National Pollutant Inventory

Emission Estimation Technique Manual

for

Structural & Fabricated Metal Product Manufacture

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EMISSION ESTIMATION TECHNIQUES
FOR
STRUCTURAL AND FABRICATED
METAL PRODUCT MANUFACTURE

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LIST OF TABLES AND EXAMPLES

1.0   Introduction

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

EET MANUAL:	Structural & Fabricated Metal Product Manufacture
HANDBOOK:	Structural & Fabricated Metal Product Manufacture
ANZSIC CODES:	274 series (2741, 2742, 2749)
	275 series (2751, 2759)
	276 series (2761, 2762, 2763, 2765, 2769)

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

Industry Sectors covered by this Manual

This Manual applies to facilities involved in the following activities:

* Structural steel fabrication;
* Architectural aluminium product manufacture;
* Structural metal product manufacture (eg window frames, doors, gates, etc);
* Metal container manufacture;
* Sheet metal product manufacture (eg spun metal hollow ware, air ducts, guttering or bottle closures);
* Hand tool and general hardware manufacture (excluding wooden, pneumatic, or power operated);
* Spring and wire product manufacture;
* Nut, bolt, rivet and screw manufacture;
* Non-ferrous pipe fitting manufacture; and
* Fabricated metal product manufacture (eg safes, firearms, gas or water meters, hinges, locks, door handles).

This Manual does not apply to the activities covered by ANZSIC Code 2764 (Metal Coating and Finishing). These activities are covered by the Industry Handbook for *Metal Coating and Finishing,* which comprises the following Emission Estimation Technique Manuals:

* Surface Coating;
* Galvanising; and
* Electroplating & Anodising.

1.1 Manual Structure

This Manual is structured as follows:

- **Section 2** discusses the NPI reporting requirements, which apply to the structural and fabricated metal product manufacturing industry. Category 1, 2 and 3 substances are discussed in **Sections 2.1, 2.2** and **2.3** respectively.
- **Section 3** outlines the activities/processes that are covered by this Manual. **Sections 3.1, 3.2** and **3.3** detail the expected emissions to air, water and land respectively from the structural and fabricated metal product manufacturing process. These sections also detail the sources of these emissions and where emission estimation techniques for each of these sources are to be found.
- **Section 4** provides a glossary of technical terms and abbreviations used in this Manual.
- **Section 5** 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 structural and fabricated metal product manufacturing industry.
- **Appendix B** provides a discussion of the reliability and uncertainty associated with each of the techniques presented in **Appendix A.**
- **Appendix C** provides a list of variables and symbols used throughout this Manual.

1.2 Manual Application

Context and use of this Manual

To effectively utilise this Manual for the purposes of NPI reporting, you should, first of all, determine whether reporting under the NPI is required for your facility and identify those substance(s) for which reporting is required (see the *NPI Guide* and **Section 2** of this Manual). If reporting is required, you should:

1. Identify all of the process units at your facility. A process flow diagram could provide a useful starting point for this activity. In addition, you will need to identify other potential sources of emissions (eg. combustion, wastewater treatment systems).
2. Recognising that the order in which each of the unit processes are presented in this Manual may not be the same as your facility, identify the relevant section(s) of Table 3 in this Manual, which correspond to each unit process.
3. Select the estimation techniques that best suit your facility's current methods of measuring or estimating emissions or flows.
4. Apply the emission estimation technique that is most appropriate to your activities/operations.

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 generated in this process will have varying degrees of accuracy with respect to the actual emissions from

structural and fabricated metal product manufacturing facilities. In some cases, there will, necessarily, be a large potential error due to inherent assumptions in the various emissions estimation techniques (EETs).

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 to be gained by applying an EET, which required significant additional sampling.

