



**National Pollutant Inventory**

# **Emission Estimation Technique Manual**

**for**

## **Fugitive Emissions**

*First published in December 1999*

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**EMISSION ESTIMATION TECHNIQUES  
FOR  
FUGITIVE EMISSIONS**

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## 1.0 Introduction

The purpose of all Emission Estimation Technique (EET) Manuals in this series is to assist Australian manufacturing, industrial and service facilities to report emissions of listed substances to the National Pollutant Inventory (NPI). This Manual describes the procedures and recommended approaches for estimating fugitive emissions.

Fugitive emissions can be defined as releases not confined to a stack, duct or vent. 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 in Section 1.2 provides an overview of the fugitive emissions covered in this Manual.

Pacific Air & Environment prepared this Manual on behalf of the Commonwealth Government. The Manual has been developed through a process of national consultation involving State and Territory environmental authorities and key stakeholders.

### 1.1 Structure of Manual

- Section 2 describes the categories of fugitive emissions covered by this Manual. Table 3 in Section 2.2 provides an overview of these specific sources and lists other NPI Manuals that provide useful information on each source.
- Emission Estimation Techniques for each of the listed fugitive emissions in this Manual (see Table 1 in Section 1.2 of this Manual) are presented in Section 3. Each of the sources are considered in turn by providing a brief description of each source, an examination of previous coverage under the National Pollutant Inventory and a presentation of suitable emission estimation techniques (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 emission estimation techniques presented in Section 3 of this Manual 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 emission estimation techniques arrive at an estimation of total pollutant emissions, which are, in general, 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 the development of this Manual.
- Appendix A provides an overview of the four general types of emission estimation techniques: sampling or direct measurement; mass balance; engineering calculations and emission factors, as well as example calculations to illustrate their use. Reference

to relevant sections of this appendix is recommended in understanding the application of these techniques with particular respect to the characterisation of fugitive emissions.

- **Appendix B** provides a general discussion of the reliability and uncertainty of each of the emission estimation techniques discussed in **Appendix A**.
- **Appendix C** provides a list of variables and symbols used throughout this Manual.

## 1.2 Location of Information

In this Manual, fugitive emissions are examined in two ways. In **Section 3**, each of the listed fugitive sources is estimated with the use of engineering equations or process specific emission factors. Emissions from groups of point sources can be estimated by either using process specific emission factors or using a generic estimation methodology, based on the physical dimensions of the release. These EETs are presented in **Section 4** of this Manual.

The location of the various emission estimation techniques covered in this Manual is shown in Table 1.

**Table 1 - Location of Estimation Techniques in this Manual**

<b>Fugitive Emissions Source</b>	<b>Section in this Manual</b>
<b>Point Sources</b>	<b>3.0</b>
Equipment Leaks	3.1
Open Vats and Mixing	3.2
Storage Tanks	3.3
Wastewater Treatment	3.4
Emissions from Cooling Towers	3.5
Maintenance Operations	3.6
Vehicle Movement and Exhaust	3.7
Liquid Spills	3.8
Storage Piles	3.9
Bulk Materials Handling and Unit Operations	3.10
Loading and Unloading of Vehicles	3.11
Painting	3.12
Equipment Cleaning and Solvent Degreasing	3.13
Surface Coating	3.14
Abrasive Blasting	3.15
Asphalt Paving	3.16
Construction and Demolition	3.17
Welding	3.18
Open Area Wind Erosion	3.19
<b>Alternative Estimation Methodology</b>	<b>4.0</b>
Quasi-stack Method	4.1
Roof Monitor Method	4.2
Upwind Downwind Method	4.3

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### 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 is generated in this process will have varying degrees of accuracy with respect to the actual emissions from industrial facilities. In some cases there will necessarily be a large potential error due to inherent assumptions in the various emissions estimation techniques (EETs) and/or a lack of available information of chemical processes.

*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. Each has associated error bands that are potentially quite large. **Appendix B** discusses the general reliability associated with the various methods. 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. Also the availability of pre-existing data and the effort required to decrease the error associated with the estimate will need to be considered. For example, if emissions of a substance are clearly very small no matter which EET is applied, then there would be little gained by applying an EET which required significant additional sampling. 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 and 1a 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.



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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.

The accuracy of particular EETs is discussed in **Appendix B**.

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

<sup>a</sup>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 emission estimates only. It does not attempt to relate emissions to potential environmental impacts, bioavailability of emissions or natural background levels.

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## 2.0 Processes and Emissions

### 2.1 Manual Development Process

In defining the scope of the Fugitive Emissions Manual, the previous coverage of fugitive emissions under the NPI was reviewed and the areas for which further research was required were identified.

Under the NPI, a series of Industry Handbooks have been developed to aid in the estimation of emissions of NPI-listed substances. A number of these Handbooks (listed in Table 2) refer to a Fugitive Emissions Manual.

**Table 2 - NPI Industry Handbooks that Refer to Fugitive Emissions**

INDUSTRY HANDBOOK
Glass and Glass Product Manufacturing
Paper and Paper Product Manufacturing
Concrete Product Manufacturing
Electricity Supply
Metal Coating and Finishing
Surface Coating
Fertiliser Manufacturing
Inorganic Industrial Chemical Manufacturing
Hot Mix Asphalt Manufacturing
Log Sawmilling, Timber Dressing and Wood Product Manufacturing
Dairy Product Manufacturing
Precious Metal Manufacturing: Gold Ore Processing
Basic Non-Ferrous Metal Manufacturing: Nickel Concentrating, Smelting & Refining
Railway Equipment Manufacturing
Mining of Non-Metallic Minerals
Defence

However, fugitive emissions are not solely restricted to these industries and can also arise from processes and activities other than those listed above.

### 2.2 Emission Categories

Following the review process described above, it was decided that fugitive emissions could be divided into a number of generic categories (as shown in Table 3). A number of these categories have been previously covered in other National Pollutant Inventory Manuals.

The sources marked as 'No' in Table 3 are those sources considered in most detail in this Manual.

**Table 3 - Previous Coverage of Fugitive Emissions under the NPI**

<b>Fugitive Emissions Type</b>	<b>Previous Coverage Under NPI?</b>	<b>Which Manual?</b>
<b>Equipment Leaks</b> Valves, Flanges, Connectors, Pumps, Compressors, Drains, Open Ended Lines, Pressure Relief Valves, Sampling Connections	Yes	<ul style="list-style-type: none"> <li>• Petroleum Refining</li> <li>• Oil and Gas Exploration and Production</li> <li>• Inorganic Chemicals Manufacturing</li> <li>• Organic Chemical Processing Industries</li> </ul>
<b>Open Vats and Mixing</b>	Yes	<ul style="list-style-type: none"> <li>• Organic Chemical Processing Industries</li> <li>• Inorganic Chemicals Manufacturing</li> <li>• Alumina Refining</li> </ul>
<b>Storage Tanks</b>	Yes	<ul style="list-style-type: none"> <li>• Organic Chemical Processing Industries</li> <li>• Alumina Refining</li> </ul>
<b>Liquid Spills</b>	Yes	<ul style="list-style-type: none"> <li>• Petroleum Refining</li> <li>• Organic Chemical Processing Industries</li> </ul>
<b>Storage Piles</b> Wind Erosion	Yes	<ul style="list-style-type: none"> <li>• Mining</li> </ul>
<b>Wastewater Treatment</b> 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	<ul style="list-style-type: none"> <li>• Sewage and Wastewater Treatment</li> </ul>
<b>Vehicle Movement and Exhaust</b> Bulldozers, Trucks, Scrapers, Graders, Tractors and Loaders	Yes	<ul style="list-style-type: none"> <li>• Mining</li> <li>• Railway Yard Operations</li> </ul>
<b>Bulk Materials Handling and Unit Operations</b> Draglines, Excavators, Shovels, Front-end Loaders, Drilling, Blasting, Wheel and Bucket Operations, Loading, Unloading, Transfer, Crushing, Grinding, Drying, Screening	Yes	<ul style="list-style-type: none"> <li>• Mining</li> </ul>

