Australian Government

Department of Sustainability, Environment, Water, Population and Communities

National Pollutant Inventory

Emission estimation technique manual for

Fugitive Emissions
Version 2.0

January 2012

First published in December 1999
Version 2.0 published January 2012

GPO Box 787, Canberra, ACT 2601,
e-mail: npi@environment.gov.au
web: www.npi.gov.au
phone: 1800 657 945.

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 guidance material 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.

Emission Estimation Techniques for Fugitive Emissions
Table of Contents

1 INTRODUCTION 1
1.1 STRUCTURE OF MANUAL 1
1.2 LOCATION OF INFORMATION 2
1.3 FUGITIVE EMISSIONS UNDER THE NATIONAL POLLUTANT INVENTORY 2

2 PROCESSES AND EMISSIONS 4
2.1 MANUAL DEVELOPMENT PROCESS 4

3 EMISSION ESTIMATION TECHNIQUES FOR FUGITIVE SOURCES 6
3.1 VOLATILE LIQUIDS AND GASES 6
3.1.1 Asphalt Paving 6
3.1.2 Equipment Leaks and Spills 7
3.1.3 Loading and Unloading of Vehicles – Liquids 10
3.1.4 Open Vats and Mixing 11
3.1.5 Storage Tanks 12
3.1.6 Surface Coating 13
3.2 DUST EMISSIONS 14
3.2.1 Abrasive Blasting 14
3.2.2 Bulk Materials Handling and Unit Operations 15
3.2.3 Earth Moving, Excavation and Demolition 16
3.2.4 Loading and Unloading of Vehicles - Solids 18
3.2.5 Open Area Wind Erosion 18
3.2.6 Storage Piles 21
3.2.7 Vehicle Movement 22
3.3 OTHER INDUSTRIAL SOURCES 23
3.3.1 Equipment Cleaning and Solvent Degreasing 23
3.3.2 Explosives Detonation and Discharge of Ammunition 23
3.3.3 Fire Training and Emergency Simulations 24
3.3.4 Maintenance Operations 24
3.3.5 Vehicle exhaust 25
3.3.6 Wastewater Treatment 26
3.3.7 Welding 26

4 SITE SPECIFIC EMISSION ESTIMATION TECHNIQUES 32
4.1 UPWARD-DOWNWIND METHOD 32
4.2 QUASI-STACK METHOD 33
4.3 ROOF MONITOR METHOD 33

5 SPECIATION OF AGGREGATE EMISSIONS 35
5.1 SPECIATION OF VOC EMISSION ESTIMATES 35
5.1.1 Speciation Based on Process Stream Composition 35
5.1.2 Speciation Using Developed Weight Fraction Data 36
5.2 SPECIATION OF PARTICULATE EMISSION ESTIMATES 37

6 GLOSSARY OF TERMS AND ABBREVIATIONS 39

7 REFERENCES 40

List of Figures, Tables and Examples

Figure 1 –The Types of Welding 27

Table 1 – Location of Estimation Techniques in this Manual 2
Table 2 – Coverage of Fugitive Emissions under NPI 4
Table 3 – Coverage of Bulk Materials Handling in the Mining Sector 15
Table 4 – Coverage of Bulk Materials Handling in Industries outside the Mining Sector 16
Table 5 – Emission Factors for Earth Moving and Excavation Operations 17
Table 6 – Percentage Reduction to Emission Factors with Control Systems 21
Table 7 – PM10 Emission Factors for Welding Operations 29
Table 8 – NPI-listed Substances Emitted from Welding Operations 30
Table 9 – Default PM10 Collection Efficiency Values for Pollution Control Equipment 31
Table 10 – Site Specific Estimation Techniques for Area and Volume Sources 32
Table 11 – Recommended Criteria for use of Quasi-Stack Method 33
Table 12 – Available Volatile Organic Compounds USEPA Species Profiles 37

1 Introduction

The purpose of all emission estimation technique (EET) Manuals is to assist Australian facilities to report emissions of listed substances to the National Pollutant Inventory (NPI). This Manual describes the procedures and recommended approaches for estimating fugitive emissions.

Fugitive emissions can be defined as releases “which could not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening” (40CFR70.2, 2010). These emissions generally include equipment leaks, emissions from the bulk handling or processing of raw materials, windblown dust and a number of other specific industrial processes. **Table 1**[1] of **Section 1.2** provides an overview of the fugitive emissions covered in this Manual.

PAEHolmes prepared this Manual on behalf of the Commonwealth Government. This Manual has been developed through a process of national consultation involving state and territory environmental authorities and key industry stakeholders.

1.1 Structure of Manual

The structure of this Manual is summarised below:

- **Section 1.2** provides a directory for the location of EETs within this Manual.
- **Section 1.3** provides the context for the development of this Manual and guidance related to the application of EETs and the use of emissions data.
- **Section 2** describes the categories of fugitive emissions covered by this Manual. **Table 2** in **Section 2** lists the specific sources covered by other NPI Manuals and provides useful information for each source.
- EETs for each of the listed fugitive emissions in this Manual are presented in **Section 3**. Each of the sources is considered in turn by providing a brief description of each source, an examination of coverage under the National Pollutant Inventory and a description of alternative EETs (if required).
- **Section 4** presents an alternative estimation methodology for groups of point sources, area sources and volume sources. This methodology may be suitable if the specific EETs presented in **Section 3** are considered unsuitable for application to a particular situation. This methodology may also be applied to area and volume sources not covered elsewhere in this Manual (such as ponds and buildings).
- **Section 5** presents a method for the speciation of emissions. Many EETs arrive at an estimation of total pollutant emissions, which are in the form of either total particulate matter or total VOCs. However, for many facilities, reporting under the National Pollutant Inventory will require that information on individual pollutants be provided. **Section 5** provides guidance on the speciation of both organic chemicals and the speciation of metals in particulate matter.
- **Section 6** provides a glossary of technical terms and abbreviations used in this Manual.
- **Section 7** provides a list of references used in this Manual.
- **Appendix A** provides a list of variables and symbols used throughout this Manual.

---

[1] As this Manual references many other EET Manuals, references made to sections within this Manual appear in bold.

1.2 Location of Information

The location of the various EETs covered in this Manual is shown in **Table 1.** In **Section 3**, techniques for the estimation of fugitive sources are presented. **Section 4** presents generic methodologies that can be used if no suitable methods are available.

Table 1 – Location of Estimation Techniques in this Manual

Fugitive Sources	3
Volatile Liquids and Gases	3.1
Asphalt Paving	**3.1.1**
Equipment Leaks and Spills	**3.1.2**
Loading and Unloading Vehicles - Liquids	**3.1.3**
Open Vats and Mixing	**3.1.4**
Storage Tanks	**3.1.5**
Surface Coating	**3.1.6**
Dust Emissions	3.2
Abrasive Blasting	**3.2.1**
Bulk Materials Handling and Unit Operations	**3.2.2**
Earth Moving, Excavation and Demolition	**3.2.3**
Loading and Unloading Vehicles - Solids	**3.2.4**
Open Area Wind Erosion	**3.2.5**
Storage Piles	**3.2.6**
Vehicle Movement	**3.2.7**
Other Industrial Sources	3.3
Equipment Cleaning and Solvent Degreasing	**3.3.1**
Explosives Detonation and Discharge of Ammunition	**3.3.2**
Fire Training and Emergency Simulations	**3.3.3**
Maintenance Operations	**3.3.4**
Vehicle Exhaust	**3.3.5**
Wastewater Treatment	**3.3.6**
Welding	**3.3.7**
Alternative Estimation Methodology	
Upwind Downwind Method	**4.1**
Quasi-Stack Method	**4.2**
Roof Monitor Method	**4.3**

1.3 Fugitive Emissions under the National Pollutant Inventory

Context and use of this Manual

This NPI Manual provides a 'how to' guide for the application of various methods to estimate emissions as required by the NPI. It is recognised that the data that are generated in this process will have varying degrees of accuracy. In some cases there will necessarily be a large uncertainty due to inherent assumptions in the various EETs and/or a lack of available information of the activities being considered.

EETs should be considered as 'points of reference'

The EETs and generic emission factors presented in this Manual should be seen as 'points of reference' for guidance purposes only. The potential errors associated with the different EET options should be considered on a case by-case basis as to their suitability for a particular facility. Facilities may use EETs that are not outlined in this document. They must, however, seek the consent of their relevant environmental authority to determine whether any 'in-house' EETs are suitable for meeting their NPI reporting requirements.

Hierarchical approach recommended in applying EETs

This Manual presents a number of different EETs, each of which could be applied to the estimation of NPI substances. The range of available methods should be viewed as a hierarchy of available techniques in terms of the error associated with the estimate. Each substance needs to be considered in terms of the level of error that is acceptable or appropriate with the use of the various estimation techniques. The availability of pre- existing data and the effort required to decrease the error associated with the estimate will also need to be considered. For example, if emissions of a substance are clearly very small then there would be little gained by applying complex or costly methods. However, it is also important to recognise that, if a reporting threshold for a substance is triggered, then all emissions of that substance must be reported, even if actual emissions are very low or zero.

The steps in meeting the reporting requirements of the NPI can be summarised as follows:

- For Category 1, 1a and 1b substances, identify which reportable NPI substances are used, produced or stored, if any, and determine whether the amounts used or handled are above the 'threshold' values and therefore trigger reporting requirements;
- For Category 2a and 2b substances, determine the amount and rate of fuel (or waste) burnt each year, the annual power consumption and the maximum potential power consumption, and assess whether the threshold limits are exceeded;
- For Category 3 substances, determine the annual emissions to water and assess whether the threshold limits are exceeded; and
- For those substances above the threshold values, examine the available range of EETs and determine emission estimates using the most appropriate EET.

Generally, it will be appropriate to consider various EETs as alternative options whose suitability should be evaluated in terms of:

- The associated reliability or error bands; and
- The cost/benefit of using a more reliable method.

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

NPI emissions in the environmental context

It should be noted that the NPI reporting process generates estimates of emissions only. It does not attempt to relate emissions to potential environmental impacts, bioavailability of emissions or natural background levels.

2 Processes and Emissions

2.1 Manual Development Process

Under the NPI, a series of Industry Manuals have been developed to aid in the estimation of emissions of NPI-listed substances. A number of these Manuals provide techniques for estimating fugitive emissions.

In defining the scope of the Fugitive Emissions Manual, the previous coverage of fugitive emissions under the NPI was reviewed, so as not to duplicate information already available.

Fugitive emissions have been categorised in this Manual as either:

- Emissions from volatile gases or liquids;
- Dust emissions; or
- Other industrial sources.

Table 2 summarises where EETs are provided in other NPI Manuals or where information is provided in this Manual.

Table 2 – Coverage of Fugitive Emissions under NPI

Fugitive Emissions Type	Coverage Under NPI	Manual
	Volatile Liquids and Gases	
Asphalt Paving		
Manufacture of Asphalt	Yes	• Hot Mix Asphalt Manufacturing
Paving of Asphalt	No	
Equipment Leaks Valves, Flanges, Connectors, Pumps, Compressors, Drains, Open Ended Lines, Pressure Relief Valves, Sampling Connections	Yes	• Petroleum Refining • Oil and Gas Exploration and Production v1.2 • Gas Supply • Inorganic Chemicals Manufacturing v2.0
Equipment Spills	Yes	• Inorganic Chemicals Manufacturing v2.0 • Organic Chemical Processing Industries • Railway Yard Operations v2.0 • Electroplating and Anodising • Solvent Recycling
Loading and Unloading of Vehicles – Liquids	Yes	• Inorganic Chemicals Manufacturing v2.0 • Electroplating and Anodising • Solvent Recycling
Open Vats and Mixing	Yes	• Organic Chemical Processing • Industries • Inorganic Chemicals Manufacturing v2.0 • Alumina Refining v2.0
Storage Tanks	Yes	• Fuel and Organic Liquid Storage v3.2 • Alumina Refining v2.0
Surface Coating	Yes	• Surface Coating • Motor Vehicle Manufacturing • Aggregated Emissions from Architectural Surface Coatings v1.1
	Dust Emissions	
Abrasive Blasting	Yes	• Surface Coating • Railway Yard Operations v2.0
Bulk Materials Handling and Unit Operations	Yes	• Mining v3.0 • Animal and Bird Feed Manufacture • Glass and Glass Manufacture v2.0 • Iron and Steel Production • Lead Concentrating, Smelting and Refining • Sugar Milling and Refining v1.1 • Minerals and Processing of Non-metallic

		Minerals v2.0
Earth Moving, Excavation and Demolition	Yes	• Mining v3.0 • Explosives Detonation and Firing Ranges v2.0
Loading and Unloading of Vehicles – Solids	Yes	• Mining v3.0 • Mining and Processing of Non-Metallic Minerals v2.0
Open Area Wind Erosion	No	
Storage Piles	Yes	• Mining v3.0
Vehicle Movement Bulldozers, Trucks, Scrapers, Graders, Tractors and Loaders	Yes	• Mining v3.0
Other Industrial Sources		
Equipment Cleaning and Solvent Degreasing	Yes	• Surface Coating
Explosives Detonation and Discharge of Ammunition	Yes	• Explosives Detonation and Firing Ranges v2.0
Fire Training and Emergency Simulations	Yes	• Airports v2.0 • Defence Facilities • Maritime Operations v2.0
Maintenance Operations	Yes	• Surface Coating
Vehicle Exhaust Road transport and industrial vehicles	Yes	• Combustion Engines v3.0
Wastewater Treatment Open Trenches, API Separators, Lagoons, Mixing Tanks, Primary Clarifiers, Equalisation, Aerated Biotreatment, Cooling Towers, Secondary Clarifiers, Storage Tanks, Covered Separators, Trickling Filters, Activated Sludge Units, Bar Screens, Grit Separators, Oil Film Units, Waterfalls, Diffused Air Biotreatment and Effluent	Yes	• Sewage and Wastewater Treatment v2.0
Welding	No	

3 Emission Estimation Techniques for Fugitive Sources

3.1 Volatile Liquids and Gases

3.1.1 Asphalt Paving

3.1.1.1 Description

Both the manufacture and paving of asphalt lead to the release of fugitive volatile organic compounds (VOCs). Emissions during manufacture occur during mixing and stockpiling. Once the paving is laid, VOCs are emitted to the atmosphere over time until almost the entire VOC content of the applied asphalt is lost.