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

Category 1 and 1a Substances:

Identify which reportable NPI substances are used (or handled by way of their incidental presence in ore or materials, or exceeds the bulk storage capacity for Category 1a substances) and determine whether the amounts used or handled are above the 'threshold' values and therefore trigger reporting requirements. See **Section 2.1** of this Manual for guidance on which Category 1 substances are likely to require reporting for the structural and fabricated metal product manufacturing industry.

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. See **Section 2.2** of this Manual for a discussion regarding which Category 2 substances are likely to be triggered for the structural and fabricated metal product manufacturing industry.

Category 3 Substances:

Determine the annual emissions to water and assess whether the threshold limits are exceeded. It is unlikely that this NPI Category will require reporting for the structural and fabricated metal product manufacture industry.

For those substances above the threshold values:

Examine the available range of EETs and determine emission estimates using the most appropriate EET.

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

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

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

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.

2.0 NPI Reporting Requirements

2.1 Category 1 Threshold

The reporting threshold for Category 1 substances is exceeded if the activities of a facility involve the use of 10 tonnes or more of the substance in a year. Therefore, the total amount of a Category 1 substance used must be estimated in order to determine whether the threshold is exceeded. If the threshold is exceeded, then emissions of these substances must be reported for all operations/processes relating to the facility, even if actual emissions are very low or zero.

There is a wide range of cutting oils, quenching materials, degreasing and cleaning solvents, acids, alkalis and heavy metals used within the structural and fabricated metal product manufacturing industry and as a consequence, it is possible that reporting could be triggered for any of the NPI Category 1 substances. The total amount of each Category 1 substance 'used' must be estimated in order to determine whether the threshold is exceeded. For all NPI substances, consideration of whether or not reporting is triggered depends upon the concentration of each substance in the feedstock materials.

Example 1 provides an example of the type of calculation that could be performed to determine if a Category 1 substance triggers the NPI reporting threshold.

Example 1 - Category 1 Substance Reporting Threshold

A structural and fabricated metal product manufacture facility consumes 100 000 litres of solvent per annum. The solvent contains 96% methyl ethyl ketone (MEK). Is the Category 1 NPI reporting threshold exceeded for MEK?

Total amount of solvent used	=	$1 * 10^5$ L/yr
Concentration of MEK	=	96%
Volume of MEK consumed	=	$0.96 * 1 * 10^5$ L/yr
	=	96 000 L/yr
Density of MEK	=	0.805 kg/L
Mass of MEK consumed	=	Density * Volume consumed
	=	0.805 kg/L * 96 000 L/yr
	=	77 280 kg/yr
	=	77.3 tonnes/yr

So, in this case, the Category 1 threshold for MEK of 10 tonnes per annum has been exceeded and the facility is required to report on all emissions of MEK to the environment.

2.2 Category 2 Threshold

The Category 2 threshold is based on energy consumption or fuel use. The Category 2a threshold for fuel usage is triggered if:

- A facility burns 400 tonnes or more of fuel or waste per year; or
- A facility burns 1 tonne or more of fuel or waste per hour.

The Category 2b threshold is triggered if:

- A facility burns 2000 tonnes or more of fuel or waste per year; or
- A facility uses 60 000 megawatt hours (MWh) or more of energy in a year; or
- A facility's maximum potential power consumption is rated at 20 megawatts (MW) or more at any time during the year.

Based on these thresholds, the amount of fuel usage required to trigger these thresholds may be calculated (as shown in Table 1). It should be noted that Category 2 threshold calculations should be performed for total fuel usage. If a number of different fuels are used at one facility, the sum of each individual fuel use needs to be calculated to determine whether or not the Category 2 threshold is triggered.

The fuel consumption required to trigger the Category 2 thresholds is presented in Table 1.