**Table 3 - Previous Coverage of Fugitive Emissions under the NPI cont'**

<b>Loading and Unloading of Vehicles</b>		
Solids	Yes	• Mining
Organic Liquids	Yes	• Fuel and Organic Liquid Storage • Surface Coating • Railway Yard Operations
<b>Painting</b>	Yes	• Surface Coating
Aerosol, Brush-on, Spray-on		
<b>Equipment Cleaning and Solvent Degreasing</b>	Yes	• Surface Coating • Railway Yard Operations
<b>Surface Coating</b>	Yes	• Surface Coating
<b>Abrasive Blasting</b>	Yes	• Surface Coating • Railway Yard Operations
<b>Emissions from Cooling Towers</b>	Yes	• Fossil Fuel Electric Power Generation
<b>Asphalt Paving</b>		
Manufacture of Asphalt	Yes	• Hot Mix Asphalt Manufacturing
Paving of Asphalt	No	
<b>Construction and Demolition</b>	No	
<b>Open Area Wind Erosion</b>	No	
<b>Area/Volume Sources</b>	No	
Buildings, Ponds, Groups of Point Sources, Other Non-point Sources		
<b>Maintenance Operations</b>	No	
Discarded Containers, Spills, Waste Solvents, Tank and Drum Cleaning.		
<b>Welding</b>	No	

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## 3.0 Emission Estimation Techniques for Fugitive Sources

### 3.1 Equipment Leaks

#### 3.1.1 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.

#### 3.1.2 Previous Coverage under the National Pollutant Inventory

Fugitive emissions from equipment leaks have been previously 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* (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);
- Emission estimation techniques (EETs) (Section 4.3.1). The EETs presented involve the standard application of factors and equations, which are independent of the facility. The specific sources considered are valves, flanges, connectors, pumps, compressors, drains, open ended lines, pressure relief valves and sampling connections; and
- Speciation of VOC estimates (Section 4.3.2).

The *Emission Estimation Technique Manual for Oil and Gas Exploration and Production* 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.

#### 3.1.3 Further Information

Fugitive emissions of inorganic chemicals have not been previously covered in other manuals and are examined here (see Section 3.1.3.1 below). An approach for developing unit-specific correlations is also briefly discussed.

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

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### 3.1.3.1 Inorganic Chemicals

The emission factors and correlations presented here and in other manuals are generally intended for use with organic chemicals. Emissions of inorganic chemicals may need to be estimated in cases where the compounds exist or potentially exist (eg. when vented) 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;
- Sulfuric Acid.

You should 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. A technique suitable for the estimation of emissions from spills of volatile liquids may be found in the *Emission Estimation Technique Manual for Organic Chemical Processing Industries*.

The most reliable method of estimating leak emissions of inorganic compounds would be to develop unit specific correlations (see Section 3.1.3.2 of this Manual). If a portable monitoring instrument (or some other approach) can be used to indicate the actual concentration of the inorganic compound at the equipment/leak interface, then the "screening values" obtained with this instrument can be entered into the applicable correlations or emission factors presented here or in other NPI handbooks.

### 3.1.3.2 Unit-Specific Correlation Approach

To develop unit-specific correlations screening value and corresponding mass emissions data (ie. bagging data) must be collected from process unit equipment. This data must then be manipulated and analysed in such a way as to produce reliable correlations. See *Protocol for Equipment Leak Emission Estimates* (USEPA, 1995) for a detailed discussion on the procedures for developing unit-specific correlations.

---

## 3.2 Open Vats and Mixing

### 3.2.1 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:

- Topping up vessels such as mixers;
- Air displacement from mixtures;
- Emissions from vapour pressure and mass transfer;
- Emissions from surface evaporation; and
- Emissions from material loading operations.

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

### 3.2.2 Previous Coverage under the National Pollutant Inventory

#### 3.2.2.1 Organic Chemicals

The *Emission Estimation Technique Manual for Organic Chemical Processing Industries* (Section 5.0) provides guidance on the estimation of emissions from topping up operations and air displacement from mixtures of organic liquids.

#### 3.2.2.2 Inorganic Chemicals

The *Emission Estimation Technique Manual for Inorganic Chemicals Manufacturing* (Section 5.1) provides emission estimation techniques for losses from mass transfer operations and spills.

The *Emission Estimation Technique Manual for Alumina Refining* (Section 6.5.1) provides an emission estimation technique for acid emissions during filling of storage tanks.

### 3.2.3 Further Information

The data necessary for EET computations presented in the above Manuals is summarised in Table 4.

**Table 4 - Data Required for Open Vats and Mixing EETs**

EET Manual for Organic Chemical Processing Industries (Section 5.0)	EET Manual for Inorganic Chemicals Manufacturing (Section 5.1)	EET Manual for Alumina Refining (Section 6.5.1)
<ul style="list-style-type: none"><li>• Vapour pressure of material loaded</li><li>• Temperature of mixture</li><li>• Vapour molecular weight</li><li>• Volume of material loaded</li></ul>	<ul style="list-style-type: none"><li>• Vapour mole fraction</li><li>• Liquid mole fraction</li><li>• Vapour pressure of component in the tank</li><li>• System pressure. For open reactors, this will be ambient pressure (101.3kPa)</li></ul>	<ul style="list-style-type: none"><li>• Mass of acid emitted during filling</li><li>• Molecular weight of acid</li><li>• Volume of the vapour space in the tank</li></ul>

Fugitive emissions from open vats and mixing are suitably covered in other EET Manuals. No other EETs are therefore required.

### 3.3 Storage Tanks

#### 3.3.1 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.

#### 3.3.2 Previous Coverage under the National Pollutant Inventory

It is recommended that emissions from small tanks (ie. less than 30 tonnes capacity) be calculated using the EET for air displacement provided in Section 5.2 of the *Emission Estimation Technique Manual for Organic Chemical Processing Industries*. This is a relatively simple EET, requiring only vapour mole fraction, liquid mole fraction and vapour pressure data for each of the components being stored.

Alternatively, TANKS 4.0 software may be used for estimating emissions from small tanks. TANKS 4.0 is a software package that requires more detailed 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.

For large tanks (ie. greater than 30 tonnes capacity) the TANKS 4.0 model should be used for emissions estimation.



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The *Emission Estimation Technique Manual for Alumina Refining* (Section 6.5.1) provides EETs for fugitive emissions from the storage of acids.

### 3.3.3 Further Information

Fugitive emissions from storage tanks are suitably covered in other EET Manuals. No other EETs are therefore required. Methods for speciating total volatile organic compound emissions are presented in Section 5.1.