Asphalt surfaces and pavements are composed of compacted aggregate and an asphalt binder. The compacted aggregate can be obtained from:

- Rock quarries as manufactured stone;
- Natural gravel or soil deposits; or
- Metal ore refining processes as an artificial by-product.

The asphalt binder holds the aggregate together. This prevents displacement and loss of aggregate and provides a waterproof cover for the base. Asphalt binders may be either:

- Asphalt Cement (ie. residue from the distillation of crude oils); or
- Liquid Asphalt, which is either:
  (a) Asphalt cutback (ie. asphalt cement thinned or cutback with volatile petroleum distillates such as naptha or kerosene); or
  (b) Asphalt emulsions (ie. nonflammable liquids produced by combining asphalt and water with an emulsifying agent such as soap).

Hot cutback asphalt is the most commonly used binder for most sealing works in Australia (Austroads, 2008). Cutback asphalt generally falls into the category of either rapid cure (RC), medium cure (MC) or slow cure (SC) road oils. It is prepared by blending asphalt cement with heavy residual oils, kerosene-type solvents, naptha or gasoline type solvents depending on the desired viscosity.

Volatile organic compounds are the major contributors to NPI emissions from asphalt paving operations. The major source of VOC emissions is cutback asphalt. Only minor amounts of VOCs are emitted from emulsified asphalts and asphalt cement (USEPA, 1995a). During paving, VOCs are emitted from the equipment used to apply the asphaltic product and from the road surface. The major factors affecting VOC emissions are the type and quantity of petroleum distillate used as a diluent.

Volatile organic compound emissions from asphalt paving operations generally decay exponentially (i.e. initially high emissions levelling off to zero (USEPA, 1995a)). For the purposes of NPI reporting, emissions from cutback asphalts should be assumed as once-off, long-term emissions in the year the asphalt was laid.

3.1.1.2 Coverage under the National Pollutant Inventory

EETs for both controlled and uncontrolled emissions from asphalt paving plants are covered in the *Emission Estimation Technique Manual for Hot Mix Asphalt Manufacturing*.

The *Emission Estimation Technique Manual for Aggregated Emissions from Cutback Bitumen Version 1.0* provides EETs for estimating VOC emissions from road construction and repair activities using cutback bitumen (Section 3.0). The best practice technique presented in the Manual is based on the consumption of diluent.

This EET requires the following information:

- Consumption of diluent;
- Fraction of diluent evaporated; and
- Density of diluent.

In the absence of site specific data, default properties of cutter oil and flux oil are provided in Table 2 of Section 3.3 of that Manual. The default EET presented in that Manual is based on bitumen consumption. A default volume-based emission factor is given in Section 3.3 of that Manual.

3.1.1.3 Further Information and Alternative Estimation Methodologies

If VOC emissions contain NPI-listed substances that trigger the Category 1 threshold, they need to be speciated for each reportable substance**.** For guidance on the speciation of VOC emissions, please refer to **Section 5.1** of this Manual.

A number of sources provide alternative techniques for estimating emissions from asphalt paving. For long term emissions, the following default values may be used: (USEPA, 1995a):

- 95% of diluent (VOC) evaporates from RC cutback asphalts;
- 70% of diluent evaporates from MC cutback asphalts; and
- 25% of diluent evaporates from SC cutback asphalts.

Alternatively, Pechan (2008a) have developed default emission factors for cutback asphalt paving based on asphalt use. Emission factors are provided for VOCs, ethyl benzene, toluene and xylenes. Pechan (2008b) also provide a default emission factor for emissions of VOCs from emulsified asphalt paving based on asphalt use.

3.1.2 Equipment Leaks and Spills

3.1.2.1 Description

Leakage of liquids or gases can occur at equipment connections, joints and interfaces. The intrinsic properties of these fluids (such as vapour pressure, temperature and pressure) can result in vapour releases through valve stems, pump seals and flanges.

When volatile liquids are spilled, evaporative losses[2] occur. These losses depend on the volatility of the compounds and the effectiveness of the cleanup operation.

---

[2] Evaporative losses occur from volatile liquids. Section 4.3.1.3 of the *Emission Estimation Technique Manual for Petroleum Refining* defines a light liquid (i.e. volatile liquid) as material "in a liquid state in which the sum of the concentrations of individual constituents with a vapour pressure over 0.3 kilopascals (kPa) at 20 °C is greater than (or equal to) 20 weight percent (wt%)."

3.1.2.2 Coverage under the National Pollutant Inventory

3.1.2.2.1 Equipment Leaks

Organic Chemicals

Fugitive emissions of organic compounds from equipment leaks are covered under the National Pollutant Inventory in the *Emission Estimation Technique Manual for Petroleum Refining* (Section 4.3) and the *Emission Estimation Technique Manual for Oil and Gas Exploration and Production Version 1.2* (Section 4.2). Refer to the former Manual for information on:

- Estimation methodology (Section 4.3.1.1);
- Measuring equipment (Section 4.3.1.4);
- Process controls (Section 4.3.3);
- Leak detection and repair (LDAR) programs (Section 4.3.3.2). LDAR programs involve the systematic measurement, estimation and reporting of leaks to minimise fugitive emissions;
- EETs for fugitive emissions of VOCs from valves, flanges, connectors, pumps, compressors, drains, open ended lines, pressure relief valves and sampling connections (Section 4.3.1); and
- Speciation of VOC estimates (Section 4.3.2).

The *Emission Estimation Technique Manual for Oil and Gas Exploration and Production Version 1.2* provides a series of emission factors for fugitive emissions. These factors have been developed specifically for the oil and gas production industry and are not generally applicable outside this industry.

The *Emission Estimation Technique Manual for Gas Supply* provides an EET to estimate the emissions of VOCs due to line losses (Section 3.2). Using this EET, the volume of gas lost can be estimated if the unaccounted for gas (UAFG) value is known. The mass of VOCs released can then be determined assuming that VOCs make up 6.8% of the total volume of gas lost and that the density of the VOCs is the same as natural gas.

When applying these factors to other sectors (e.g. coal seam gas extraction) in the absence of other information, please consider how differences in operating conditions (e.g. temperature, pressure, composition) could affect emissions estimates.

Inorganic Chemicals

Emissions of inorganic chemicals from leaks may need to be estimated in cases where the compounds are present as a gas or a vapour.

To determine whether an inorganic substance meets the criteria of volatility for it to be susceptible to equipment leaks, please refer to the *Emission Estimation Technique Manual for Petroleum Refining* (Section 4.3.1.3). If an inorganic liquid in your facility falls into one of these categories, it is likely to require estimation if it triggers any thresholds under the NPI.

Inorganic National Pollutant Inventory listed substances that may require estimation include:

- Hydrogen sulfide;
- Nitric acid;
- Hydrochloric acid;
- Phosphoric acid; and
- Sulfuric acid.

Note that if the spill is a volatile liquid, it is reasonable to assume that the entire light end fraction is volatilised, and the remaining liquid is released into the ground. However, if the liquid is not volatile and no material is collected, it is reasonable to assume that all material is released to land. The time, quantity of spill, temperature, and porosity of the soil all play an important part in the estimation of release. Refer to **Section 3.1.2.2.2** of this Manual for details on estimating emissions from spills.

Fugitive emissions of inorganic compounds from equipment leaks are covered under the National Pollutant Inventory in the *Emission Estimation Technique Manual for Inorganic Chemicals Manufacturing Version 2.0* (Section 5.1.5). The Manual outlines the following methods for estimating fugitive emissions of inorganic compounds:

- Developing unit specific correlations by obtaining actual concentrations of the inorganic compounds at the equipment/leak interface using a portable monitoring instrument and then applying the screening value obtained with this instrument to the applicable correlation equation (Table 4 and Equation 24);
- Using average emission factors to calculate emissions when site-specific screening data are unavailable (Table 5 and Equation 25); and
- Developing process specific correlations.

The *Emission Estimation Technique Manual for Gas Supply* provides an EET to estimate the emissions of hydrogen sulphide due to line losses (Section 3.2). Using this EET, the volume of gas lost can be estimated. The mass of hydrogen sulphide emitted can then be determined if the concentration of hydrogen sulphide in the 'lost' gas is known.

3.1.2.2.2 Equipment Spills

Evaporative losses from spills of organic liquids are covered in a number of NPI Manuals. The *Emission Estimation Technique Manual for Inorganic Chemicals Manufacturing Version 2.0* provides a vaporisation equation which can be used to estimate the evaporation rate of a liquid chemical spill if the size area of the spill is known or can be estimated. The following data are required for the application of this EET:

- Molecular weight of the spilled substance;
- Gas-phase mass transfer coefficient for the spilled substance;
- Surface area of spilled material;
- Vapour pressure of the spilled substance (if a pure chemical is spilled) or partial pressure of the spilled substance (if a mixture of VOCs is spilled) at the spill temperature;
- Duration of spill; and
- Temperature of the liquid spilled.

The *Emission Estimation Technique Manual for Organic Chemical Processing Industries* also provides an EET for estimating the evaporation rate of compounds into the atmosphere (Section 9.2). The following data are required for the application of this EET:

- Wind speed over the surface of the spill;
- Molecular weight of the spilled substance;
- Vapour pressure of the spilled substance at the spill temperature;
- Temperature of the spilled substance;
- Surface area of spilled material;
- Quantity of material spilled; and
- Time between spill occurring and clean up.

The *Emission Estimation Technique Manual for Railway Yard Operations Version 2.0* provides an equation to estimate emissions to atmosphere from spills on land of volatile materials. This equation is based on the quantity of material spilled, the mass fraction of volatile compounds in the material spilled and the mass fraction of the NPI substance in the material spilled. The typical VOC composition of Australian fuels can be found in Table 1 of the *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage.*

Emission factors based on throughput for fugitive emissions from spillage during the loading and operation of a distillation device are provided in both the *Emission Estimation Technique Manual for Electroplating and Anodising* (Section 5.6) and the *Emission Estimation Technique Manual for Solvent Recycling* (Section 4.3).

3.1.2.3 Further Information and Alternative Estimation Methodologies

Fugitive emissions from equipment leaks and spills are suitably covered in other EET Manuals. No additional EETs have been provided.

For information on the speciation of total VOC emissions, please refer to **Section 5.1** of this Manual.

3.1.3 Loading and Unloading of Vehicles – Liquids

3.1.3.1 Description

Fugitive emissions occur when liquids are either loaded or unloaded into vehicles. Liquid emissions are usually volatile organic compounds, which may contain NPI-listed substances.

3.1.3.2 Coverage under the National Pollutant Inventory

The loading and unloading of organic liquids is covered in a number of EET Manuals. Fugitive emissions associated with the addition of organic solvents to vessels or storage tanks are covered in the *Emission Estimation Technique Manual for Inorganic Chemical Manufacturing Version 2.0* (Section 5.1.1). This equation is only suitable for organic materials and should not be used to estimate emissions from loading inorganic compounds to vessels. This EET requires the following data:

- Vapour pressure of material loaded;
- Vapour molecular weight;
- Volume of material loaded; and
- Temperature of material loaded.

Emission factors based on throughput for fugitive emissions from the loading of a distillation device are covered in the *Emission Estimation Technique Manual for Electroplating and Anodising* (Section 5.6) and the *Emission Estimation Technique Manual for Solvent Recycling* (Section 4.3).