Table 1 - Approximate Fuel Usage Required to Trigger Category 2 Thresholds

Fuel Type	Category 2a	Category 2b
Natural Gas[a]	$2.06 * 10^7$ MJ per reporting year, or at least $5.14 * 10^4$ MJ in any one hour in the reporting year	$1.03 * 10^8$ MJ per reporting year
Simulated Natural Gas (SNG)[b]	$1.25 * 10^7$ MJ per reporting year, or at least $3.13 * 10^4$ MJ in any one hour in the reporting year	$6.24 * 10^7$ MJ per reporting year
Liquefied Petroleum Gas (LPG)[c]	$7.87 * 10^5$ L per reporting year, or at least $1.97 * 10^3$ L in any one hour in the reporting year	$3.94 * 10^6$ L per reporting year
Liquefied Natural Gas (LNG)[d]	$9.47 * 10^5$ L per reporting year, or at least $2.37 * 10^3$ L in any one hour in the reporting year	$4.73 * 10^6$ L per reporting year
Diesel[e]	$4.44 * 10^5$ L per reporting year, or at least $1.11 * 10^3$ L in any one hour in the reporting year	$2.22 * 10^6$ L per reporting year
Propane[f]	$2.02 * 10^7$ MJ per reporting year, or at least $5.04 * 10^4$ MJ in any one hour in the reporting year	$1.01 * 10^8$ MJ per reporting year
Butane[g]	$1.98 * 10^7$ MJ per reporting year, or at least $4.96 * 10^4$ MJ in any one hour in the reporting year	$9.92 * 10^7$ MJ per reporting year

[a] Assuming natural gas with a gross heating value of 51.4 MJ/kg. Natural gas (NSW) data from the *Natural Gas Technical Data Handbook* (AGL Gas Company (NSW) Limited, 1995).

[b] Assuming natural gas with a gross heating value of 31.27 MJ/kg. Natural gas (NSW) data from the *Natural Gas Technical Data Handbook* (AGL Gas Company (NSW) Limited, 1995).

[c] Assuming ideal gas with a density of 508 kg/m^3 at 15°C under pressure from the *Natural Gas Technical Data Handbook* (AGL Gas Company (NSW) Limited, 1995)

[d] Assuming 100% methane ideal gas with a density of 422.4 kg/m^3 at 15°C at its boiling point from the *Natural Gas Technical Data Handbook* (AGL Gas Company (NSW) Limited, 1995)

[e] Assuming a density of 900 kg/m^3 at 15°C for fuel oil for commercial use (Perry, et al., 1997)

[f] Assuming a gross heating value of 50.4 MJ/kg at 25°C and 101.325 kPa (Lide, 1994).

[g] Assuming a gross heating value of 49.6 MJ/kg at 25°C and 101.325 kPa (Lide, 1994).

If a facility triggers the Category 2a threshold, all Category 2a pollutants need to be reported. If a facility triggers the Category 2b threshold, all Category 2a and Category 2b pollutants need to be reported. Category 2 substances are listed in Table 2.

Table 2 - NPI-listed Category 2 Substances

Category 2a Substances	Category 2b Substances
Carbon Monoxide	Arsenic & compounds
Fluoride Compounds	Beryllium & compounds
Hydrochloric Acid	Cadmium & compounds
Oxides of Nitrogen	Chromium (III) compounds
Particulate Matter (PM_{10})	Chromium (VI) compounds
Polycyclic Aromatic Hydrocarbons	Copper & compounds
Sulfur Dioxide	Lead & compounds
Total Volatile Organic Compounds	Magnesium Oxide Fume
	Manganese & compounds
	Mercury & compounds
	Nickel & compounds
	Nickel Carbonyl
	Nickel Subsulfide
	Polychlorinated Dioxins & Furans
	PLUS all Category 2a substances

2.3   Category 3 Threshold

Under Clause 13 of the *NPI NEPM,* the reporting threshold for a Category 3 substance is exceeded in a reporting period if the activities of the facility involve the emission to water (excluding groundwater) of:

- 15 tonnes or more per year of Total Nitrogen; or
- 3 tonnes per year or more of Total Phosphorus.