## 3.4 Wastewater Treatment

### 3.4.1 Description

The process of wastewater treatment includes several unit operations. Table 3 in Section 2.2 of this Manual provides a list of unit operations that are found in wastewater treatment. Fugitive emissions from these operations are generally evaporative losses.

### 3.4.2 Previous Coverage under the National Pollutant Inventory

The *Emission Estimation Technique for Sewage and Wastewater Treatment* provides a range of EETs including engineering equations, WATER8 software and emission factors which can be used to characterise fugitive emissions from wastewater treatment.

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

### 3.4.3 Further Information

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

## 3.5 Emissions from Cooling Towers

### 3.5.1 Description

Cooling towers are heat exchangers that are used to dissipate large heat loads to the atmosphere. They are used to transfer waste heat from cooling water to the atmosphere by allowing the water to cascade through a series of decks and slat-type grids.

Although cooling towers can be classified several ways, the primary classification is into dry towers or wet towers, although some combinations of these also exist. Wet (or evaporative) cooling towers use water as their heat transfer medium and rely on the latent heat of water evaporation to exchange heat between the process and the air passing through the cooling tower. The aspirated droplets are dispersed into the atmosphere as

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aerosols and, depending on the composition of the droplet may need to be considered under the NPI. This process does not occur in dry cooling towers and, therefore, only wet cooling towers are considered under the NPI.

### **3.5.2 Previous Coverage under the National Pollutant Inventory**

Fugitive emissions from cooling towers are examined in the *Emission Estimation Technique Manual for Fossil Fuel Electric Power Generation* (Section 5.2.8). Separate emission factors are given for induced draft and natural draft cooling towers. A method for the estimation of Particulate Matter (PM<sub>10</sub>) emissions from plant data is also presented. The EETs presented in this Manual are not specific to power plant cooling towers and may be applied to cooling towers from any industry.

### **3.5.3 Further Information**

Particulate matter emissions may need to be speciated for organic compounds and trace metals. Methods for speciation of total particulate emissions are presented in Section 5.2 of this Manual.

## **3.6 Maintenance Operations**

### **3.6.1 Description**

Ancillary operations such as equipment cleaning and related operations give rise to fugitive emissions. These are usually evaporative losses and may be estimated using emission factors. These emissions can usually be traced back to one point or to small area sources and can therefore be considered as point sources. For information on the speciation of total volatile organic compounds, please refer to Section 5.1 of this Manual.

### **3.6.2 Previous Coverage under the National Pollutant Inventory**

The emissions from a number of maintenance operations have been estimated in the *Emission Estimation Technique Manual for Railway Yard Operations* (Section 5.1, Table 2). Emission factors for discarded raw materials from containers, equipment cleaning, spills and waste solvents are presented in this Manual.

### **3.6.3 Further Information**

Fugitive emissions from maintenance operations are suitably covered in other EET Manuals. No other EETs are therefore required.

### 3.7 Vehicle Movement and Exhaust

#### 3.7.1 Description

The movement of vehicles over various surfaces leads to emissions of particulate matter (PM<sub>10</sub>). Emissions from vehicle exhausts contain a range of NPI listed substances including PM<sub>10</sub>, carbon monoxide, volatile organic compounds, sulfur dioxide, various organic compounds and oxides of nitrogen.

#### 3.7.2 Previous Coverage under the National Pollutant Inventory

The *Emission Estimation Technique Manual for Mining* and the *Emission Estimation Technique Manual for Railway Yard Operations* provide a number of useful emission estimation techniques as shown in Table 5.

**Table 5 - Location of Emission Estimation Techniques for Vehicles**

Vehicle Movement EETs	Vehicle Exhaust EETs	
<i>EET Manual for Mining</i> (Section)	<i>EET Manual for Railway Yard Operations</i> (Section)	<i>EET Manual for Mining</i> (Section)
<ul style="list-style-type: none"> <li>• Bulldozers (4.4.1)</li> <li>• Trucks (4.4.1)</li> <li>• Wheel Generated Dust (A1.1.11)</li> <li>• Scrapers (4.4.1)</li> <li>• Graders (4.4.1)</li> <li>• Loaders (4.4.1)</li> </ul>	<ul style="list-style-type: none"> <li>• Off-highway trucks (5.3)</li> <li>• Uncontrolled line haul diesel locomotives in yard operations (5.3)</li> <li>• On-road vehicle emission factors (5.3)</li> <li>• Off-road vehicle emission factors (5.3)</li> </ul>	<ul style="list-style-type: none"> <li>• Tractors (4.6)</li> <li>• Dozers (4.6)</li> <li>• Scrapers (4.6)</li> <li>• Graders (4.6)</li> <li>• Off-highway trucks (4.6)</li> <li>• Wheeled loaders (4.6)</li> <li>• Track type loaders (4.6)</li> </ul>

#### 3.7.3 Further Information

Each of the vehicle movement EETs presented in the *Emission Estimation Technique Manual for Mining* requires the following input data:

- Surface silt loading (g/m<sup>2</sup>); and
- Surface moisture content (%).

It is recommended that site-specific data be used in the application of these EETs. In the absence of this information, default values for various types of soils are provided in Table 6.

**Table 6 - Default Values for Various Soil Types for Use with Vehicle Movement EETs**

Soil Type	Moisture Content <sup>a</sup> (%)	Industry	Silt Loading <sup>b</sup> (g/m <sup>2</sup> )
Uniform sand, loose	24	Copper smelting	292
Uniform sand, dense	16	Iron and steel production	9.7
Mixed-grain sand, loose	20	Asphalt batching	120
Mixed grain sand, dense	14	Concrete batching	12
Glacial till, very mixed-grained	8.3	Sand and gravel processing	70
Soft glacial clay	31	Municipal solid waste landfills	7.4
Stiff glacial clay	18	Quarry	8.2
Soft slightly organic clay	41		
Soft very organic clay	52		
Soft Bentonite	66		

<sup>a</sup> Terzaghi et al., 1967.

<sup>b</sup> USEPA, 1997.

### 3.8 Liquid Spills

#### 3.8.1 Description

When volatile liquids are spilled, evaporative losses occur. These losses depend on the volatility of the compounds and the effectiveness of the clean up operation.

#### 3.8.2 Previous Coverage under the National Pollutant Inventory

Evaporative losses from spills of organic liquids are covered under the *Emission Estimation Technique Manual for Organic Chemical Processing Industries* (Section 9.2).

The following information is required for the application of the estimation technique provided in the *Emission Estimation Technique Manual for Organic Chemical Processing Industries*:

- 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.

#### 3.8.3 Further Information

Fugitive emissions from liquid spills are suitably covered in other EET Manuals. No other EETs are therefore required.

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## 3.9 Storage Piles

### 3.9.1 Description

Storage piles of bulk solids 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 3.10 of this Manual for further guidance on the estimation of emissions from materials handling and unit operations.

### 3.9.2 Previous Coverage under the National Pollutant Inventory

EETs for emissions from storage piles are presented in the *Emission Estimation Technique Manual for Mining*, for both coal and metalliferous mining operations (Section 4.4). The effectiveness of various dust control techniques is also discussed in the Manual (Section 4.5).

A general equation for wind erosion from active stockpiles is presented in Appendix A1.1.15 of the *Emission Estimation Technique Manual for Mining*. This EET is generally applicable to all activities handling bulk solids and accounts for silt content and weather effects. This EET can also be tailored to operations at a specific facility if information is available on:

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

Guidance on speciation of particulate emissions may be found in Section 5.2 of this Manual

### 3.9.3 Further Information

Fugitive emissions from storage piles are suitably covered in other EET Manuals. No other EETs are therefore required.