3.1.3.3 Further Information and Alternative Estimation Methodologies

Guidance on the speciation of total volatile organic compound emissions is presented in **Section 5.1** of this Manual.

Methods for estimating emissions from gasoline tanks in trucks can be found in *Emission Inventory Improvement Program (EIIP), Volume III: Chapter II: Gasoline Marketing* (ERG, 2001). Sources of evaporative VOC emissions include trucks in transit, fuel delivery to outlets, vehicle refuelling and storage tank breathing. The methods covered in the report generally involve the use of an emission factor relating emissions to the volume of gasoline distributed.

Emission factors based on throughput for gasoline trucks in transit, fuel delivery to outlets and storage tank breathing are provided in Table 11.3-1 of that report. The USEPA's MOBILE6 Model should be used to develop emission factors for vehicle refuelling. This model generates a custom VOC emission factor using local data such as temperature and fuel volatility.

3.1.4 Open Vats and Mixing

3.1.4.1 Description

This category includes emissions from open vessels and associated process operations such as mixing. The specific activities that give rise to fugitive emissions are:

- Air displacement from mixtures or topping up substances – **Section 3.1.4.2.1**;
- Emissions from surface evaporation – **Section 3.1.4.2.2**;
- Emissions from spills – **Section 3.1.4.2.3**; and
- Emissions from material loading and unloading – **Section 3.1.4.2.4**.

For information on the speciation of total volatile organic compound estimates, please refer to **Section 5.1** of this Manual.

3.1.4.2 Coverage under the National Pollutant Inventory

3.1.4.2.1 Air Displacement

The *Emission Estimation Technique Manual for Organic Chemical Processing Industries* (Section 5.1) provides an EET that can be used to calculate emissions from storage tanks and blending and mixing operations. This EET assumes that the volume of vapour released from the vessel is equal to the volume of liquid added. This EET can be used to estimate emissions from topping up a substance with the same substance (i.e. single component process) or to determine the composition of vented gases from mixtures (i.e. multi-component process). The following data are required for this equation:

- Vapour mole fraction;
- Liquid mole fraction;
- Vapour pressure of component in the tank; and
- System pressure – for open reactors this will be ambient pressure (101.3 kPa).

3.1.4.2.2 Surface Evaporation

The *Emission Estimation Technique Manual for Inorganic Chemicals Manufacturing Version 2.0* (Section 5.1.4) provides an EET to estimate emissions from surface evaporation during organic chemical mixing operations. The following data are required for this equation:

- Molecular weight of substance;
- Surface are of substance;
- Vapour pressure of substance (if a pure chemical is used) of partial pressure of substance (if a mixture of VOCs is used);
- Event duration time;
- Wind speed;
- Temperature of the liquid; and

- Number of events per year.

3.1.4.2.3 Liquid Spills

The *Emission Estimation Technique Manual for Inorganic Chemicals Manufacturing Version 2.0* and the *Emission Estimation Technique Manual for Organic Chemical Processing* both provide EETs to estimate the evaporation rate of a liquid chemical spill if the size area of the spill is known or can be estimated. Refer to **Section 3.1** of this Manual for further details on these techniques.

3.1.4.2.4 Material Loading and Unloading

The *Emission Estimation Technique Manual for Inorganic Chemicals Manufacturing Version 2.0* (Section 5.1.1) provides an EET to estimate emissions of VOCs due to the loading or unloading of organic materials to vessels or storage tanks. Refer to **Section 3.1.3** of this Manual for further details on this EET.

The *Emission Estimation Technique Manual for Alumina Refining Version 2.0* (Section 3.1.1.4.1) provides an EET for acid emissions during filling of storage tanks. Refer to **Section 3.1.3** for further details on this EET.

3.1.4.3 Further Information and Alternative Estimation Methodologies

Fugitive emissions from open vats and mixing are suitably covered in other EET Manuals. No additional EETs have been provided.

3.1.5 Storage Tanks

3.1.5.1 Description

Fugitive emissions from storage tanks include evaporative losses from filling and transfer operations as well as standing losses. For the purposes of fugitive emissions estimation, storage tanks are:

- Fixed roof tanks;
- Floating roof tanks; or
- Variable vapour space tanks.

3.1.5.2 Coverage under the National Pollutant Inventory

The *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage Version 3.2* provides reference to the USEPA TANKS 4.09D software to estimate emissions from fuel and organic liquid storage. TANKS 4.09D is a software package that requires information such as the physical characteristics of the storage tanks, typical atmospheric conditions (such as wind speeds and temperatures), the contents of the tank and throughput. Australian meteorological data should be used to configure TANKS 4.09D and fuel specific vapour pressures should be checked as each state and territory sets specific Reid Vapour Pressure[3] (RVP) limits. As regional temperatures directly affect volatility, there is no national RVP standard at present (WAGBT, 2007).

The *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage Version 3.2* (Section 5.0) also provides guidance on the estimation of emissions from facilities storing

---

[3] RVP is an absolute pressure (kPa) at 37.8°C measured using ASTM Test Method D 323 (Wray, 1992).

liquid fuels and organic liquids. Emission factors are listed for each tank type by climatic zone and fuel type in Appendix F of that Manual.

The *Emission Estimation Technique Manual for Alumina Refining Version 2.0* (Section 3.1.1.4.1) provides an EET for fugitive emissions from the storage of acids.

3.1.5.3 Further Information and Alternative Estimation Methodologies

Fugitive emissions from storage tanks are suitably covered in other EET Manuals. No additional EETs have been provided. Methods for speciation of total volatile organic compound emissions are presented in **Section 5.1**.

3.1.6 Surface Coating

3.1.6.1 Description

The preparation and coating of surfaces can result in the release of volatile organic compounds to the atmosphere.

3.1.6.2 Coverage under the National Pollutant Inventory

Surface coating is covered in the following EET Manuals:

- Surface Coating;
- Motor Vehicle Manufacturing; and
- Aggregated Emissions from Architectural Surface Coatings v1.1.

The *Emission Estimation Technique Manual for Surface Coating* presents EETs for surface preparation, paint, lacquer, varnish and primer coating, heat up emissions and surface evaporation.

The EET for surface coating (Section 3.2) requires four data inputs:

- The type of coating used;
- The quantity of coating used;
- An uncontrolled emission factor; and
- An air pollution control efficiency factor (if applicable).

The heat-up emission estimation technique (Section 3.4.2) requires the initial and final partial pressure of each VOC species in the vessel headspace at the initial and final temperature, the initial and final pressure in the coating vessel, the average vapour molecular weight and the number of coating cycles per year.

The surface evaporation EET (Section 3.4.4) requires:

- The molecular weight of each VOC species;
- The gas-phase mass transfer coefficient for each VOC species;
- The surface area of tank, the vapour pressure of each VOC (if a pure chemical is used) or the partial pressure of each chemical (if a mixture of VOCs is used);
- The operating temperature;
- The batch time; and
- The number of batches per year.

The *Emission Estimation Technique Manual for Motor Vehicle Manufacturing* (Section 4.1) provides EETs for the coating of motor vehicles, light duty surface trucks and commercial vehicles. Default emission factors based on number of vehicles or hours of use for motor vehicles and light duty trucks are provided in Table 3. Default emission factors based on throughput are presented for passenger and non-commercial vehicles (Table 4) and commercial vehicles (Table 5). An equation to calculate a site-specific emission factor can be used if the following information is available:

- Area coated per vehicle;
- Thickness of the dry coating film;
- VOC content of coating as applied (less water);
- Volume fraction of solids in coating as applied; and
- Fraction of total coating solids used that remains on the coated parts.

The *Emission Estimation Technique Manual for Aggregated Emissions from Architectural Surface Coatings Version 1.1* provides VOC emission factors for architectural surface coatings based on consumption (Table 2, Section 3.3.1).

3.1.6.3 Further Information and Alternative Estimation Methodologies

Fugitive emissions from surface preparation and equipment cleaning are suitably covered in other EET Manuals. No additional EETs have been provided.

Further information relating to VOCs from surface coatings can be found in *VOCs from Surface Coatings – Assessment of the Categorisation, VOC Content and Sales Volumes of Coating Products Sold in Australia* (ENVIRON, 2009). Appendix 7 of that report lists the VOC content for several product types.

For guidance on the speciation of total volatile organic compound emissions, please refer to **Section 5.1** of this Manual.

3.2 Dust Emissions

3.2.1 Abrasive Blasting

3.2.1.1 Description

Abrasive blasting is the use of abrasive material to clean or texturize a material such as metal or masonry. Sand is the most widely used blasting abrasive. Other abrasive materials include coal slag, smelter slags, mineral abrasives, metallic abrasives, and synthetic abrasives. Abrasive blasting results in fugitive emissions of particulate matter (PM_{10}).

3.2.1.2 Coverage under the National Pollutant Inventory

EETs for emissions from abrasive blasting are presented in the *Emission Estimation Technique Manual for Surface Coating* (Section 3.1). The input data required are:

- Operating hours per year;
- Concentration of NPI-listed substances in abrasive used; and
- Flow rate of abrasive during process.

The *Emission Estimation Technique Manual for Railway Yard Operations Version 2.0* provides default emission factors based on throughput for emissions from abrasive blasting in Appendix B.

3.2.1.3 Further Information and Alternative Estimation Methodologies

Chapter 13.2.6 of AP 42 provides default particulate emission factors based on throughput for sand blasting of mild steel panels and abrasive blasting of unspecified metal parts (USEPA, 1997).

For guidance on the speciation of particulate emissions, please refer to **Section 5.2** of this Manual.

3.2.2 Bulk Materials Handling and Unit Operations

3.2.2.1 Description

Any process operations that move or manipulate dusty material can cause fugitive emissions of particulate matter.

3.2.2.2 Coverage under the National Pollutant Inventory

The *Emission Estimation Technique Manual for Mining Version 3.0* provides emission estimation techniques for bulk materials handling for both coal and metalliferous mines. The coverage in these Manuals is summarised in Table 3. The effectiveness of various control measures for both coal and metalliferous mines is also discussed in the *Emission Estimation Technique Manual for Mining Version 3.0* (Section 5.3).

Table 3 – Coverage of Bulk Materials Handling in the Mining Sector

Coal Mines (Section of EET Manual for Mining v3.0)	Metalliferous Mines (Section of EET Manual for Mining v3.0)
• Draglines (A1.1.1) • Excavators/shovels/front-end loaders (A1.1.2 and A1.1.3) • Bulldozers (A1.1.4 and A1.1.5) • Trucks (A1.1.6 to A1.1.7) • Drilling (A.1.1.8) • Blasting (A1.1.9) • Wheel and bucket operations (A1.1.10) • Loading stockpiles (A.1.1.15) • Unloading from stockpiles (A.1.1.15) • Loading to trains (A.1.1.15) • Miscellaneous transfer and conveying (A1.1.16) • Wind erosion (A.1.1.17 and A.1.1.18) • Bulk Highwall Mining (A.1.1.19)	• Primary, secondary and tertiary crushing (5.5.2) • Wet grinding/milling (5.5.2) • Dry grinding with/without air conveying or classification (5.5.2) • Drying of all minerals except titanium/zirconium sands (5.5.2) • Handling, transferring and conveying including wheel and bucket reclaimers except bauxite (5.5.2) • Screening (5.5.2) • Bauxite/alumina operations (5.5.2) • Miscellaneous transfer and conveying (5.2.1) • Wind erosion (A.1.1.17 to A.1.1.18)

Several EET Manuals also provide default emission factors based on throughput for bulk materials handling and unit operations, as shown in Table 4. These emission factors are not generally applicable outside the specific industry.

Table 4 – Coverage of Bulk Materials Handling in Industries outside the Mining Sector

EET Manual	Section	Emission Factors
Animal and Bird Feed Manufacture	3.5.1 (Table 4)	• Grain receiving • Feed Shipping
Glass and Glass Manufacturing v2.0	4.1 (Table 6)	• Unloading and conveying • Storage bins • Mixing and weighing
Iron and Steel Production	8.5.2 (Table 5)	• Transfer point inc Stacker Ore • Transfer point inc stacker lump
Lead Concentrating, Smelting and Refining	6.3.2 (Table 6.1)	• Ore crushing • Ore screening • Sinter building fugitives
Sugar Milling and Refining v1.1	3.4.1 (Table 3)	• Bagasse stockpile (carting) • Bagasse dust (crushing)
Mining and Processing of Non-metallic Minerals v2.0	4.1.6 (Table 8)	• Transfer and storage of phosphate rock
	4.1.6 (Table 21)	• Crushed stone processing operations o Screening o Primary, secondary and tertiary crushing o Fines crushing o Fines screening o Conveyor transfer point o Wet drilling o Truck loading and unloading

3.2.2.3 Further Information and Alternative Estimation Methodologies

Typical silt loading and moisture content default values based on data for US mines can be found in Section 11.9 (Table 11.9-3) of AP 42 (USEPA, 1998). Guidance on developing site-specific EETs for dust emissions is provided in **Section 4** of this Manual. Assistance on speciation of particulate emissions is presented in **Section 5.2** of this Manual.