For structural and fabricated metal product manufacturing facilities, it is extremely unlikely there will be licensed discharges to surface or ground waters. Stormwater run-off may trigger NPI reporting requirements, although it is unlikely that this run-off would contain levels of nitrogen or phosphorus that would lead to the triggering of the Category 3 threshold. If, however, your facility has a significant, or potentially significant, release of aqueous nitrogen or phosphorus, you will need to go through the process of determining whether or not Category 3 reporting requirements are triggered for your facility.

3.0   Process Description

This Manual covers the structural and fabricated metal product manufacturing industry as defined under ANZSIC Codes 274 - Structural Metal Product Manufacturing, 275 - Sheet Metal Product Manufacturing and 276 - Fabricated Metal Product Manufacture.

For the purposes of estimating emissions for NPI reporting, facilities in this industry can be considered as consisting of a series of unit processes as follows:

- Melting and die casting;
- Cutting;
- Shearing;
- Forming;
- Welding and soldering;
- Heat treatment;
- Forging;
- Dressing/grinding;
- Machining;
- Non-destructive testing;
- Surface preparation and surface coating;
- Combustion processes; and
- Wastewater treatment.

3.1   Emissions to Air

Table 3 describes the various sources of air emissions associated with the structural and fabricated metal product manufacturing industry. For each of these sources, guidance is provided on appropriate emission estimation techniques that may be adopted.

It is important to recognise that the vast majority of the activities in this industry will occur indoors (or in an enclosed area). As a consequence, it may be easier to consider all of these sources as fugitive emission sources. In this situation, the focus of emissions estimation is not on the individual points of release of substances (ie source by source assessment) but on the total quantity of pollutants released. These releases may be either fugitive releases from a building or releases through a stack or other exhaust point. The *Emission Estimation Technique Manual for Fugitive Emissions* provides guidance on the characterisation of such emissions.

Table 3 - Sources of Air Emissions from Structural Fabricated Metal Product Manufacturing Processes

Activity	Potential NPI Emissions	Sources of Information on Emission Estimation Techniques
Melting and Die Casting	Antimony & compounds Beryllium & compounds Boron & compounds Cadmium & compounds Carbon monoxide Chromium (III) compounds Chromium (VI) compounds Cobalt & compounds Copper & compounds Fluoride compounds Hydrochloric acid Lead & compounds Magnesium oxide fume Manganese & compounds Mercury & compounds Nickel & compounds Nickel carbonyl Nickel subsulfide Oxides of nitrogen PM_{10} Polychlorinated dioxins & furans Polycyclic aromatic hydrocarbons Selenium & compounds Sulfur dioxide Total VOCs Zinc & compounds	Some facilities are likely to perform stack sampling (eg. for licensing purposes) to characterise emissions. If such data are available, they may be used as a basis for emissions estimations. The *Emission Estimation Technique Manual for Ferrous Foundries* and the *Emission Estimation Technique Manual for Non-Ferrous Foundries* provide guidance on estimating emissions from furnaces and casting operations. Emissions from furnace operations are highly site-specific and depend on the specific materials that are being handled and the reactions that occur in the furnace. The best option for the application of analysing furnace emissions is to use site-specific data (which most facilities will already gather to meet regulatory requirements). The application of these estimation techniques is outlined in **Appendix A**.

Table 3 - Sources of Air Emissions from Structural Fabricated Metal Product Manufacturing Processes cont'

Activity	Potential NPI Emissions	Sources of Information on Emission Estimation Techniques

Cutting
    Thermal
    Abrasive
    Laser
    Plasma
	Antimony & compounds
	Beryllium & compounds
	Boron & compounds
	Cadmium & compounds
	Carbon monoxide
	Chromium (III) compounds
	Chromium (VI) compounds
	Cobalt & compounds
	Copper & compounds
	Lead & compounds
	Magnesium oxide fume
	Manganese & compounds
	Mercury & compounds
	Nickel & compounds
	Oxides of nitrogen
	PM_{10}
	Selenium & compounds
	Sulfur dioxide
	Zinc & compounds
		There is limited information available on emission estimation techniques for the various cutting operations listed here. **Section 3.1.1** of this Manual presents the available emission factors, which may be used to estimate emissions of metal fume and oxides of nitrogen from the plasma cutting of steel.