## 3.10 Bulk Materials Handling and Unit Operations

### 3.10.1 Description

Any process operations that move or manipulate bulk solids can cause fugitive particulate emissions.

### 3.10.2 Previous Coverage under the National Pollutant Inventory

The *Emission Estimation Technique Manual for Mining* provides emission estimation techniques for bulk materials handling for both from coal and metalliferous mines. The coverage in these Manuals is summarised in Table 7. The effectiveness of various control measures for both coal and metalliferous mines is also discussed in the *Emission Estimation Technique Manual for Mining*.

**Table 7 - Coverage of Bulk Materials Handling in the *Emission Estimation Technique Manual for Mining***

Coal Mines (Section)	Metalliferous Mines (Section)
<ul style="list-style-type: none"> <li>• Draglines (4.4.1)</li> <li>• Excavators (4.4.1)</li> <li>• Shovels (4.4.1)</li> <li>• Front-end loaders (4.4.1)</li> <li>• Bulldozers (4.4.1)</li> <li>• Trucks (4.4.1)</li> <li>• Drilling (4.4.1)</li> <li>• Blasting (4.4.1)</li> <li>• Wheel and bucket operations (4.4.1)</li> <li>• Loading stockpiles (4.4.1)</li> <li>• Unloading from stockpiles (4.4.1)</li> <li>• Loading to trains (4.4.1)</li> <li>• Miscellaneous transfer and conveying (A1.1.14)</li> <li>• Wind erosion (A1.1.15)</li> </ul>	<ul style="list-style-type: none"> <li>• Primary, secondary and tertiary crushing (4.4.2)</li> <li>• Wet grinding/milling (4.4.2)</li> <li>• Dry grinding with/without air conveying or classification (4.4.2)</li> <li>• Drying of all minerals except titanium/zirconium sands (4.4.2)</li> <li>• Handling, transferring and conveying including wheel and bucket reclaimers except bauxite (4.4.2)</li> <li>• Screening (4.4.2)</li> <li>• Bauxite/alumina operations (4.4.2)</li> <li>• Miscellaneous transfer and conveying (A1.1.14)</li> <li>• Wind erosion (A1.1.15)</li> </ul>

The equation for particulate emissions from general transfer and conveying operations provided in the *Emission Estimation Technique Manual for Mining* is generally applicable to all cases of miscellaneous transfer. The equation accounts for mean wind speed and material moisture content and can be tailored to operations at a specific facility.

### 3.10.3 Further Information

Typical silt loadings and moisture contents of various Australian soils are presented in Table 6 (Section 3.7.3) of this Manual. Guidance on speciation of particulate emissions is presented in Section 5.2 of this Manual.

## 3.11 Loading and Unloading of Vehicles

### 3.11.1 Description

Fugitive emissions occur when solids or liquids are either loaded or unloaded into vehicles. Solid emissions consist of particulate matter (PM<sub>10</sub>) which often contain metals. Liquid emissions are usually volatile organic compounds, which may contain NPI-listed substances.

### 3.11.2 Previous Coverage under the National Pollutant Inventory

#### *Liquids*

The loading and unloading of organic liquids is covered in a number of EET Manuals. Fugitive emissions associated with the filling and withdrawal of tanks are covered in the *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage* (Section 3). These EETs may be applied to vehicle storage tanks.

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Losses from the loading of organic liquids are covered in the *Emission Estimation Technique Manual for Railway Yard Operations* (Section 5.4). The EETs presented in the Manual can be applied to tanks or vessels. Specific emission factors are presented for road and rail tankers and marine vessels.

### *Solids*

The *Emission Estimation Technique Manual for Mining* (Section 4.4.1) presents EETs for:

- Trucks dumping overburden and coal;
- Loading and unloading of vehicles from stockpiles; and
- Loading to trains.

A general equation for particulate emissions loading and unloading trucks is also presented in *Emission Estimation Technique Manual for Mining* (Section A1.2.2). This equation is generally applicable to all cases of miscellaneous transfer. It accounts for mean wind speed and material moisture content. This EET can be tailored to operations at a specific facility.

### **3.11.3 Further Information**

Typical silt loadings and moisture contents of various Australian soils are provided in Table 6 (Section 3.7.3) of this Manual. Guidance on the speciation of total volatile organic compound emissions is presented in Section 5.1 of this Manual. Guidance on the speciation of particulate emissions is provided in Section 5.2 of this Manual.

## **3.12 Surface Coating**

### **3.12.1 Description**

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

### **3.12.2 Previous Coverage under National Pollutant Inventory**

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) require 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).

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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 values for the industry are provided.

### 3.12.3 Further Information

Fugitive emissions from equipment cleaning and solvent degreasing are suitably covered in other EET Manuals. No other EETs are therefore required.

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

## 3.13 Equipment Cleaning and Solvent Degreasing

### 3.13.1 Description

Solvent degreasing (or solvent cleaning) is the physical 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 emissions of concern from the perspective of the NPI being volatile organic compounds (VOCs) plus some specific listed Category 1 substances.

### 3.13.2 Previous Coverage under the National Pollutant Inventory

VOC 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 is:

- 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.



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### 3.13.3 Further Information

Fugitive emissions from equipment cleaning and solvent degreasing are suitably covered in other EET Manuals. No other EETs are therefore required.

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

## 3.14 Abrasive Blasting

### 3.14.1 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<sub>10</sub>).

### 3.14.2 Previous 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 is:

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

### 3.14.3 Further Information

Fugitive emissions from abrasive blasting are suitably covered in other EET Manuals. No other EETs are therefore required.

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

## 3.15 Asphalt Paving

### 3.15.1 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.

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### 3.15.2 Previous 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*.

### 3.15.3 Further Information

EETs for fugitive emissions from asphalt paving have not been covered previously and will be presented here. For guidance on the speciation of VOC emissions, please refer to Section 5.1 of this Manual.

#### *Asphalt Paving*

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 naphtha or kerosene); or
  - (b) Asphalt emulsions (ie. nonflammable liquids produced by combining asphalt and water with an emulsifying agent such as soap).

Cutback asphalt generally falls into the category of either rapid cure (RC), medium cure (MC) or slow cure (SC) road oils and is prepared by blending asphalt cement with heavy residual oils, kerosene-type solvents, naphtha 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, 1995b). During paving, VOCs are emitted from the equipment used to apply the asphaltic product and from the road surface. Emissions are believed to be the same regardless of stockpiling, mixing and application times (USEPA, 1995b). 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 (ie. initially high emissions levelling off to zero (USEPA, 1995b)). For the

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purposes of NPI reporting, emissions from cutback asphalts should be assumed as once-off, long-term emissions in the year the asphalt was laid.

For long term emissions, the following default values may be used (USEPA, 1995b):

- 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.

If VOC emissions contain NPI-listed substances that trigger the Category 1 threshold, they need to be speciated for each substance. Guidance on the speciation of total VOC emissions may be found in **Section 5.1** of this Manual.

### Example 1 - Determining VOC Emissions from Cutback Asphalts

Records indicate that 10,000 kg of RC cutback asphalt (containing 40 percent VOC, by mass) was applied in a given area during the year. Calculate the mass of VOC emitted during the year from this application.

