Total Phosphorus

Emissions of Total Nitrogen and Total Phosphorus to surface waters (lakes, rivers, dams, estuaries), coastal or marine waters, or contained in stormwater runoff are only reportable if a Category 3 threshold has been exceeded. This is unlikely to be common practice in malt manufacturing.

Total Nitrogen and Total Phosphorus discharged to sewer is to be reported as transfers. For more information on transfers to mandatory and voluntary reporting transfer destinations, see Section Five.

3.3 Emissions to land

It is expected that the only emissions to land from malt manufacturing will be associated with spills and leaks. Refer to the *Organic Chemical Processing Industries Emission Estimation Technique* manual (Sections 9.1 and 9.2) for guidance in estimating releases due to spills and leaks or other releases to groundwater. Note: for NPI reporting purposes, emissions to groundwater are reported as emissions to land.

4 Transfers of NPI substances

General information regarding transfers of NPI substances can be located in the *NPI Guide* and the Transfers Information Booklet. For malt manufacturing, the quantities of NPI substances contained in wastewater transferred off-site to sewer or other final destinations will need to be reported as they are considered to be mandatory transfers. For example, if 15 tonnes or more of Total Nitrogen is sent to sewer in the reporting year, or 3 tonnes or more of Total Phosphorus is sent to sewer in the reporting year, then the amount of both Total Nitrogen and Total Phosphorus emitted to sewer will need to be reported as a transfer to a mandatory reporting transfer destination.

The transfer of NPI substances to a destination for reuse, recycling, reprocessing, purification, partial purification, immobilisation, remediation or energy recovery, can be reported voluntarily. Wastewater being recycled and reused in malting is considered as part of the process, and therefore does not need to be considered when reporting transfers to voluntary reporting transfer destinations.

5 Next steps for reporting

This manual has been written to reflect the common processes employed by facilities in the malting industry. To ensure a complete report of the emissions and transfers from the facility, it may be necessary to refer to other EET manuals such as, but not limited to:

- Fuel and Organic Liquid Storage;
- Combustion Engines;
- Combustion in Boilers;
- Fugitive Emissions.

When estimates of substance emissions and transfers from the facility are complete, report the emissions and transfers according to the instructions in the *NPI Guide*.

6 References

Passant, N, Richardson, S, Swannell, R, Gibson, N, Woodfield, M 1993, 'Emissions of Volatile Organic Compounds (VOCs) from the Food and Drink industries of the European Community', *Atmospheric Environment*, vol. 27A, no.16, pp. 2555-2566

US EPA 1996, *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, AP-42 Section 9.12.1 Malt Beverages*, United States Environmental Protection Agency. Accessed online: 3 December 1999 and 4 January 2000, www.epa.gov/ttn/chief/ap42pdf/c9s12-1.pdf

US EPA 1996, *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources Backup Documentation, AP-42 Section 9.9.1 Grain Handling*, United States Environmental Protection Agency. Accessed online: 23 May 2000, URL: <http://www.epa.gov/ttn/chief/fbgdocs/b09s09-1.pdf>

US EPA 1996, *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources Backup Documentation, AP-42 Section 9.9.1 Grain Elevators and Processes*, United States Environmental Protection Agency. Accessed online: 28 October 2010, URL: <http://www.epa.gov/ttn/chief/ap42/ch09/final/c9s0909-1.pdf>

The following EET Manuals were referenced in this Manual and are available at the NPI Homepage (<http://www.npi.gov.au>) or from your local NPI jurisdiction:

- Emission Estimation Technique Manual for Combustion in Boilers;
- Emission Estimation Technique Manual for Fugitive Emissions;
- Emission Estimation Technique Manual for Organic Chemical Processing Industries;
- Emission Estimation Technique Manual for Beer and Ready to Drink Alcoholic Beverage Manufacturing;
- Emission Estimation Technique Manual for Fuel and Organic Liquid Storage;
- Emission Estimation Technique Manual for Combustion Engines.

Appendix A: Definitions and abbreviations

A_{in}	Total grain input (tonnes/yr)
ANZSIC	Australian and New Zealand Standard Industrial Classification
USEPA	United States Environmental Protection Agency
EET	Emission estimation technique
EF	Emission factor
Emission	For the purpose of NPI reporting means the release of a substance to the environment, whether in pure form or contained in other matter, and whether in solid, liquid or gaseous form. It does not include the transfer of a substance; however, it does include the release of a substance to the environment, during transfer and from a transfer destination.
Evoc	Emissions of VOCs
Facility	Any building, land or offshore site from which an NPI substance may be emitted, together with any machinery, plant, appliance, equipment, implement, tool or other item used in connection with any activity carried out.
Mandatory reporting transfer destination	For the purposes of NPI reporting, mandatory reporting transfer destination means destination for containment, including landfill, tailings storage facility, underground injection or other long term purpose-built waste storage structure; an off-site destination for destruction; an off-site sewage system; or an off-site treatment facility which leads solely to one or more of the above.
PAH	Polycyclic aromatic hydrocarbons
PM	Particulate Matter
PM _{2.5}	Particulates which have an aerodynamic diameter equal to or less than 2.5 micrometers ($\leq 2.5\mu\text{m}$)
PM ₁₀	Particulates which have an aerodynamic diameter equal to or less than 10 micrometers ($\leq 10\mu\text{m}$)
NPI	National Pollutant Inventory
Total VOC	<p>Total Volatile Organic Compounds</p> <p>For the purpose of NPI reporting, Total VOC are defined as any chemical compound based on carbon chains or rings with a vapour pressure greater than 0.01kPa at 293.15K (i.e. 20°C), that participate in atmospheric photochemical reactions. Specifically excluded are:</p> <ul style="list-style-type: none"> • carbon monoxide, • methane, • acrylamide, • benzene hexachloro, • biphenyl, • chlorophenols,

- n-dibutyl phthalate,
- ethylene glycol,
- di-(2-ethylhexyl) phthalate (DEHP),
- 4,4-methylene bis 2,4 aniline (MOCA),
- methylenebis,
- phenol,
- toluene-2,4-diisocyanate.

Transfer	<p>The transport or movement, onsite or offsite, of substances contained in waste for:</p> <ul style="list-style-type: none"> • containment; • destruction; • treatment that leads to: <ul style="list-style-type: none"> ○ reuse, recycling or reprocessing; ○ purification or partial purifications; ○ remediation; or ○ immobilisation; • energy recovery.
Usage	The handling, manufacture, import, processing, coincidental production or other use of the substance.
VOC	Volatile Organic Compounds
Voluntary reporting transfer destination	A destination for reuse, recycling, reprocessing, purification, partial purification, immobilisation, remediation or energy recovery.

Appendix B: Erratum to the Malt Manufacturing manual

Version 1.1 – October 2014

Page	Outline of alteration
Throughout	The manual has been transcribed into a new template resulting in the restructuring of content and removal of information covered in the <i>NPI Guide</i> . No changes to emission factors have occurred.
1	ANZSIC Codes were changed to reflect 2006 codes
Section 4	A section providing guidance on transfers has been added