3.2.3 Earth Moving, Excavation and Demolition

3.2.3.1 Description

The operations commonly found in earth moving, excavation and demolition activities include:

- Land clearing;
- Drilling and blasting;
- Cut and fill operations;
- Materials storage and handling; and
- Truck traffic on unpaved surfaces.

3.2.3.2 Coverage under the National Pollutant Inventory

Some aspects of earth moving, excavation and demolition activities are covered in EET Manuals. The *Emission Estimation Technique Manual for Mining Version 3.0* presents a series of EETs that can be applied to earth moving, excavation and demolition operations.

Table 5 below provides a list of the earth moving, excavation and demolition activities giving rise to PM_{10} emissions and emission factors or sources of information on other EETs.

Table 5 – Emission Factors for Earth Moving, Excavation and Demolition Operations

Phase	Activity	Recommended Emission Factor
Demolition and Debris Removal	1. Demolition of buildings or other (natural) obstacles such as trees and boulders.	
	a. Mechanical dismemberment ("headache ball" of existing structures)	Not available
	b. Implosion of existing structures	Appendix C of the *Emission Estimation Technique for Explosives Detonation and Firing Ranges Version 2.0* contains emission factors for detonation.
	c. Drilling and blasting of soil	Drilling factor in *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.8). Blasting factor in *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.9)
	d. General land clearing	Bulldozing on material other than coal from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.5)
	2. Loading of debris onto trucks	Miscellaneous Transfer and Conveying EET from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.16)
	3. Truck transport of debris	Wheel Generated Dust EET from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.11)
	4. Truck unloading of debris	Miscellaneous Transfer and Conveying EET from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.16)
Site Preparation	1. Bulldozing	Bulldozer on overburden EET from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.5)
	2. Scraper unloading topsoil	Scraper unloading EET from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.13)
	3. Scrapers in travel	Scraper in travel mode EET from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.12)
	4. Scrapers removing topsoil	5.7 kg TSP/vehicle kilometre travelled, emission factor rating E (USEPA, 1995b)
	5. Loading of excavated material into trucks	Miscellaneous Transfer and Conveying EET from Emission *Estimation Technique Manual for Mining v3.0* (Section A1.1.16)
	6. Truck dumping of fill material, road base, or other materials	Miscellaneous Transfer and Conveying EET from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.16)
	7. Compacting	Bulldozer on overburden correlation from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.5)
	8. Motor Grading	See grader correlation in *Emission Estimation Technique Manual for Mining* (Section A1.1.14)
General	1. Vehicular Traffic	Wheel Generated Dust EET from *Emission Estimation Technique Manual for Mining v3.0* (Section A1.1.11)
	2. Portable Plants	Refer to *Emission Estimation Technique Manual for Mining v3.0* (Section 5.2.2). See also the Miscellaneous Transfer and Conveying EET (Section A1.1.16) in the same EET Manual
	a. Crushing	
	b. Screening	
	c. Material Transfers	

3.2.3.3 Further Information and Alternative Estimation Methodologies

Alternatively, Chapter 3 of the *Fugitive Dust Handbook* published by the Western Regional Air Partnership presents several techniques for estimating emissions from earth moving, excavation and demolition activities (WRAP, 2006). These techniques have been adapted from *Estimating Particulate Matter Emissions from Construction Operations* (Midwest Research Institute, 1999). Control efficiencies for earth moving, excavation and demolition operations are provided in Section 3.6 of the Handbook.

Default emission factors for general earth moving, excavation and demolition operations are provided in Table 3-2 of the Handbook. Different emission factors are provided based on the level of detailed information available, with the most basic emission factor requiring only acres of land disturbed by the activity and duration of the activity.

Alternatively, AP 42 provides an emission factor of 2.69 tonnes/ha/month of operation for an entire site (USEPA, 1995b). This is a very crude factor and is unlikely to provide a reasonable estimate of emissions. Therefore, it is recommended that this factor only be used in the absence of any other information. It should also be noted that the techniques covered in the *Fugitive Dust Handbook* may not be applicable to Australian conditions.

3.2.4 Loading and Unloading of Vehicles - Solids

3.2.4.1 Description

Fugitive emissions occur when solids are either loaded or unloaded into vehicles. Solid emissions consist of particulate matter (PM_{10}) which often contains metals.

3.2.4.2 Coverage under the National Pollutant Inventory

The *Emission Estimation Technique Manual for Mining Version 3.0* presents EETs for:

- Trucks dumping overburden and coal (A1.1.6 and A.1.1.7);
- Loading and unloading of vehicles from stockpiles (A1.1.15);
- Loading to trains (A1.1.15); and
- Miscellaneous transfer points (including conveying) (A1.1.16).

The *Emission Estimation Technique Manual for Mining and Processing of Non-Metallic Minerals Version 2.0* provides default emission factors based on throughput for crushed talc railcar loading (Table 18, Section 4.16) and for truck loading and unloading of crushed stone (Table 21, Section 4.16).

3.2.4.3 Further Information and Alternative Estimation Methodologies

Often site- or industry-specific data are available for variables such as moisture content, silt content, wind speed and vehicle weight, and should be used where available.

In the absence of site- or industry-specific data, default literature values may be used. For example, The Department of Natural Resources and Mines has published the moisture content of several Queensland coals (Mutton, 2003). Typical moisture content default values based on data for US mines can also be found in Section 11.9 (Table 11.9-3) of AP 42 (USEPA, 1998). Guidance on the speciation of particulate emissions is provided in **Section 5.2** of this Manual.

3.2.5 Open Area Wind Erosion

3.2.5.1 Description

Particulate matter emissions may be generated by wind erosion of open aggregate storage piles and exposed areas within an industrial facility. Surfaces subject to wind erosion are considered to consist of a mixture of erodible and non-erodible surfaces.

3.2.5.2 Coverage under the National Pollutant Inventory

The *Emission Estimation Technique Manual for Mining Version 3.0* provides a factor of 0.4 kg/ha/h for TSP and 0.2 kg/ha/h for PM_{10}. Alternative methodologies for the estimation of fugitive emissions from open areas are presented in **Section 3.2.5.3** below.

3.2.5.3 Further Information and Alternative Estimation Methodologies

Section 13.2.5 of AP 42 provides an EET for "wind erosion of open aggregate storage piles and other exposed areas within an industrial facility" using the concept of friction velocity[4] (UESPA, 2006a). When the actual friction velocity (u^*) at a site exceeds the threshold friction velocity (u_t), wind erosion is expected to occur.

A field procedure for determining the threshold friction velocity is provided in Section 13.2.5.3 of USEPA (2006a). This procedure uses a sieving test to determine the dry aggregate structure of the soil and is recommended for un-crusted surfaces. Alternatively, Gillette (1982) provides graphical relationships to determine the threshold friction velocity from the mode the aggregate size distribution. Table 13.2.5-2 of USEPA (2006a) presents the threshold friction velocity for several materials determined by field measurements using a portable wind tunnel.

The actual friction velocity can be calculated using the following relationship:

Equation 1

$$u^* = 0.053\, u_{10^+}$$

where:

u_{10^+} = fastest mile of reference anemometer of period between disturbances (m/s)

The above equation assumes a typical roughness height of 0.5 cm for open terrain and is limited to wind exposure from non-elevated surfaces. Techniques for elevated piles (i.e., with a height-to-base ratio exceeding 0.2) are provided in Section 13.2.5 of USEPA (2006a).

The fastest mile is defined as "the wind speed corresponding to the whole mile of wind movement that has passed by the 1 mile contact anemometer in the least amount of time" (USEPA, 2006a). A limitation of using this technique in Australia is that the fastest mile data is not routinely recorded by the Bureau of Meteorology and must therefore be estimated.

Generally, mean atmospheric wind speeds are not sufficient to sustain wind erosion from flat surfaces and estimated emissions should be related to wind gusts of highest magnitude (USEPA, 2006a). An alternative method for calculating friction velocity is to determine the relationship between mean wind speed and wind gust data for that period. In the absence of these data, the fastest mile wind speed has been found to be approximately 1.18 to 1.27 times the hourly wind speed (Krayer & Marshall (1992) in SKM (2005)).

Once the friction velocity and threshold friction velocity have been determined, the erosion potential for a dry, exposed surface can be calculated using the following equation:

---

[4] Friction velocity is a "measure of wind shear stress on the erodible surface" (USEPA, 2006a).

Equation 2

$$P = 58\left(u^* - u_t\right)^2 + 25\left(u^* - u_t\right) \text{ for } u^* \geq u_t$$

$$P = 0 \text{ for } u^* \leq u_t$$

where:

P = erosion potential (g/m^2)

More accurate estimates can be obtained by adjusting these equations during periods of rainfall. Approval should be sought for any method not listed in an NPI Manual.

The PM$_{10}$ emission factor for wind-generated particulate emissions can then be calculated as follows:

Equation 3

$$\text{Emission factor} = k\sum_{i=1}^{N} P_i$$

where:

k = particle size multiplier (-)

N = number of disturbances per year (-)

P$_i$ = erosion potential corresponding to the observed (or probable) fastest mile of wind for the ith period between disturbances (g/m^2)

The California Air Resources Board (CARB) presents a methodology for estimating windblown dust from agricultural lands (CARB, 1997a). During the 1960s, the United States Department of Agriculture – Agricultural Research Service (USDA-ARS) developed a wind erosion equation (WEQ) for estimating windblown agricultural emissions. In 1974, the USEPA adapted the USDA-ARS methodology for use in estimating PM agricultural emissions. As this equation was developed in the Midwestern Unites States, the CARB have added adjustments to the WEQ to estimate windblown agricultural emissions in California.

The USEPA adapted USDA-ARS WEQ is as follows (Cowherd et al. 1974):

Equation 4

E_s = AIKCL′v′

where:

E$_s$ = suspended particulate fraction of wind erosion losses of tilled fields (tons/acre/year)

A = portion of total wind erosion losses that would be measured as suspended particulate (estimated to be 0.025) (-)

I = soil erodibility (tons/acre/year)

K = surface roughness factor, dimensionless (-)

C = climatic factor (-)

L′ = unsheltered field width factor (-)

v′ = vegetative cover factor (-)

The details of the parameters in the WEQ are outlined in *Development of Emission Factors for Fugitive Dust Sources* (Cowherd et al. 1974). The CARB derives the values for "I", "K" and "L′" directly from the USEPA methodology. However, CARB has replaced the "V′" factors with site-specific factors and modified the annual "C" factor calculation method. This technique would require adjustment to account for Australian environmental conditions and farm practices.

The CARB also utilise the above equation to estimate windblown dust emissions from unpaved roads (CARB, 1997b). In this case, the default "A" value is 0.038 for unpaved roads. As most unpaved roads are flat and have no vegetative cover, the "K" factor and the "V′" factor are assumed to be 1.0. The "L′" factor is assumed to be 0.32 based on a USEPA report (USEPA, 1977). The "I" factor and "C" factor are derived from the USEPA methodology (Cowherd et al. 1974). Once again, this methodology may require adjustment to accurately represent Australian conditions.

Table 6 provides reduction factors for a variety of control measures for open area wind erosion. It is recommended that once a control strategy is implemented on-site (or if one is already in use), that dust monitoring be performed to determine the actual reduction in emissions.

Table 6 – Percentage Reduction to Emission Factors with Control Systems

Control Method	Factor Reduction (%)
Apply dust suppressants to stabilise disturbed area after cessation of disturbance	84[a]
Apply gravel to stabilise open areas	84[a]
Primary rehabilitation	30[b]
Vegetation established but not demonstrated to be self-sustaining - weed control and grazing control	40[b]
Secondary rehabilitation	60[b]
Revegetation	90[b]

a. CARB, 2002.
b. The Emission Estimation Technique Manual for Mining v3.

3.2.6 Storage Piles

3.2.6.1 Description

Storage piles of dusty material are subject to wind erosion. In addition, there are emissions from the materials (or aggregate) handling operations associated with these storage piles. Please refer to **Section 3.2.2** of this Manual for further guidance on the estimation of emissions from materials handling and unit operations.

3.2.6.2 Coverage under the National Pollutant Inventory

An equation for wind erosion from active stockpiles is presented in Appendix A1.1.17 of the *Emission Estimation Technique Manual for Mining Version 3.0*. This EET can also be tailored to operations at a specific facility if information is available on:

- silt content;
- the number of days per year that rainfall is above 0.25 mm; and
- the percentage of time that wind speed is greater than 5.4 m/s at the mean height of the stockpile.

Default emission factors are supplied for use in the absence of site specific data. The effectiveness of various dust control techniques is also discussed in that Manual (Section 5.3). Guidance on speciation of particulate emissions may be found in **Section 5.2** of this Manual.