If the default values for RC cutback are used, then it can be assumed that 95% of VOCs evaporate.

$$E_{\text{kpy},i} = 10\,000 \frac{\text{kg asphalt}}{\text{year}} * \frac{40 \text{ kg VOC}}{100 \text{ kg asphalt}} * \frac{95 \text{ kg VOC emitted}}{100 \text{ kg VOC}}$$

$$E_{\text{kpy},i} = 3800 \text{ kg/yr}$$

## 3.16 Construction and Demolition

### 3.16.1 Description

The operations commonly found in construction and demolition activities include:

- Land clearing;
- Drilling and blasting;
- Excavation;
- Cut and fill operations (ie. earth moving);
- Materials storage and handling;
- Truck traffic on unpaved surfaces; and
- Demolition.

### 3.16.2 Previous Coverage under NPI

Some aspects of construction and demolition activities have been covered in previous EET Manuals. The *Emission Estimation Technique Manual for Mining* presents a series of EET that can be applied to construction and demolition operations.

Table 8 below provides a list of the construction and demolition activities giving rise to PM<sub>10</sub> emission and emission factors or sources of information on other EETs.

### 3.16.3 Further Information

At present, the only available emission factor for an entire construction site is 2.69 tonnes/ha/month of operation (USEPA, 1995c). This is a very crude factor and is unlikely to provide a reasonable estimate of emissions. It is, therefore, recommended that the emission factors in Table 8 be used as a basis for characterising emissions.

**Table 8 - Emission Factors for Construction Operations**

<b>Construction Phase</b>	<b>Activity</b>	<b>Recommended Emission Factor</b>
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	Not Available
	c. Drilling and blasting of soil	Drilling factor in <i>Emission Estimation Technique Manual for Mining</i> (Section 4.4.1) Blasting factor in <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.9) <sup>a</sup>
	d. General land clearing	Bulldozer on overburden correlation from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.5)
	2. Loading of debris into trucks	Miscellaneous Transfer and Conveying EET from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.14)
	3. Truck transport of debris	Wheel Generated Dust EET from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.11)
4. Truck unloading of debris	Miscellaneous Transfer and Conveying EET from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.14)	

**Table 8 - Emission Factors for Construction Operations cont'**

<b>Construction Phase</b>	<b>Activity</b>	<b>Recommended Emission Factor</b>
Site Preparation	1. Bulldozing	Bulldozer on overburden EET from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.5)
	2. Scraper unloading topsoil	Topsoil removal by scraper EET from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.10)
	3. Scrapers in travel	Wheel Generated Dust EET from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.11)
	4. Scrapers removing topsoil	5.7 kg TSP/vehicle kilometre travelled, emission factor rating E (USEPA, 1995c)
	5. Loading of excavated material into trucks	Miscellaneous Transfer and Conveying EET from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.14)
	6. Truck dumping of fill material, road base, or other materials	Miscellaneous Transfer and Conveying EET from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.14)
	7. Compacting	Bulldozer on overburden correlation from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.5)
	8. Motor Grading	See grader correlation in <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.12)
General Construction	1. Vehicular Traffic	Wheel Generated Dust EET from <i>Emission Estimation Technique Manual for Mining</i> (Section A1.1.11)
	2. Portable Plants	Refer to <i>Emission Estimation Technique Manual for Mining</i> (Section 4.4.2). See also the Miscellaneous Transfer and Conveying EET (Section 6.4.3.1) in the same EET Manual
	a. Crushing	
b. Screening		
	c. Material Transfers	

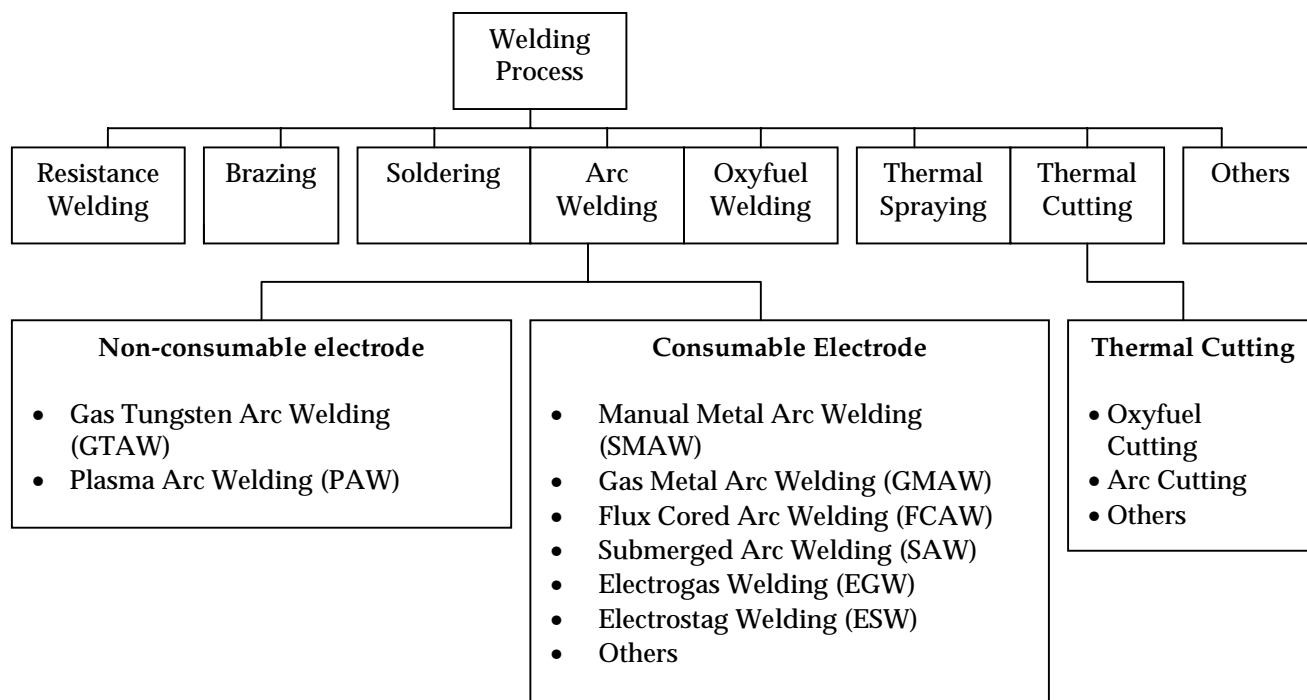
<sup>a</sup>The blasting factor is generally not considered applicable (USEPA, 1995i), but may be used in the absence of other information.

### 3.17 Welding

#### 3.17.1 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, 1995g).



**Figure 1 - Relationships between Different 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.

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### *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.

## **3.17.2 Previous Coverage under the National Pollutant Inventory**

Fugitive emissions from welding have not been previously covered under the NPI.

## **3.17.3 Further Information**

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, 1995g). 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<sub>10</sub> (USEPA, 1995g).

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, 1995g).

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 (NO<sub>x</sub>) (USEPA, 1995g).

Table 9 presents PM<sub>10</sub> emission factors from the four major arc welding processes, for commonly used electrode types. Table 10 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 1**

$$E_i \text{ (g/yr)} = \text{Mass of Electrode Consumed (kg/yr)} * EF_i \text{ (g/kg)}$$

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 11 provides default PM<sub>10</sub> collection efficiencies for a range of pollution control equipment.