Shearing	PM_{10}	Small quantities of PM_{10} may be released from this process. There are, currently, no emission factors for shearing operations.
Forming	PM_{10}	Small quantities of PM_{10} may be released from this process. There are currently no emission factors for forming operations.

Table 3 - Sources of Air Emissions from Structural Fabricated Metal Product Manufacturing Processes cont'

Activity	Potential NPI Emissions	Sources of Information on Emission Estimation Techniques
Welding and Soldering	Antimony & compounds Beryllium & compounds Boron & compounds Cadmium & compounds Carbon monoxide Chromium (III) compounds Chromium (VI) compounds Cobalt & compounds Copper & compounds Lead & compounds Magnesium oxide fume Manganese & compounds Mercury & compounds Nickel & compounds Oxides of nitrogen PM_{10} Selenium & compounds Sulfur dioxide Zinc & compounds	Please refer to the *Emission Estimation Technique Manual for Fugitive Emissions* (Section 3.18) for guidance on estimating emissions from welding operations. This Section also provides a starting point for estimating emissions from soldering.
Heat Treatment	Carbon monoxide Fluoride Compounds Hydrochloric Acid Oxides of nitrogen PM_{10} Polycyclic Aromatic Hydrocarbons Sulfur dioxide VOCs	Emissions from furnace operations are highly site-specific and depend on the specific materials that are being handled and the reactions that occur in the furnace. The best option for analysing furnace emissions is to use site-specific monitoring data (which most facilities will already gather to meet regulatory requirements). Guidance on the use of these estimation techniques is outlined in **Appendix A**. Quenching emissions are caused by the volatisation of quenchant material. In the absence of other information, these emissions could be estimated using a mass balance, where it can be assumed that all quenchant lost from the quenchant tanks is volatised (ie. lost to the atmosphere). It can then be assumed that the quantity of quenchant required for topping up is equal to the material lost to atmosphere.

Table 3 - Sources of Air Emissions from Structural Fabricated Metal Product Manufacturing Processes cont'

Activity	Potential NPI Emissions	Sources of Information on Emission Estimation Techniques
Forging	Antimony & compounds Beryllium & compounds Boron & compounds Cadmium & compounds Carbon monoxide Chromium (III) compounds Chromium (VI) compounds Cobalt & compounds Copper & compounds Lead & compounds Magnesium oxide fume Manganese & compounds Mercury & compounds Nickel & compounds Oxides of nitrogen PM_{10} Selenium & compounds Sulfur dioxide Zinc & compounds	Emissions from furnace operations are highly site-specific and dependent on the materials that are being handled and the reactions that occur in the furnace. The best option for analysing furnace emissions is to use site-specific monitoring data (which most facilities will already gather to meet regulatory requirements). Guidance on the use of these estimation techniques is provided in **Appendix A.**
Dressing/Grinding	PM_{10}	Small quantities of metallic PM_{10} may be released from dressing processes and there could also be some PM_{10} released due to the loss of friction material from grinding apparatus. There are no emission factors presently available for these operations.