3.2.6.3 Further Information and Alternative Estimation Methodologies

Guidance on developing site-specific EETs for dust emissions is provided in **Section 4** of this Manual.

The USEPA method for estimating emissions from open areas provided in Section 3.2.5.3 can also be adapted for estimating emissions from stockpiles. Please refer to USEPA (2006a) for information on how this method should be applied in that case.

Alternatively, the following equation is listed in Section 11.9 of AP 42 to calculate the TSP emission factor for emissions from an active storage pile (USEPA, 1998):

Equation 5

$$EF_{TSP} = 1.8 \times u$$

where:

EF_{TSP} = TSP emission factor for active storage pile (kg/ha/hr)

u = wind speed (m/s)

This equation is based on data from storage piles at five different Western surface coal mines in the US and care should be taken when applying this technique in other contexts (Axtell, 1978).

3.2.7 Vehicle Movement

3.2.7.1 Description

The movement of vehicles over various surfaces leads to emissions of particulate matter (PM_{10}).

3.2.7.2 Coverage under the National Pollutant Inventory

The *Emission Estimation Technique Manual for Mining Version 3.0* presents emission factor equations and default emission factors for estimating particulate emissions associated with vehicle movement (Table 5-1 and Appendix A). The effectiveness of various dust control techniques is also discussed in the Manual (Section 5.3). Specifically, this Manual covers the following activities:

- Bulldozers (A1.1.4 and A1.1.5);
- Trucks (A1.1.6 and A1.1.7);
- Wheel generated dust on unpaved roads (A1.1.11);
- Scrapers (A1.1.12 and A1.1.13);
- Graders (A1.1.14); and
- Loaders (A1.1.2 and A1.1.3).

The EET for wheel generated dust on unpaved roads requires the silt content of the road surface material and the vehicle mass. Each of the other vehicle movement EETs mentioned above requires the silt content and moisture content of the road surface material.

It is recommended that site-specific data be used in the application of these EETs. In the absence of this information, information on moisture and silt contents for US mines can be found in Section 11.9 (Table 11.9-3) of AP 42 (USEPA, 1998). The typical silt content values of surface material on industrial paved roads are provided in Section 13.2.2 (Table 13.2.2-1) of AP 42 (USEPA, 2006b).

3.2.7.3 Further Information and Alternative Estimation Methodologies

An EET for estimating particulate emissions from paved roads is presented in Section 13.2.1 of AP 42 (USEPA, 2011). This EET requires the road surface silt loading and average weight of the vehicles travelling on the road.

If the number of "wet" days or hours with at least 0.254 mm of precipitation during the averaging period is known, a precipitation correction term can be applied to the paved roads equation. In the absence of site specific data, typical silt loading values for paved roads at industrial facilities are provided in Section 13.2.1 (Table 13.2.1-3) of AP 42 (USEPA, 2011).

An alternative technique for estimating wheel generated dust from unpaved roads is provided by the CARB. Please refer to **Section 3.2.5.3** of this Manual for further details of this methodology.

3.3 Other Industrial Sources

3.3.1 Equipment Cleaning and Solvent Degreasing

3.3.1.1 Description

Solvent degreasing (or solvent cleaning) is the process of using organic solvents to remove grease, fats, oils, wax or soil from various metal, glass or plastic items.

The types of equipment used in this method are generally categorised as cold cleaners, open top vapour degreasers or conveyorised degreasers. Solvents such as petroleum distillates, chlorinated hydrocarbons, ketones and alcohols are generally used with the main NPI reportable emission being volatile organic compounds (VOCs) plus some specific listed Category 1 substances.

3.3.1.2 Coverage under the National Pollutant Inventory

EETs for parts cleaning in cold cleaners, open-top vapour degreasers, or conveyor degreasers are presented in the *Emission Estimation Technique Manual for Surface Coating* (Section 3.3). The input data required are:

- Surface area of solvent exposed to the atmosphere;
- Hours per year that the cold cleaner or vapour degreaser is in operation;
- Number of cleaning units in use; and
- Concentration of VOC species in the cleaning solvent.

3.3.1.3 Further Information and Alternative Estimation Methodologies

Fugitive emissions from equipment cleaning and solvent degreasing are suitably covered in other EET Manuals. No additional EETs have been provided.

For guidance on the speciation of total volatile organic compound emissions, please refer to **Section 5.1** of this Manual.

3.3.2 Explosives Detonation and Discharge of Ammunition

3.3.2.1 Description

Explosives are used in the extraction (mining and quarrying) industry, the demolition (construction) industry and in firearm activities at military and civilian firing ranges.

Explosives may be mixed on site from raw materials or may come in packaged pre-mixed forms. The explosive type and volume used will dictate the level of NPI substance emitted.

3.3.2.2 Coverage under the National Pollutant Inventory

Appendix C of the *Emission Estimation Technique Manual for Explosives Detonation and Firing Ranges Version 2.0* provides default emission factors based on throughput for detonation of explosives and discharge of ammunition.

3.3.2.3 Further Information and Alternative Estimation Methodology

Fugitive emissions from explosives detonation and discharge of ammunition are suitably covered in other EET Manuals. No additional EETs have been provided.

For guidance on the speciation of particulate emissions, please refer to **Section 5.2** of this Manual.

3.3.3 Fire Training and Emergency Simulations

3.3.3.1 Description

Burning of fuel during fire training activities leads to emissions of PM_{10}, $PM_{2.5}$, NO_x, SO_2, CO and VOCs. Fire drills are conducted at airports, ports and most Australian defence facilities. Defence facilities also simulate emergency simulations by burning fuel in a pit, ship, building or aircraft replica.

3.3.3.2 Coverage under the National Pollutant Inventory

Default emission factors based on throughput for fuels typically used in fire training can be found in the following EET Manuals:

- Airports v2.0 (Table 7, Section 6.2.4);
- Defence Facilities (Table 2, Section 3.7.1); and
- Maritime Operations v2.0 (Section 6.2.2).

3.3.3.3 Further Information and Alternative Estimation Methodology

Fugitive emissions from fire training and emergency simulations are suitably covered in other EET Manuals. No additional EETs have been provided.

For guidance on the speciation of total volatile organic compound emissions, please refer to **Section 5.1** of this Manual. For guidance on the speciation of particulate emissions, please refer to **Section 5.2** of this Manual.

3.3.4 Maintenance Operations

3.3.4.1 Description

Ancillary operations such as equipment cleaning and related operations lead to fugitive emissions. These are usually evaporative losses and may be estimated using emission factors. For information on the speciation of total volatile organic compounds, please refer to **Section 5.1** of this Manual.

3.3.4.2 Coverage under the National Pollutant Inventory

The EETs to estimate emissions from surface preparation, painting, and equipment cleaning can be found in the *Emission Estimation Technique Manual for Surface Coating* (Section 3). Refer to **Section 3.1.6** for further details on surface coating and **Section 3.3.1** for further details on equipment cleaning and solvent degreasing.

3.3.4.3 Further Information and Alternative Estimation Methodologies

Fugitive emissions from maintenance operations are suitably covered in other EET Manuals. No additional EETs have been provided.

3.3.5 Vehicle exhaust

3.3.5.1 Description

Emissions from vehicle exhausts contain a range of NPI listed substances including PM_{10}, carbon monoxide, volatile organic compounds, sulfur dioxide, various organic compounds and oxides of nitrogen.

3.3.5.2 Coverage under the National Pollutant Inventory

The *Emission Estimation Technique Manual for Combustion Engines Version 3.0* provides a number of useful EETs for estimating emissions from vehicle exhausts (Section 5.0).

This Manual provides EETs for:

- Road transport vehicles (Section 5.4.1.1); and
- Industrial vehicles (Section 5.4.1.2).

The EET for road transport vehicles is based on distance travelled whereas the EET for industrial vehicles is based on either fuel use or engine power and hours of use.

The *Emission Estimation Technique Manual for Mining Version 3.0* lists typical vehicles used on mine sites (Section 5.4) and how they are classified in the *Emission Estimation Technique Manual for Combustion Engines Version 3.0.*

3.3.5.3 Further Information and Alternative Estimation Methodologies

Facilities may also use the publicly available USEPA NONROAD 2008 Model to estimate emissions from non road engines. The NONROAD 2008 Model requires several input files in order to calculate and allocate emissions estimates. These files contain detailed information such as the equipment use per year, seasonal adjustment factors, exhaust technology type distributions, future year projection or back-casting data, deterioration adjustment factors and retrofit data. This model needs to be configured with Australian fuel specifications.

It is also possible to extract emission factors from the NONROAD 2008 Model where appropriate. Obtaining emission factors from the NONROAD 2008 Model is consistent with the emission estimation method outlined in the USEPA documents *Current Methodologies and Best Practices in Preparing Port Emission Inventories* (USEPA, 2006c) and *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories – Cargo Handling Equipment* (USEPA, 2009).

3.3.6 Wastewater Treatment

3.3.6.1 Description

Table 2 in **Section 2** of this Manual provides a list of unit operations that are found in wastewater treatment. Fugitive emissions from these operations are generally evaporative losses.

3.3.6.2 Coverage under the National Pollutant Inventory

The Emission Estimation Technique for Sewage and Wastewater Treatment Version 2.0 provides a range of emission estimation techniques including engineering equations, software programs (TOXCHEM+ Version 4.0 and WATER9 Version 2.0) and emission factors which can be used to characterise fugitive emissions from wastewater treatment.

TOXCHEM+ Version 4.0 is a commercially available, EPA approved program developed by the Wastewater Technology Centre of Environment Canada and Environmega. WATER9 Version 2.0 was developed by the USEPA and is publically available.

The EETs provided relate primarily to volatile organic compounds, as these are likely to be of greatest concern from this activity.

3.3.6.3 Further Information and Alternative Estimation Methodologies

Fugitive emissions from wastewater treatment are suitably covered in other EET Manuals. No additional EETs have been provided. For information on the speciation of total volatile organic compound emissions, please refer to **Section 5.1** of this Manual.

3.3.7 Welding

3.3.7.1 Description

Welding is the process by which 2 metal parts are joined by melting the parts at the points of contact and simultaneously forming a connection with molten metal from these same parts or from a consumable electrode. In welding, the most frequently used methods for generating heat employ either an electric arc or a gas-oxygen flame. There are more than 80 different types of welding operations in commercial use. The general categories of welding operations are presented in Figure 1 (USEPA, 1995c).

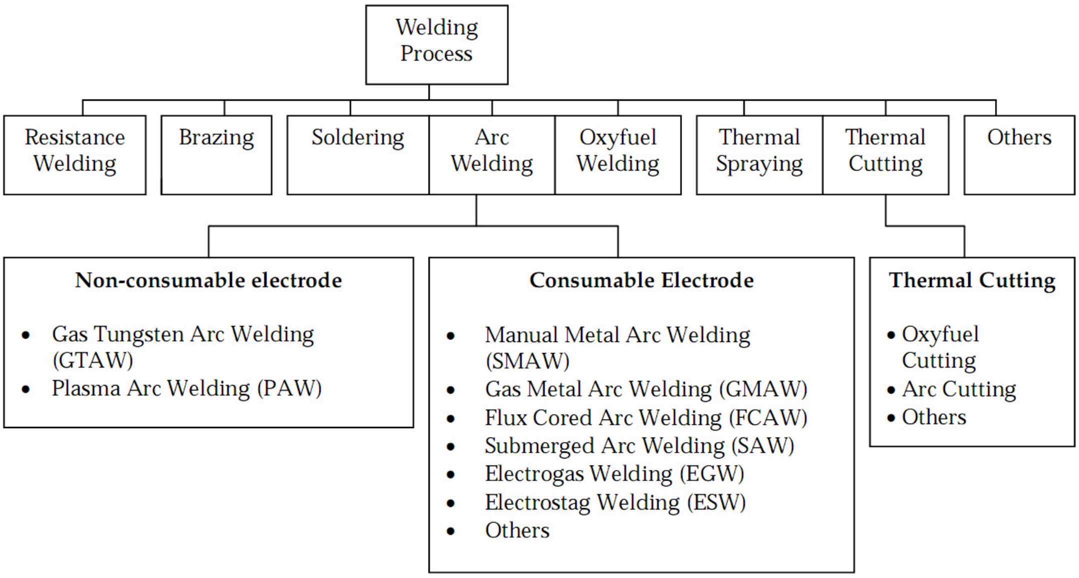

Figure 1 –The Types of Welding

Of the various processes illustrated in Figure 1, electric arc welding is by far the most commonly found. It is also the process that has the greatest potential for emissions of NPI-listed substances. The four types of electric arc welding are:

- Manual metal arc welding;
- Gas metal arc welding;
- Flux cored arc welding; and
- Submerged arc welding.