**Table 9 - PM<sub>10</sub> 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, 1995g.

**Table 10 - NPI-listed Substances Emitted from Welding Operations**

Welding Process	Electrode Type	Emission Factor (10 <sup>-1</sup> g/kg of electrode consumed)						Emission Factor Rating
		Cr (III) <sup>a,b</sup>	Cr(VI) <sup>b</sup>	Co <sup>c</sup>	Mn <sup>c</sup>	Ni <sup>b</sup>	Pb <sup>b</sup>	
Manual Metal Arc Welding	14Mn-4Cr	13.9	ND <sup>e</sup>	ND <sup>e</sup>	232	17.1	ND <sup>e</sup>	C
	E11018	ND	ND <sup>e</sup>	ND <sup>e</sup>	13.8	ND	ND <sup>e</sup>	C
	E308	0.34	3.59	0.01	2.52	0.43	ND <sup>e</sup>	D
	E310	6.50	18.8	ND <sup>e</sup>	22.0	1.96	0.24	C
	E316	1.90	3.32	ND <sup>e</sup>	5.44	0.55	ND <sup>e</sup>	D
	E410	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	6.85	0.14	ND <sup>e</sup>	C
	E6010	0.02	0.01	ND <sup>e</sup>	9.91	0.04	ND <sup>e</sup>	B
	E6011	0.05	ND <sup>e</sup>	0.01	9.98	0.05	ND <sup>e</sup>	C
	E6012	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND	ND	ND <sup>e</sup>	ND <sup>e</sup>
	E6013	0.04	ND <sup>e</sup>	<0.01 <sup>d</sup>	9.45	0.02	ND <sup>e</sup>	B
	E7018	0.06	ND <sup>e</sup>	<0.01 <sup>d</sup>	10.3	0.02	ND <sup>e</sup>	C
	E7024	0.01	ND <sup>e</sup>	ND <sup>e</sup>	6.29	ND	ND <sup>e</sup>	C
	E7028	0.13	ND <sup>e</sup>	ND <sup>e</sup>	8.46	ND	1.62	C
	E8018	0.17	ND <sup>e</sup>	ND <sup>e</sup>	0.3	0.51	ND <sup>e</sup>	C
	E9016	ND	ND <sup>e</sup>	ND <sup>e</sup>	ND	ND	ND <sup>e</sup>	ND <sup>e</sup>
	E9018	2.12	ND <sup>e</sup>	ND <sup>e</sup>	7.83	0.13	ND <sup>e</sup>	C
	EcoCr	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND	ND	ND <sup>e</sup>	ND <sup>e</sup>
	ENi-Cl	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	0.39	8.90	ND <sup>e</sup>	C
	EniCrMo	4.20	ND <sup>e</sup>	ND <sup>e</sup>	0.43	2.47	ND <sup>e</sup>	C
	ENi-Cu-2	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	2.12	4.23	ND <sup>e</sup>	C
Gas Metal Arc Welding	E308	5.24	ND <sup>e</sup>	<0.01 <sup>d</sup>	3.46	1.84	ND <sup>e</sup>	C
	E70S	0.01	ND <sup>e</sup>	<0.01 <sup>d</sup>	3.18	0.01	ND <sup>e</sup>	A
	ER1260	0.04	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	D
	ER5154	0.10	ND <sup>e</sup>	ND <sup>e</sup>	0.34	ND <sup>e</sup>	ND <sup>e</sup>	D
	ER316	5.18	0.10	ND <sup>e</sup>	2.45	2.26	ND <sup>e</sup>	D
	ERNiCrMo	3.53	ND <sup>e</sup>	ND <sup>e</sup>	0.70	12.5	ND <sup>e</sup>	B
	ERNiCu	<0.01 <sup>d</sup>	ND <sup>e</sup>	ND <sup>e</sup>	0.22	4.51	ND <sup>e</sup>	C
Flux Cored Arc Welding	E110	0.02	ND <sup>e</sup>	ND <sup>e</sup>	20.2	1.12	ND <sup>e</sup>	D
	E11018	9.69	ND <sup>e</sup>	ND <sup>e</sup>	7.04	1.02	ND <sup>e</sup>	C
	E308	ND	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>
	E316	8.30	1.40	ND <sup>e</sup>	5.90	0.93	ND <sup>e</sup>	B
	E70T	0.04	ND <sup>e</sup>	ND <sup>e</sup>	8.91	0.05	ND <sup>e</sup>	B
	E71T	0.02	ND <sup>e</sup>	<0.01 <sup>d</sup>	6.62	0.04	ND <sup>e</sup>	B
Submerged Arc Welding	EM12K	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>	ND <sup>e</sup>

Source: USEPA, 1995g.

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

<sup>b</sup> Listed as both a Category 1 and Category 2b Substance.

<sup>c</sup> Listed as a Category 1 substance.

<sup>d</sup> These values are below the lower limit of the measurement technique. In the absence of other data, use 0.01 \* 10<sup>-1</sup> g/kg as a conservative estimate.

<sup>e</sup> ND = No Data.

**Table 11 - Default PM<sub>10</sub> 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	94
• Other	97
Electrostatic precipitator - low-efficiency	
• Boilers	90
• Other	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 1995j.

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### 3.18 Open Area Wind Erosion

#### 3.18.1 Description

Particulate matter (PM<sub>10</sub>) 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.

#### 3.18.2 Previous Coverage under the National Pollutant Inventory

Emissions from storage piles have been covered previously (see Section 3.9 in this Manual). A general methodology for the estimation of fugitive emissions from open surfaces is presented in Section 3.19.3 below.

#### 3.18.3 Further Information

A general emission factor for wind erosion from exposed area is (USEPA, 1995i):

$$EF = 0.85 \frac{\text{tonnes}}{\text{ha.yr}}$$

where:

EF = Emissions of total suspended particulates (t/ha/yr)

This is a very crude factor and is not likely to provide an extremely accurate estimate of emissions. However, there are, at present, no other simple EETs, which can be used as a basis for characterising emission from exposed areas.

Table 12 provides reduction factors for a variety of control measures. These estimations are based on the approximate level of control that each method produces, and the values given are very conservative (ie. it is assumed that the desired level of control is low). Therefore, 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 12 - Percentage Reduction to Emission Factors with Control Systems**

Control Method	Factor Reduction (%)
Watering - periodic spraying	35
Watering - wind activated spraying system	65
Chemical wetting agents or foam	70
Continuous chemical spray onto input material	70
Surface crusting agents	80

Source: USEPA, 1995h.

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## 4.0 Alternative Estimation Methodology

The *National Environment Protection Measure (NEPM) for the National Pollutant Inventory* does not envisage that additional sampling will be required for facilities to meet the 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 general 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 have been taken from *A Review of Methods for Measuring Fugitive PM<sub>10</sub> Emission Rates* (USEPA, 1993) and require:

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, these methods may be useful. A summary of the methods presented in this Manual is presented in Table 13.

**Table 13 - Alternative Estimation Methods for Area and Volume Sources**

Method	Applicability	Sampling Required	Additional Modelling Required
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
Upwind-Downwind	Area Sources	Upwind and downwind	Yes <sup>a</sup>

<sup>a</sup> Dispersion modelling back calculation is required to obtain source emission rates.

### 4.1 Quasi-Stack Method

This method has been taken from *A Review of Methods for Measuring Fugitive PM<sub>10</sub> 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 14.