Table 3 - Sources of Air Emissions from Structural Fabricated Metal Product Manufacturing Processes cont'

Activity	Potential NPI Emissions	Sources of Information on Emission Estimation Techniques
Machining	Acetone Dichloromethane PM_{10} Tetrachloroethylene Toluene Trichloroethane Trichloroethylene VOCs Xylene	Small quantities of PM_{10} may be released from this process. There are, at present, no emission factors for these operations. VOCs will be released as a result of cutting oils and solvent use on machining tools. There is, currently, very little information available on emission estimation techniques for these operations. **Section 3.1.1** of this Manual provides some emission factors for solvent use. Emissions of volatile solvents can be estimated on the basis of annual usage, assuming that all solvents are volatilised (ie released direct to air). Any vapour recovery or other control systems should be accounted for in characterising these emissions. Emissions from the storage of fuel can be determined using the *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage*.
Non-Destructive Testing	PM_{10} VOCs	Refer to the *Emission Estimation Technique Manual for Fugitive Emissions* (Sections 3.12 and 3.14) for a discussion of how emissions can be estimated from non-destructive testing operations.
Surface Preparation and Surface Coating	Acetone Dichloromethane PM_{10} Tetrachloroethylene Toluene Trichloroethane Trichloroethylene VOCs Xylene	Refer to the *Emission Estimation Technique Manual for Surface Coating*, the *Emission Estimation Technique Manual for Galvanising* and the *Emission Estimation Technique Manual for Electroplating and Anodising* for information regarding emissions from surface preparation and coating operations.

Table 3 - Sources of Air Emissions from Structural Fabricated Metal Product Manufacturing Processes cont'

Activity	Potential NPI Emissions	Sources of Information on Emission Estimation Techniques
Combustion Processes	Arsenic & compounds Beryllium & compounds Cadmium & compounds Carbon Monoxide Chromium (III) compounds Chromium (VI) compounds Copper and compounds Fluoride Compounds Hydrochloric Acid Lead & compounds Magnesium Oxide Fume Manganese & compounds Mercury & compounds Nickel & compounds Nickel Carbonyl Nickel Subsulfide Oxides of Nitrogen Particulate Matter (PM_{10}) Polychlorinated Dioxins & Furans Polycyclic Aromatic Hydrocarbons Sulfur Dioxide Total Volatile Organic Compounds	These emissions can be estimated by referring to the *Emission Estimation Technique Manual for Combustion in Boilers* and the *Emission Estimation Technique Manual for Combustion Engines.*
Wastewater Treatment	Chlorine Hydrogen sulfide Total Volatile Organic Compounds	The *Emission Estimation Technique Manual for Sewage and Wastewater Treatment* provides guidance on estimating emissions from wastewater treatment.

3.1.1 Emission Factors for Releases to Air

Plasma Cutting

Table 4 provides emission factors for emissions of metal fume and oxides of nitrogen for the plasma cutting of steel. The note to the table provides additional guidance on characterising the metal composition of the fume. The emission factors presented are for 'uncontrolled' emissions (ie. assuming no pollution controls in place). If these emissions are routed through some form of pollution control equipment, the efficiency of this pollution control equipment needs to be accounted for in characterising emissions. Collection efficiencies of various control techniques are presented in Table 6 of this Manual.

Table 4 - Uncontrolled Emission Factors for Plasma Cutting

Steel, thickness	Dry Cutting (g/min)	Semi-dry Cutting (g/min)	Wet Cutting (g/min)
Metal Fume			
Mild steel, 8mm	23[a]	3.0[a]	0.25[a]
Stainless, 8mm	35[a]	4.1[a]	0.35[a]
Stainless, 35mm	2.6[a]	0.2[a]	0.02
NO_x			
Mild steel, 8mm	6.6[a]	3.7[a]	1.4[a]
Stainless, 8mm	6.3[a]	3.3[a]	1.5[a]
Stainless, 35mm	9.8[a]	5.2[a]	2.6[a]

Source: Bromssen *et al*, 1994

Note: The figures shown are based on air as the plasma gas. Using oxygen as the plasma gas results in fume emissions 25% lower than those shown below. Using nitrogen as the plasma gas results in a 20% reduction in the NO_x levels shown. The components of the metal oxide fume from mild steel were 67-73% iron, 2-10% manganese and copper from undetectable to 1.4%. It is recommended that, in the absence of information for metal composition, use average values for these substances can be used. For 310 stainless steel the fume chemistry was 25.4% Fe, 4.4% Mn, 10.3% Ni, 20.2% Cr(VI).