Manual Metal Arc Welding (SMAW)

This process uses heat produced by an electric arc to melt a covered electrode and the welding joint at the base metal. During operation, the rod core both conducts electric current to produce the arc and provides filler metal for the joint. The core of the covered electrode consists of either a solid metal rod of drawn or cast material or a solid metal rod fabricated by encasing metal powders in a metallic sheath. The electrode covering provides stability to the arc and protects the molten metal by creating shielding gases by vaporisation of the cover.

Gas Metal Arc Welding (GMAW)

This is a consumable electrode welding process that produces an arc between the pool of weld and a continuously supplied filler metal. An externally supplied gas is used to shield the arc.

Flux Cored Arc Welding (FCAW)

In this process, a consumable electrode welding process uses the heat generated by an arc between the continuous filler metal electrode and the weld pool to bond the metals. Shielding gas is provided from flux contained in the tubular electrode. This flux-cored electrode consists of a metal sheath surrounding a core of various powdered materials. During the welding process, the electrode core material produces a slag cover on the face of the weld bead. The welding pool can be protected from the atmosphere either by self- shielded vaporisation of the flux core or with a separately supplied shielding gas.

Submerged Arc Welding (SAW)

This process uses an arc between a bare metal electrode and the work contained in a blanket of granular fusible flux. The flux submerges the arc and welding pool. The electrode generally serves as the filler material. The quality of the weld depends on the handling and care of the flux. The process is limited to the downward and horizontal positions, but it has an extremely low fume formation rate.

3.3.7.2 Coverage under the National Pollutant Inventory

Fugitive emissions from welding are not covered elsewhere under the NPI.

3.3.7.3 Further Information and Alternative Estimation Methodologies

Particulate matter and particulate-phase hazardous air pollutants are the major concerns in welding processes. Only electric arc welding generates these pollutants in substantial quantities (USEPA, 1995c). The lower operating temperatures of the other welding processes cause fewer fumes to be released and the small size of the particulate matter produced by welding is such that it may all be considered as PM_{10} (USEPA, 1995c).

The elemental composition of the fume varies with the electrode type and with the workpiece composition. NPI-listed substances present in the welding fume can include manganese (Mn), nickel (Ni), chromium (Cr), cobalt (Co), and lead (Pb) (USEPA, 1995c).

Gas phase pollutants are also generated during welding operations, but little information is available on these pollutants. Known gaseous NPI-listed substances include carbon monoxide (CO) and nitrogen oxides (NOx) (USEPA, 1995c).

Table 7 presents PM_{10} emission factors from the four major arc welding processes, for commonly used electrode types. **Table 8** presents default factors for NPI-listed Category 1 substances. Actual emissions will depend not only on the process and the electrode type, but also on the base metal material, voltage, current, arc length, shielding gas, travel speed, and welding electrode angle.

The emissions may then be estimated from:

Equation 6

$$Ei_{\left(g/yr\right)} = \text{Mass of Electrode Consumed}_{\left(kg/yr\right)} \times EF_{i\left(g/kg\right)}$$

Fumes from welding processes are often captured by welding booths, hoods, torch fume extractors, flexible ducts, portable ducts, high efficiency filters, electrostatic precipitators, particulate scrubbers, and activated carbon filters. When estimating final emissions, collection efficiencies of these control systems need to be taken into account. **Table 9** provides default PM_{10} collection efficiencies for a range of pollution control equipment.

Table 7 – PM_{10} Emission Factors for Welding Operations

Welding Process	Electrode Type	Total Fume Emission Factor (g/kg of electrode consumed)	Emission Factor Rating
Manual Metal Arc Welding	14Mn-4Cr	81.6	C
	E11018	16.4	C
	E308	10.8	C
	E310	15.1	C
	E316	10.0	C
	E410	13.2	D
	E6010	25.6	B
	E6011	38.4	C
	E6012	8.0	D
	E6013	19.7	B
	E7018	18.4	C
	E7024	9.2	C
	E7028	18.0	C
	E8018	17.1	C
	E9015	17.0	D
	E9018	16.9	C
	ECoCr	27.9	C
	ENi-Cl	18.2	C
	ENiCrMo	11.7	C
	ENi-Cu	10.1	C
Gas Metal Arc Welding	E308L	5.4	C
	E70S	5.2	A
	ER1260	20.5	D
	ER5154	24.1	D
	ER316	3.2	C
	ERNiCrMo	3.9	C
	ERNiCu	2.0	C
Flux Cored Arc Welding	E110	20.8	D
	E11018	57.0	D
	E308LT	9.1	C
	E316LT	8.5	B
	E70T	15.1	B
	E71T	12.2	B
Submerged Arc Welding	EM12K	0.05	C

Source: USEPA (1995c)

Table 8 – NPI-listed Substances Emitted from Welding Operations

Welding Process	Electrode Type	Emission Factor (10^{-1} g/kg of electrode consume)						Emission Factor Rating
		Cr(III)[a,b]	Cr(VI)[b]	Co[c]	Mn[c]	Ni[b]	Pb[b]	
Manual Metal Arc Welding	14Mn-4Cr	13.9	ND[e]	ND[e]	232	17.1	ND[e]	C
	E11018	ND[e]	ND[e]	ND[e]	13.8	ND[e]	ND[e]	C
	E308	3.93	3.59	0.01	2.52	0.43	ND[e]	D
	E310	25.3	18.8	ND[e]	22.0	1.96	0.24	C
	E316	5.22	3.32	ND[e]	5.44	0.55	ND[e]	D
	E410	ND[e]	ND[e]	ND[e]	6.85	0.14	ND[e]	C
	E6010	0.03	0.01	ND[e]	9.91	0.04	ND[e]	B
	E6011	0.05	ND[e]	0.01	9.98	0.05	ND[e]	C
	E6012	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]
	E6013	0.04	ND[e]	<0.01[d]	9.45	0.02	ND[e]	B
	E7018	0.06	ND[e]	<0.01[d]	10.3	0.02	ND[e]	C
	E7024	0.01	ND[e]	ND[e]	6.29	ND[e]	ND[e]	C
	E7028	0.13	ND[e]	ND[e]	8.46	ND[e]	1.62	C
	E8018	0.17	ND[e]	ND[e]	0.3	0.51	ND[e]	C
	E9016	ND[e]	ND[e]	ND[e]	ND[e]	ND	ND[e]	ND[e]
	E9018	2.12	ND[e]	ND[e]	7.83	0.13	ND[e]	C
	EcoCr	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]
	ENi-Cl	ND[e]	ND[e]	ND[e]	0.39	8.90	ND[e]	C
	EniCrMo	4.20	ND[e]	ND[e]	0.43	2.47	ND[e]	C
	ENi-Cu-2	ND[e]	ND[e]	ND[e]	2.12	4.23	ND[e]	C
Gas Metal Arc Welding	E308	5.24	ND[e]	<0.01[d]	3.46	1.84	ND[e]	C
	E70S	0.01	ND[e]	<0.01[d]	3.18	0.01	ND[e]	A
	ER1260	0.04	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	D
	ER5154	0.10	ND[e]	ND[e]	0.34	ND[e]	ND[e]	D
	ER316	5.28	0.10	ND[e]	2.45	2.26	ND[e]	D
	ERNiCrMo	3.53	ND[e]	ND[e]	0.70	12.5	ND[e]	B
	ERNiCu	<0.01[d]	ND[e]	ND[e]	0.22	4.51	ND[e]	C
Flux Cored Arc Welding	E110	0.02	ND[e]	ND[e]	20.2	1.12	ND[e]	D
	E11018	9.69	ND[e]	ND[e]	7.04	1.02	ND[e]	C
	E308	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]
	E316	9.70	1.40	ND[e]	5.90	0.93	ND[e]	B
	E70T	0.04	ND[e]	ND[e]	8.91	0.05	ND[e]	B
	E71T	0.02	ND[e]	<0.01[d]	6.62	0.04	ND[e]	B
Submerged Arc Welding	EM12K	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]

Source: USEPA (1995c)

a. Chromium (III) emission factor was calculated assuming that Chromium (III) was equal to the Total Chromium emission factor minus the Chromium (VI) emission factor.

b. Listed as both a Category 1 and Category 2b Substance.

c. Listed as a Category 1 substance.

d. These values are below the lower limit of the measurement technique. In the absence of other data, use 0.01 x 10^{-1} g/kg as a conservative estimate.

e. ND = No Data.

Table 9 – Default PM_{10} Collection Efficiency Values for Pollution Control Equipment

Control Equipment	Collection Efficiency (%)
Wet scrubber - hi-efficiency	99
Wet scrubber – med-efficiency	95
Wet scrubber - low-efficiency	90
Gravity collector - hi-efficiency	6
Gravity collector - med-efficiency	4.8
Gravity collector - low-efficiency	3.7
Centrifugal collector - hi-efficiency	95
Centrifugal collector - med-efficiency	85
Centrifugal collector - low-efficiency	50
Electrostatic precipitator - hi-efficiency	99.5
Electrostatic precipitator - med-efficiency • Boilers • Other	 94 97
Electrostatic precipitator - low-efficiency • Boilers • Other	 90 90
Mist eliminator - high velocity >250 FPM	90
Mist eliminator - low velocity <250 FPM	75
Fabric filter - high temperature	99.5
Fabric filter - med temperature	99.5
Fabric filter - low temperature	99.5
Process change	NA
Liquid filtration system	85
Packed-gas absorption column	99
Tray-type gas absorption column	95
Spray tower	90
Venturi scrubber	99
Process enclosed	3.7
Impingement plate scrubber	99
Dynamic separator (dry)	99
Dynamic separator (wet)	85
Mat or panel filter - mist collector	97
Metal fabric filter screen	20
Dust suppression by water sprays	90
Dust suppression by chemical stabilizer or wetting agents	90
Gravel bed filter	80
Annular ring filter	97
Fluid bed dry scrubber	90
Single cyclone	50
Multiple cyclone w/o fly ash reinjection	95
Multiple cyclone w/fly ash reinjection	85
Wet cyclonic separator	85
Water curtain	90

Source: USEPA (January 1995d)

4 Site Specific Emission Estimation Techniques

The *NPI National Environment Protection Measure (NEPM) 1998* (Cwlth) does not envisage that additional sampling will be required for facilities to meet their NPI reporting requirements. There may, however, be cases in which none of the available EETs are suitable for a particular application. In such cases, the following guidance on the use of sampling to characterise emissions may be of use to facilities in helping them meet their reporting requirements.

A number of generic methods exist for estimating emissions from area and volume sources. These methods vary greatly in accuracy and difficulty and may not always be applicable. They are intended as an alternative to the methods already presented in this Manual.

Three methods have been described in this section. Each of these methods has been taken from *A Review of Methods for Measuring Fugitive PM_{10} Emission Rates* (USEPA, 1993) and requires:

1. Sampling for the pollutant of interest at various points in relation to the source; and
2. Application of an engineering equation or model.

If the pollutant of interest can be easily measured at ambient conditions, the methods in **Table 10** may be useful.

Table 10 – Site Specific Estimation Techniques for Area and Volume Sources

Method	Applicability	Sampling Required	Additional Modelling Required
Upward-Downwind	Area sources	Upwind and downwind	Yes[a]
Quasi-Stack	Small sources such as individual pieces of equipment	Sampling of hooded source	No
Roof Monitor	Buildings	At each exit point of buildings	No

a. Dispersion modelling back calculation is required to obtain source emission rates

4.1 Upward-Downwind Method

This method has been taken from *A Review of Methods for Measuring Fugitive PM_{10} Emission Rates* (USEPA, 1993). In the upwind-downwind method, at least one ambient concentration is obtained upwind of the pollution source, and several concentrations are obtained downwind. The difference between the upwind and downwind concentrations is considered to be the contribution of the source.

Wind speed, wind direction and other meteorological variables are monitored during the sampling procedures. Methods for sampling for this method may be obtained from the USEPA (USEPA, 1993). Using a dispersion model and available meteorological information, the net concentration is used to solve for the emission rate. Air dispersion models such as AUSPLUME and CALPUFF may be used to estimate emissions from volume and area sources in this manner to obtain downwind concentrations for this method.

Care should be exercised with this method because only a tiny fraction of the greatly diluted plume is actually sampled. A large number of samples are usually required for the data to accurately represent ambient concentrations. The modelling tends to be the greatest cause of error in this method and should be carefully applied. In many cases however, this may be the only estimation technique available.

4.2 Quasi-Stack Method

This method has been taken from *A Review of Methods for Measuring Fugitive PM_{10} Emission Rates* (USEPA, 1993). The quasi-stack method is suited to small materials handling operations and small components of industrial processes. If a particular unit operation or piece of equipment is the major source of fugitive emissions, this method may also be useful.

This method consists of enclosing or hooding the fugitive source to be measured. The source is ducted away from the source at a known velocity by using a fan and the exhaust is sampled isokinetically (uniform velocity profile).

If the quasi-stack method is used it should satisfy the criteria in Table 11.