**Table 14 - Recommended Criteria for use of Quasi-Stack Method**

Criteria
1. Reynolds Number $\approx 200\ 000$ (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, 1999b) may be used as protocols for standard stack sampling trains. Methods of sampling may be obtained from USEPA Method 1 (EMTIC, 1999c), 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.

## 4.2 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 2

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

where:

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

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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. See USEPA Method 201 (EMTIC, 1999a) and USEPA Method 201A (EMTIC, 1999b) for 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.

### 4.3 Upwind-Downwind Method

This method has been taken from *A Review of Methods for Measuring Fugitive PM<sub>10</sub> 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 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.

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## 5.0 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 limited speciation data in the form of weight fractions developed by USEPA.

The first methodology is likely to give more accurate estimates than the use of generic weight fractions developed by the USEPA. 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/vapourous material, or liquid mixtures containing constituents of similar volatilities (USEPA, 1995a). The USEPA (1995a) 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 3

$$E_i = E_{\text{voc}} * (WP_i / WP_{\text{voc}})$$

where:

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

### 5.1.2 Speciation Using Developed Weight Fraction Data

A limited amount of published data exists on the speciation of VOC emissions for individual processes by equipment type (USEPA, 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 15 provides a list of industries for which speciation profiles exist. If your facility has its own speciation profiles, they may be used, but only with the permission of the relevant environmental authority.

For access to USEPA speciation information please refer to *Air Emissions Species Manual - Volume I Volatile Organic Compound Species Profiles* (USEPA, 1990). It should be noted that the speciation profiles from the USEPA may not accurately represent Australian conditions. However, this is the best information currently available.

**Table 15 - Available Volatile Organic Compounds Species Profiles**

Chemical Industry for which Profiles are Available	
Organic Chemical Storage	Food and Agriculture
Railcar, Tank Truck and Drum Cleaning	Primary and Secondary Metal Production
Surface Coating Operations	Petroleum Products
Asphalt Products	Plywood Products
Mobile Sources - Gasoline Fuelled Vehicles	Synthetic Rubber Production
Organic Solvent Evaporation	Oil and Gas Production
External and Internal Combustion Engines	Textile Products
Carbon Black Production	Storage, Transportation and Marketing of Petroleum Products
Paint and Varnish Manufacture	Printing and Publishing Processes
Plastics Production	Solid Waste Disposal
Printing Ink Manufacture	Wood Combustion
Synthetic Organic Fibre Production	Aircraft
Organic Chemical Manufacture	Forest Fires

Source: USEPA, 1990.

Speciation profiles only exist for certain pieces of equipment. This methodology can, therefore, only be used for the equipment types identified (USEPA, 1990).

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

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#### Equation 4

$$E_i = E_{\text{voc}} * (WP_i/100)$$

where:

$E_i$	=	The mass emission rate of pollutant i from the equipment	(kg/s)
$E_{\text{voc}}$	=	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. A list of naturally occurring concentrations of elements reportable under the NPI in various materials may be found in Table B2 (Section B1) of the *Emission Estimation Technique Manual for Mining*.

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 5

$$E_i = \text{TSP} * (WP_i/100)$$

where:

$E_i$	=	The mass emission rate of pollutant i from the relevant source	(hg/hr)
TSP	=	The total suspended particulates mass emission rate from the relevant source	
$WP_i$	=	The concentration of pollutant i in the total emission	(Wt%)

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## 6.0 Glossary of Technical Terms and Abbreviations

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
MC	Medium Cure. Refers to cutback asphalt.
Mn	Manganese
NEPM	National Environment Protection Measure
Ni	Nickel
NO <sub>x</sub>	Oxides of Nitrogen
NPI	National Pollutant Inventory
Pb	Lead
PM <sub>10</sub>	Particles which have an equivalent aerodynamic diameter of 10 micrometers or less (ie. ≤10µm).
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 Particulates
USEPA	United States Environmental Protection Authority
VOC	Volatile Organic Compound

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## 7.0 References

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

- *Emission Estimation Technique Manual for Fossil Fuel and Electric Power Generation;*
- *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage;*
- *Emission Estimation Technique Manual for Hot Mix Asphalt Manufacturing;*
- *Emission Estimation Technique Manual for Inorganic Chemicals Manufacturing;*
- *Emission Estimation Technique Manual for Mining;*
- *Emission Estimation Technique Manual for Motor Vehicle Manufacturing;*
- *Emission Estimation Technique Manual for Oil and Gas Exploration and Production;*
- *Emission Estimation Technique Manual for Organic Chemical Processing Industries;*
- *Emission Estimation Technique Manual for Petroleum Refining;*
- *Emission Estimation Technique Manual for Railway Yard Operations; and*
- *Emission Estimation Technique Manual for Surface Coating.*

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The following software has been referenced in this Manual:

#### TANKS 4.0

The current TANKS software may be downloaded from the USEPA at the Website:  
<http://www.epa.gov/ttn/chief/tanks.html>

#### WATER8

Water 8 software may be downloaded from the USEPA at the Website:  
<http://www.epa.gov/ttn/chief/software.html#water8>

#### AUSPLUME

Information on AUSPLUME may be obtained through the Victorian Environment Protection Authority at the Website:  
<http://www.epa.vic.gov.au/aq/info/pub391.htm>

Copies of AUSPLUME (for Windows) are available from:

EPA  
27 Francis St  
Melbourne 3000  
Victoria AUSTRALIA

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## Appendix A - Emission Estimation Techniques

The format of this section is common to all NPI Manuals and provides a basic overview to Emission Estimation Techniques (EETs) and their applicability in various situations.

Estimates of emissions of NPI-listed substances to air, water and land should be reported for each substance that triggers a threshold. The reporting list and detailed information on thresholds are contained in the *NPI Guide* at the front of this Handbook.

In general, there are four types of EETs that may be used to estimate emissions from your facility.

The four types described in the *NPI Guide* are:

- Sampling or direct measurement;
- Mass balance;
- Fuel analysis or other engineering calculations; and
- Emission factors.

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

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

This Manual seeks to provide the most effective emission estimation techniques for each of the identified sources of fugitive emissions. However, the absence of an EET does not necessarily imply that an emission should not be reported to the NPI. The obligation to report on all relevant emissions remains if reporting thresholds have been exceeded.

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

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

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See Appendix C for a list of variables and symbols.

### A.1 Using Mass Balance

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

Mass balance calculations for estimating emissions to air of NPI-listed substances can be represented conceptually by Equation 6.

#### Equation 6

$$\text{Fugitive emissions}_i = \text{Amount in}_i - \text{Amount out}_i - E_{\text{kpy},i}$$

where:

$E_{\text{kpy},i}$	= Emissions of pollutant i	(kg/yr)
Amount in <sub>i</sub>	= Amount of pollutant i entering the process	(kg/yr)
Amount out <sub>i</sub>	= Amount of pollutant i leaving the process as as waste stream, article or product	(kg/yr)
Fugitive emissions <sub>i</sub>	= Fugitive emissions of pollutant i	(kg/yr)

The term “Amount out<sub>i</sub>” may actually involve several different fates for an individual pollutant. This could include the amount recovered or recycled, the amount leaving the process in the manufactured product, the amount leaving the process in wastewater, the amount emitted to the atmosphere, or the amount of material transferred off-site as hazardous waste or to landfill. A thorough knowledge of the different fates for the pollutant of interest is necessary for an accurate emission estimate to be made using the mass balance approach.