Table 11 – Recommended Criteria for use of Quasi-Stack Method

Criteria
1. Reynolds Number ≈ 200 000 (turbulent flow) for typical ducts with smooth walls
2. A minimum straight duct run of three duct diameters upstream and downstream of the sampling port
3. If measuring particulates, air velocity in the vicinity of the hood or enclosure must be sufficient to entrain an entire PM_{10} plume without being fast enough to cause excess emissions
4. If measuring particulates, there must not be significant deposition of PM_{10} within the duct work or enclosure

Source: USEPA, 1993

USEPA Method 201 (EMTIC, 1999a) and USEPA Method 201A (EMTIC, 2010) may be used as protocols for standard stack sampling trains. Methods of sampling may be obtained from USEPA Method 1 (EMTIC, 1999b), where applicable.

This method is probably the best method for estimating emissions from enclosable sources. However, there are difficulties when trying to demonstrate that the enclosure of a source does not alter the characteristics of its emissions. This is a case-specific issue that cannot be covered in a Manual such as this.

4.3 Roof Monitor Method

This method has been taken from *A Review of Methods for Measuring Fugitive PM_{10} Emission Rates* (USEPA, 1993). If processes are located inside a building, the roof monitor method may be the best way of estimating emissions from the building. In this method, pollutant concentration and air velocity measurements must be made at each opening of the building through which pollutants may be emitted. The cross-sectional area of each opening is also required. The pollutant emission rate is the sum of all the individual opening pollutant rates and is given by:

Equation 7

$$E_i = \sum_{i-1}^{N} V_a \times C_i \times A$$

where:

E_i = Emission from building (kg/s)
N = Number of openings (-)
V_a = Velocity of air flowing through opening (m/s)
C_i = Concentration of pollutant *i* in air flowing through opening (kg/m^3)
A = Cross-sectional area of opening (m^2)

Isokinetic sampling (as discussed in **Section 4.1** of this Manual) may be difficult and it may not be possible to use stack-testing methods. Ambient sampling devices may have to be used.

Concentrations of pollutants may vary across the cross-section of the opening and it may be useful to measure at several points across the cross-section. It may also be difficult to access every opening in the building. It is important to sample at times that are representative of normal and peak emissions. It is recommended that, whenever possible, stack sampling trains be used to measure emissions. USEPA Method 201 (EMTIC, 1999a) and USEPA Method 201A (EMTIC, 2010) are acceptable protocols for these measurement techniques.

To discriminate between different sources under one roof, tracer tests are required (USEPA, 1993). Alternatively, one process at a time may be operated to obtain an emission rate from each process. This method is thought to be less accurate than the quasi-stack method (USEPA, 1993). However, a facility should only do this if it needs to characterise or identify sources for the purposes of NPI reporting. Usually, the only issue of concern is the final emissions to the environment, so the identification of specific sources of emissions within a facility is not required.

This method may be the best way to estimate emissions from buildings. Sampling problems may include difficulties in sampling large openings, as well as variable flow through openings.

5 Speciation of Aggregate Emissions

In many cases, estimations of emissions using emission factors are in the form of total output (mass emission rate) of VOC or particulate matter only. Information on the composition of these output streams is often required. Particulate emissions may contain trace metals and total Volatile Organic Compounds may contain a range of Category 1 National Pollutant Inventory pollutants that need to be reported.

If your facility has triggered a reporting threshold for a substance that is emitted as part of an aggregate emission, the total output needs to be speciated for the compounds of interest. This section should be used as an aid in the calculation of these individual pollutant emission rates.

5.1 Speciation of VOC Emission Estimates

Once total VOC emission estimates have been determined, emissions can be speciated into NPI-listed substances by the use of two methods:

- Using actual composition data; and/or
- Using speciation data in the form of weight fractions.

The first methodology is likely to give more accurate estimates than the use of generic weight fractions. In addition, the published speciation data is very limited and, therefore, a combination of these two methodologies may be required.

5.1.1 Speciation Based on Process Stream Composition

This methodology involves the determination of the composition of each process stream, and applying this data to determine the vapour phase composition. This process is based on the assumption that the weight percent of the organic substances in the equipment will equal the weight percent of the substance in the released emissions. In general, this assumption is reasonably accurate for single-phase streams containing either gaseous/vaporous material, or liquid mixtures containing constituents of similar volatilities (USEPA, 1995e). The USEPA (1995e) document also indicates that there are no clear guidelines for the determination of which release mechanism is occurring for any given equipment piece, and so the assumptions used with this methodology are generally valid.

This EET relies on the following equation to speciate emissions from a single equipment piece:

Equation 8

$$E_i = E_{VOC} \times \left(WP_i / WP_{VOC} \right)$$

where:

E_i = The mass emission rate of pollutant i from the equipment (kg/hr)
E_{voc} = The total VOC mass emission rate from the piece of equipment (kg/hr)
WP_i = The concentration of pollutant i in the equipment (Wt%)
WP_{VOC} = The VOC concentration in the equipment (Wt%)

5.1.2 Speciation Using Developed Weight Fraction Data

Limited published data is available for the speciation of VOC emissions. Certain EET Manuals provide Australian speciation data and reference is also made to USEPA speciation data in several Manuals, however this may not accurately represent Australian conditions. If your facility has its own speciation profiles, they may be used, but only with the permission of the relevant environmental authority.

The following EET Manuals provide Australian speciation data:

- The *Emission Estimation Technique Manual for Aggregated Emissions from Motor Vehicles Version 1.0* presents speciation factors for several fuels that may be used to speciate VOC emissions for all types of vehicles (Table 18, Section 9). Weight fractions are given for petrol exhaust, petrol evaporation, diesel exhaust and LPG exhaust.

- The *Emission Estimation Technique Manual for Dry Cleaning* provides the weight percentages of both toluene and xylenes in the dry cleaning solvent white spirit (Table 4, Section 5.2).

- A speciation profile for vehicle coatings can be found in the *Emission Estimation Technique Manual for Motor Vehicle Manufacturing* (Table 6, Section 4.1).

- Speciation fractions of organic compounds contained in various products from oil and gas production are listed in the *Emission Estimation Technique Manual for Oil and Gas Production and Exploration Version 1.2* (Table 1, Section 4.1.4).

- The *Emission Estimation Technique Manual for Aggregated Emissions from Architectural Surface Coatings Version 1.1* provides the speciation profile of both solvent-based and water-based architectural surface coatings (Table 3, Section 3.3.1).

- The *Emission Estimation Technique Manual for Aggregated Emissions from Cutback Bitumen Version 1.0* presents a VOC speciation profile for cutter oil (Table 3, Section 3.3).

Several EET Manuals also refer to the *Air Emissions Species Manual - Volume I Volatile Organic Compound Species Profiles* for US EPA speciation data (US EPA, 1990). The data is given in the form of weight percent of compounds in the total Volatile Organic Compounds emitted on average from various pieces of equipment.

Table 12 provides a list of industries for which US EPA speciation profiles exist. It should be noted that the speciation profiles from the US EPA may not accurately represent Australian conditions. However, this is the best information currently available. Speciation profiles only exist for certain pieces of equipment. This methodology can, therefore, only be used for the equipment types identified in US EPA (1990).

CARB (2000) also provides emission factors for specific activities based on a large database of emissions estimates in California.

Table 12 – Available Volatile Organic Compounds USEPA Species Profiles

Chemical Industry for which Profiles are Available

- Organic Chemical Storage (Section 3.22)
- Railcar, Tank Truck and Drum Cleaning (Section 3.23)
- Surface Coating Operations (Section 3.19)
- Asphalt Products (Section 3.12)
- Mobile Sources - Gasoline Fuelled Vehicles (Section 3.26)
- Organic Solvent Evaporation (Section 3.18)
- External and Internal Combustion Engines (Section 3.1 and 3.2)
- Carbon Black Production (Section 3.3)
- Paint and Varnish Manufacture (Section 3.4 and 3.5)
- Plastics Production (Section 3.6)
- Printing Ink Manufacture (Section 3.7)
- Synthetic Organic Fibre Production (Section 3.8)
- Organic Chemical Manufacture (Section 3.9)
- Food and Agriculture (Section 3.10)
- Primary and Secondary Metal Production (Section 3.11)
- Petroleum Products (Section 3.13)
- Plywood Products (Section 3.14)
- Synthetic Rubber Production (Section 3.15)
- Oil and Gas Production (Section 3.16)
- Textile Products (Section 3.17)
- Storage, Transportation and Marketing of Petroleum Products (Section 3.20)
- Printing and Publishing Processes (Section 3.21)
- Solid Waste Disposal (Section 3.24)
- Wood Combustion (Section 3.25)
- Aircraft (Section 3.27)
- Forest Fires (Section 3.28)

Source: USEPA, 1990

Further information relating to VOCs from surface coatings can be found in *VOCs from Surface Coatings – Assessment of the Categorisation, VOC Content and Sales Volumes of Coating Products Sold in Australia* (ENVIRON, 2009). Appendix 7 of that report lists the VOC content for several product types.

The speciation factors obtained from speciation data can be used to calculate emissions of NPI substances using the following equation:

Equation 9

$$E_i = E_{VOC} \times \left({WP_i}/{100} \right)$$

where:

E_i = The mass emission rate of pollutant *i* from the equipment (kg/s)
E_{VOC} = The total VOC mass emission rate from the piece of equipment (kg/s)
WP_i = The concentration of pollutant *i* in the vapour released from the equipment obtained from speciation data (Wt%)

5.2 Speciation of Particulate Emission Estimates

Emissions of particulate matter will often contain trace amounts of Category 1 and Category 2 NPI-listed metals. To estimate emissions of these compounds, total suspended particulate (TSP) emissions must be known.

When total suspended particulate emissions have been estimated, speciation is performed using the weight fractions of trace metals in the emissions. In the absence of other information, particulate emissions from fugitive sources can be assumed to have the same concentration as the source.

The following EET Manuals provide speciation data:

- A list of naturally occurring concentrations of elements reportable under the NPI in various materials may be found in Table 9 (Appendix B) of the *Emission Estimation Technique Manual for Mining Version 3.0*.

- The *Emission Estimation Technique Manual for Fossil Fuel Electric Power Generation Version 2.4* presents speciation data for Australian coals commonly used by the fossil fuel electricity generation industry (Table 20-21, Appendix B).

- The *Emission Estimation Technique Manual for Alumina Refining Version 2.0* provides speciation data for bauxite and red mud (Table 3, Section 3.1.1.5).

- The *Emission Estimation Technique Manual for Shipbuilding Repair and Maintenance* lists the metal content of common Australian abrasives (Table 5, Section 4.5.1).

When total particulate emissions have been estimated, speciation is performed using the weight fractions of each of the pollutants of interest. This is done using the following equation:

Equation 10

$$E_i = TSP \times \left({WP_i}/{100} \right)$$

where:

E_i = The mass emission rate of pollutant *i* from the relevant source (kg/hr)

TSP = The total suspended particulate mass emission rate from the relevant source

WP_i = The concentration of pollutant *i* in the total emission (Wt%)

6 Glossary of Terms and Abbreviations

CARB	California Air Resources Board
Cr (III)	Chromium (III)
Cr (VI)	Chromium (VI)
Co	Cobalt
EEA	European Environment Agency
EET	Emission Estimation Technique
EFR	Emission Factor Rating
FCAW	Flux Cored Arc Welding
GMAW	Gas Metal Arc Welding
Isokinetic	Uniform velocity profile
LDAR	Leak Detection and Repair
Manual	NPI EET Manual
MC	Medium Cure. Refers to cutback asphalt
Mn	Manganese
NEPM	National Environment Protection Measure
Ni	Nickel
NOx	Oxides of Nitrogen
NPI	National Pollutant Inventory
Pb	Lead
PM_{10}	Particles which have an equivalent aerodynamic diameter of 10 micrometers or less (i.e. $\leq 10\ \mu m$)
ppmv	Parts per million by volume
RC	Rapid Cure. Refers to cutback asphalt.
SAW	Submerged Arc Welding
SC	Slow Cure. Refers to cutback asphalt.
sL	Silt loading
STP	Standard Temperature and Pressure (0°C and 101.3 kPa).
MMAW	Manual Metal Arc Welding
TDS	Total Dissolved Solids
Transfer	Transfers consist of a deposit of a substance into landfill, or discharge of a substance to a sewer or tailings dam, or removal of a substance from a facility for destruction, treatment, recycling, reprocessing, recovery or purification. Emissions classed as transfers are not required to be reported under the NPI.
TSP	Total Suspended Particulate Matter
USEPA	United States Environmental Protection Authority
VOC	Volatile Organic Compound

7 References

40CFR70.2, 2010, *State Operating Permit Programs*, Code of Federal Regulations, Title 70, Pt. 70.2.

Axtell, K. 1978, *Survey of Fugitive Dust from Coal Mines*, EPA-908/1-78-003, USEPA, Denver, CO.

Austroads, 2008, *Bitumen Emulsions*, Austroads Technical Report AP-T107/08, Austroads Incorporated, Sydney, NSW.

CARB, 1997a, *Area-Wide Source Methods, Section 7.12 Windblown Dust – Agricultural Lands,* California Air Resources Board, Sacremento, CA.
http://www.arb.ca.gov/ei/areasrc/fullpdf/full7-12.pdf

CARB, 1997b, *Area-Wide Source Methods, Section 7.13 Windblown Dust – Unpaved Roads,* California Air Resources Board, Sacremento, CA.
http://www.arb.ca.gov/ei/areasrc/fullpdf/full7-13.pdf

CARB, 2000, *California Air Toxics Emission Factor Database*, California Air Resources Board.
http://www.arb.ca.gov/app/emsinv/catef_form.html

CARB, 2002, *Evaluation of Air Quality Performance Claims for Soil-Sement Dust Suppressant,* California Air Resources Board, Sacremento, CA.
http://www.midwestind.com/assets/files/Certifications/CARBReport.pdf

Cowherd, C. Jr. et al. 1974, *Development of Emission Factors for Fugitive Dust Sources*, EPA 450/3-74-037, USEPA, Research Triangle Park, North Carolina.

EMTIC, 1999a, *Method 201 - Determination of PM10 Emissions (Exhaust Gas Recycle Procedure),* Emission Measurement Technical Information Center, NSPS Test Method.
http://www.epa.gov/ttn/emc/promgate/m-201.pdf

EMTIC, 1999b, *Method 1 - Sample and Velocity Traverses for Stationery Sources*, Emission Measurement Technical Information Center, NSPS Test Method.
http://www.epa.gov/ttn/emc/promgate/m-01.pdf

EMTIC, 2010, *Method 201A - Determination of PM10 Emissions (Constant Sampling Rate Procedure)*, Emission Measurement Technical Information Center, NSPS Test Method.
http://www.epa.gov/ttn/emc/promgate/m-201a.pdf

ENVIRON, 2009, *VOCs from Surface Coatings – Assessment of the Categorisation, VOC Content and Sales Volumes of Coating Products Sold In Australia*, Prepared for NEPC Service Corporation on behalf of the Environment Protection Heritage Council, ENVIRON Australia Pty Ltd.
http://www.ephc.gov.au/sites/default/files/AAQ_Rpt__VOCs_from_Surface_Coatings_Final_20090930.pdf

ERG, 2001, *Emission Inventory Improvement Program (EIIP), Volume III: Chapter II: Gasoline Marketing*, Prepared for Area Sources Committee, Emission Inventory Improvement Program, Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency, USA.
http://www.epa.gov/ttnchie1/eiip/techreport/volume03/iii11_apr2001.pdf

Gilette, D. A. et al. 1982, Threshold Velocities for Input of Soil Particles into the Air by Desert Soils, *Journal of Geophysical Research*, 85, 5621-5630.

Krayer, W. R. and Marshall, R. D. 1992, Gust Factors Applied to Hurricane Winds, *Bulletin of American Meteorological Society*, 73, 613-617.

Midwest Research Institute, 1999, *Estimating Particulate Matter Emissions from Construction Operations*, Midwest Research Institute, Kansas City, Missouri.

Mutton, A. J. 2003, *Queensland Coals: Physical and Chemical Properties, Colliery and Company Information*, 14th edition, Department of Natural Resources and Mines, Brisbane, QLD.

Pechan, 2008a, *2008 Nonpoint Emission Estimates, Asphalt Paving – Cutback,* Pechan Environmental Consulting.
http://projects.pechan.com/EPA/Non-Point_Emission_Estimates/index.html#AphaltPaving

Pechan, 2008b, *2008 Nonpoint Emission Estimates, Asphalt Paving – Emulsified,* Pechan Environmental Consulting.
http://projects.pechan.com/EPA/Non-Point_Emission_Estimates/index.html#AphaltPaving

SKM, 2005, *Improvement of the NPI Fugitive Particulate Matter Emission Estimation Techniques,* RFQ NO. 0027/2004, Sinclair Knight Merz, Perth, WA.
http://www.npi.gov.au/publications/emission-estimation-technique/pubs/pm10may05.pdf

USEPA, 1990, *Air Emissions Species Manual - Volume I - Volatile Organic Compound Species Profiles*, 2nd Ed, Emission Standards Division, Office of Air and Radiation Office of Air Quality Planning and Standards Research Triangle Park North Carolina.

USEPA, 1993, A *Review of Methods for Measuring Fugitive PM-10 Emission Rates* (EPA-454/R-93-037), Emission Standards Division, Office of Air and Radiation Office of Air Quality Planning and Standards Research Triangle Park North Carolina.

USEPA, January 1995a, *Emission Factor Documentation for AP-42, Section 4.5 Asphalt Paving Operations. United States Environmental Protection Agency, Office of Air Quality Planning and Standards*. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42/ch04/final/c4s05.pdf

USEPA, January 1995b, *Emission Factor Documentation for AP-42, Section 13.2.3 Heavy Construction Operations*, United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s02-3.pdf

USEPA, January 1995c, *Emission Factor Documentation for AP-42, Section 12.19, Electric Arc Welding*, United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42/ch12/final/c12s19.pdf

USEPA, January 1995d, *Emission Factor Documentation for AP-42, Appendix B.2 Generalized Particle Size Distributions*. United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42/appendix/appb-2.pdf

USEPA, 1995e, *Protocol for Equipment Leak Emission Estimates (EPA-453/R-95-017),* Emission Standards Division, Office of Air and Radiation Office of Air Quality Planning and Standards Research Triangle Park North Carolina.
http://www.epa.gov/ttnchie1/efdocs/equiplks.pdf

USEPA, 1997, *Emission Factor Documentation for AP-42, Section 13.2.6 Abrasive Blasting*, United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s02-6.pdf

USEPA, 1998, *Emission Factor Documentation for AP-42, Section 11.9 Western Surface Coal Mining*, United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s09.pdf

USEPA, 2006a, *Emission Factor Documentation for AP-42, Section 13.2.5 Industrial Wind Erosion*, United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0205.pdf

USEPA, 2006b, *Emission Factor Documentation for AP-42, Section 13.2.2 Unpaved Roads*, United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0202.pdf

USEPA, 2006, *Current Methodologies and Best Practices in Preparing Port Emission inventories – Final Report*, ICF Consulting for the Environmental Protection Agency, United States.

USEPA, 2009, *Current Methodologies in preparing Mobile Source Port-Related Emission Inventories – Cargo Handling Equipment*, ICF Consulting for the Environmental Protection Agency. http://www.epa.gov/cleandiesel/documents/ports-emission-inv-april09.pdf

USEPA, 2011, *Emission Factor Documentation for AP-42, Section 13.2.1 Paved Roads*, United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0201.pdf

WAGBT, 2007, *Western Australia Biofuels Taskforce Interim Report, Appendix 3: Environment and Health,* Western Australia Biofuels Taskforce.
http://www.agric.wa.gov.au/objtwr/imported_assets/content/sust/biofuel/biofuelstaskforceenvhealthreportapr07.pdf

WRAP, 2006, *Fugitive Dust Handbook, Chapter 3: Construction and Demolition,* Western Regional Air Partnership.
http://www.wrapair.org/forums/dejf/fdh/ch3-constdem.html

Wray, H. A. 1992, *Manual on flash point standards and their use: methods and regulations*, American Society for Testing and Materials, Philadelphia, PA.

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 Environmental Protection Authority:

- Emission Estimation Manual for Aggregated Emissions from Architectural Surface Coatings v1.1
- Emission Estimation Manual for Airports v2.0
- Emission Estimation Manual for Animal and Bird Feed Manufacture
- Emission Estimation Manual for Alumina Refining v2.0
- Emission Estimation Manual for Combustion Engines v3.0
- Emission Estimation Manual for Defence Facilities

- Emission Estimation Manual for Electroplating and Anodising
- Emission Estimation Manual for Explosives Detonation and Firing Ranges v2.0
- Emission Estimation Manual for Gas Supply
- Emission Estimation Manual for Glass and Glass Manufacture v2.0
- Emission Estimation Manual for Hot Mix Asphalt Manufacture
- Emission Estimation Manual for Inorganic Chemicals Manufacturing v2.0
- Emission Estimation Manual for Iron and Steel Production
- Emission Estimation Manual for Lead Concentrating, Smelting and Refining
- Emission Estimation Manual for Maritime Operations v2.0
- Emission Estimation Manual for Minerals and Processing of Non-metallic Minerals v2.0
- Emission Estimation Manual for Mining v3.0
- Emission Estimation Manual for Motor Vehicle Manufacture
- Emission Estimation Manual for Oil and Gas Exploration and Production v1.2
- Emission Estimation Manual for Organics Chemical Processing Industries
- Emission Estimation Manual for Petroleum Refining
- Emission Estimation Manual for Railway Yard Operations v2.0
- Emission Estimation Manual for Sewage and Wastewater Treatment v2.0
- Emission Estimation Manual for Solvent Recycling
- Emission Estimation Manual for Sugar Milling and Refining v1.1
- Emission Estimation Manual for Surface Coating

The following software has been referenced in this Manual:

AUSPLUME Version 6.0
Information on AUSPLUME may be obtained through the Victorian Environment Protection Authority at the Website:
http://www.epa.vic.gov.au/air/epa/ausplume-pub391.asp

Copies of AUSPLUME (for Windows) are available from:
Environmental Assessments
EPA Victoria
Ernest Jones Drive
Macleod VIC 3085

CALPUFF
CALPUFF is a dispersion model typically used in regulatory applications in Australia. Further information on CALPUFF can be found at:
http://www.src.com/calpuff/calpuff1.htm

MOBILE6
This software may be downloaded from the USEPA at the following Website:
http://www.epa.gov/oms/m6.htm

NONROAD 2008 Model
This software may be downloaded from the USEPA at the following Website:
http://www.epa.gov/oms/nonrdmdl.htm

TANKS 4.09D
This software may be downloaded from the USEPA at the following Website:
http://www.epa.gov/ttnchie1/software/tanks/

TOXCHEM+ Version 4.0
This software may be purchased from Hydromantis Environmental Software Solutions at the following website:
http://www.hydromantis.com/TOXCHEM.html

WATER9 Version 2.0
This software may be downloaded from the USEPA at the following Website:
http://www.epa.gov/ttnchie1/software/water/

Appendix A: List of Variables and Symbols

Variable	Symbol	Units
Annual emissions of pollutant *i*	$E_{kpy,i}$	kg/yr
Total emissions of pollutant *i* per hour	E_i	g/y, t/ha/yr
Uncontrolled emission factor for pollutant *i*	EF_i	kg of pollutant/unit of weight, volume, distance or duration of activity emitting the pollutant
Overall control efficiency	CE_i	% reduction in emissions of pollutant *i*
Fuel used	Q_f	kg/hr
Concentration of pollutant *i*	C_i	ppmv, kg/L
Total suspended particulates in exhaust gases or air	TSP	kg/hr
Average concentration of pollutant *i*	C_i	kg/m^3
Operating hours	OpHrs	hr/yr
Activity rate	A_R	t/hr
Vehicle kilometres travelled	VKT	km
Molecular weight of pollutant emitted	MW_p	kg/kg-mole
Elemental weight of pollutant in fuel	EW_f	kg/kg-mole
Concentration of pollutant *i* in the raw material, product, recycled material or waste respectively, that is processed annually	C_{in} C_{pr} C_{rec}	kg/kg, kg/L
Quantity of raw material, product, recycled material or waste respectively, that is processed annually	Q_{in} Q_{pr} Q_{rec}	Generally expressed in kg/yr for solids, L/yr for liquids
Number of openings	n	-
Road surface silt loading	sL	g/m^2
Number of disturbances per year	N	yr^{-1}
Erosion potential corresponding to the observed (or probable) fastest mile of wind for the ith period between disturbances	P_i	g/m^2
Friction velocity	u^*	m/s
Threshold friction velocity	u_t	m/s
Fastest mile of reference anemometer for period between disturbances	u_{10}^+	m/s
Velocity of air through an opening	V_a	m/s
Cross-sectional area of an opening	A	m^2
The total VOC mass emission rate from the piece of equipment	E_{VOC}	kg/s
The concentration of NPI pollutant *i* in the equipment	WP_i	% by weight (Wt%)
The VOC concentration in the equipment	WP_{VOC}	% by weight (Wt%)
Quantity of dust entrained to the air	E_S	tons/acre/year
Portion of total wind erosion losses that would be measured as suspended particulate	A	-
Soil erodibility	I	tons/acre/year
Surface roughness factor	K	-
Climatic factor	C	-
Unsheltered field width factor	L′	-
Vegetative cover factor	V′	-
Particle size multiplier	k	-
Wind Speed	u	m/s