The amount of a particular substance entering or leaving a facility is often mixed within a solution as a formulation component or as a trace element within the raw material. To determine the total weight of the substance entering or leaving the process, the concentration of the substance within the material is required. Using this concentration data, Equation 7 can be applied as a practical extension of Equation 6.



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## Equation 7

$$\text{Fugitive Emissions}_i = (Q_{in} * C_{in}) - (Q_{pr} * C_{pr}) - (Q_{rec} * C_{rec}) - E_{kpy,i}$$

where:

$E_{kpy,i}$	= Emissions of pollutant i	(kg/yr)
$Q_{in}, Q_{pr}, Q_{rec}$	= Quantity of raw material, product. Recycled material or waste respectively, processed annually (generally expressed in kg/yr for solids, L/yr for liquids)	
$C_{in}, C_{pr}, C_{rec}$	= Concentration of pollutant i in the raw material, product, recycled material or waste respectively, processed annually	(kg/kg or kg/L)

## A.2 Engineering Calculations

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

### A.2.1 Fuel Analysis

Fuel analysis is an example of an engineering calculation and can be used to predict SO<sub>2</sub>, metals, and other emissions based on application of conservation laws, if fuel rate is measured. The presence of certain elements in fuels may be used to predict their presence in emission streams. This includes elements such as sulfur that may be converted into other compounds during the combustion process.

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

## Equation 8

$$E_{kpy,i} = Q_f * C_i / 100 * (MW_p / EW_f) * OpHrs$$

where:

$E_{kpy,i}$	= Annual emissions of pollutant i	(kg/yr)
$Q_f$	= Fuel use	(kg/hr)
$OpHrs$	= Operating hours	(hr/yr)
$MW_p$	= Molecular weight of pollutant emitted	(kg/kg-mole)
$EW_f$	= Elemental weight of pollutant in fuel	(kg/kg-mole)
$C_i$	= Concentration of pollutant i in fuel	(Wt%)

For instance, SO<sub>2</sub> emissions from fuel oil combustion can be calculated based on the concentration of sulfur in the fuel oil. This approach assumes complete conversion of sulfur to SO<sub>2</sub>. Therefore, for every kilogram of sulfur (EW = 32) burned, two kilograms of SO<sub>2</sub> (MW = 64) are emitted. The application of this EET is shown in Example 2.

### Example 2 - Using Fuel Analysis Data

This example shows how SO<sub>2</sub> emissions can be calculated from fuel combustion based on fuel analysis results, and the known fuel flow of the engine. E<sub>kpy,SO<sub>2</sub></sub> may be calculated using Equation 8 and given the following:

Fuel flow (Q<sub>f</sub>) = 20 900 kg/hr  
Weight percent sulfur in fuel = 1.17 %  
Operating hours = 1500 hr/yr

$$\begin{aligned} E_{\text{kpy,SO}_2} &= Q_f * C_i / 100 * (MW_p / EW_f) * \text{OpHrs} \\ &= (20\,900) * (1.17 / 100) * (64 / 32) * 1500 \\ &= 733\,590 \text{ kg/yr} \end{aligned}$$

### A.3 Emission Factors

In the absence of other information, default emission factors can be used to provide an estimate of emissions. Emission factors are generally derived through the testing of a general source population (eg. boilers using a particular fuel type). This information is used to relate the quantity of material emitted to some general measure of the scale of activity (eg. for boilers, emission factors are generally based on the quantity of fuel consumed or the heat output of the boiler).

Emission factors require 'activity data', that is combined with the factor to generate the emission estimates. The generic formula is:

#### Equation 9

$$\text{Emission Factor} \left( \frac{\text{mass}}{\text{unit of activity}} \right) * \text{Activity Data} \left( \frac{\text{unit of activity}}{\text{time}} \right) = \text{Emission Rate} \left( \frac{\text{mass}}{\text{time}} \right)$$

For example, if the emission factor has units of '*kg pollutant/m<sup>3</sup> of fuel combusted*', then the activity data required would be in terms of '*m<sup>3</sup> fuel burned/hr*', thereby generating an emission estimate of '*kg pollutant/hr*'.

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

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

#### Equation 10

$$E_{kpy,i} = [A_R * OpHrs] * EF_i * [1 - (CE_i/100)]$$

where:

$E_{kpy,i}$	= Emission rate of pollutant i	(kg/yr)
$A_R$	= Activity rate	(t/hr)
OpHrs	= Operating hours	(hr/yr)
$EF_i$	= Uncontrolled emission factor of pollutant i	(kg/t)
$CE_i$	= Overall control efficiency of pollutant i	(%)

Emission factors developed from measurements for a specific process may sometimes be used to estimate emissions at other sites. Should a company have several processes of similar operation and size, and emissions are measured from one process source, an emission factor can be developed and applied to similar sources in this situation. It is necessary to have the emission factor reviewed and approved by State or Territory environment agencies prior to its use for NPI emissions estimation.

#### A.4 Direct Measurement

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

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## **Appendix B - Emission Estimation Techniques: Acceptable Reliability and Uncertainty**

The format of this section is common to all NPI Manuals and provides a basic overview to Emission Estimation Techniques (EETs) and their reliability and uncertainty in various situations.

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

Several techniques are available for calculating emissions from reporting facilities. The technique chosen is dependent on available data, the available resources and the degree of accuracy sought by the facility in undertaking the estimate. In general, site-specific data that is representative of normal operations is more accurate than industry-averaged data, such as the emission factors presented in Section 3 of this Manual.

### **B.1 Mass Balance**

Calculating emissions from a facility using mass balance appears to be a straightforward approach to emission estimation. However, it needs to be accurately tracked to enable mass balance to be rigorously applied. Inaccuracies associated with individual material tracking, or other activities inherent in each material handling stage, can result in large deviations for total facility emissions. Because emissions from specific materials are typically below 2 percent of gross consumption, an error of only  $\pm 5$  percent in any one step of the operation can significantly skew emissions estimates.

### **B.2 Engineering Calculations**

Theoretical and complex equations, or models, can be used for estimating emissions from industrial processes. The use of emission equations to estimate emissions is a more complex and time-consuming process than the use of emission factors. Emission equations require more detailed inputs than the use of emission factors but they do provide an emission estimate that is based on facility-specific conditions and are hence likely to provide a more accurate estimate of emissions.

### **B.3 Emission Factors**

Some published emission factors (in particular, many of those published by the USEPA) have an associated emission factor rating (EFR) code. This rating system is common to EETs for all industries and sectors and therefore, to all Industry Handbooks. They are based on rating systems developed by the United States Environmental Protection Agency (USEPA), and by the European Environment Agency (EEA). Consequently, the ratings may not be directly relevant to Australian industry. Sources for all emission factors cited

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can be found in the reference section of this document. The emission factor ratings will not form part of the public NPI database.

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

The EFR system is as follows:

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

#### **B.4 Direct Measurement**

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

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

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

## Appendix C - List of Variables and Symbols

Variable	Symbol	Units
Annual emissions of pollutant i	$E_{kpyi}$	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 <sup>3</sup>
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 <sup>2</sup>
Number of disturbances per year	N	yr <sup>-1</sup>
Erosion potential corresponding to the observed (or probable) fastest mile of wind for the ith period between disturbances	$P_i$	g/m <sup>2</sup>
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 <sup>2</sup>
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%)