[a] The numbers presented are the arithmetic mean of the minimum and maximum values from the source data (Bromssen et al, 1994).

Solvents

Table 5 provides emission factors for solvent use in the structural and fabricated metal product manufacturing industry. The emission factors presented are for 'uncontrolled' emissions (ie assuming no pollution controls in place). If these emissions are routed through some form of pollution control equipment, the efficiency of this pollution control equipment needs to be accounted for in characterising emissions.

Table 5 - Emission Factors for Solvent Use

Solvent Used	Use	Emission Factor (kg solvent emitted / kg solvent used)	Emission Factor Rating
Dichloromethane	Vapour degreasing Cold Cleaners	Uncontrolled 0.930 Controlled 0.890	E E
Tetrachloroethylene	Vapour degreasing Cold Cleaners	Uncontrolled 0.890 Controlled 0.850	E E
Trichloroethylene	Vapour degreasing Cold Cleaners	Uncontrolled 0.910 Controlled 0.870	E E

Source: USEPA, 1990

General approach for estimating PM$_{10}$ & VOC emissions

PM$_{10}$ and VOC emissions can be estimated via a facility wide approach, if individual process emissions are unavailable. To adopt this approach the following parameters are required:

- Type of pollution control equipment used;
- Collection efficiency of each piece of equipment;
- Total mass of particulates/VOCs collected;
- Size distribution of collected particulates; or
- Actual (or estimated) VOC composition data for the stream.

Step 1
Identify the types of pollution control equipment used (eg. baghouse, cyclone, scrubber etc).

Step 2
Identify which process streams lead into the equipment identified in Step 1. This may be useful for identifying stream composition.

Step 3
Estimate the total mass of pollutants collected in each piece of equipment. Waste disposal records may already provide this information.

Step 4
Estimate the total mass of PM$_{10}$ and/or VOCs collected. The size distribution of the collected particulates will provide a breakdown of PM$_{10}$ content. The stream compositions or speciation data can be used to provide a breakdown of VOCs.

Step 5
Specify the collection efficiency of the control equipment. The efficiency may be manufacturer supplied or default values may be assigned if no other data source is available (see Table 6 for default control efficiencies on pollution control equipment for PM$_{10}$).

Step 6
Calculate the mass of PM$_{10}$/VOC released, using the following formula:

Pollutant released = Pollutant flow into control device * {1 - (collection efficiency (%)/100)}

NB: Speciation of the emissions may also be required for other reportable NPI substances. Assays of the collected particulates will supply composition data if speciation is required.

For further information on the speciation of VOCs and PM$_{10}$, refer to Section 5 of the *Emission Estimation Technique Manual for Fugitive Emissions*.

Table 6 - Default PM$_{10}$ Collection Efficiency Values for Pollution Control Equipment

Control Equipment	Collection Efficiency (%)
Wet scrubber - high-efficiency	99
Wet scrubber - medium-efficiency	95
Wet scrubber - low-efficiency	90
Gravity collector - high-efficiency	6
Gravity collector - medium-efficiency	4.8
Gravity collector - low-efficiency	3.7
Centrifugal collector - high-efficiency	95
Centrifugal collector - medium-efficiency	85
Centrifugal collector - low-efficiency	50
Electrostatic precipitator - high-efficiency	99.5
Electrostatic precipitator - medium-efficiency boilers other	 94 97
Electrostatic precipitator - low-efficiency boilers other	 90 90
Mist eliminator - high velocity >250 FPM	90
Mist eliminator - low velocity <250 FPM	75
Fabric filter - high temperature	99.5
Fabric filter - medium 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 without fly ash reinjection	95
Multiple cyclone with fly ash reinjection	85
Wet cyclonic separator	85
Water curtain	90

Source: USEPA 1995

3.2   Emissions to Water

Most of the liquid releases from structural and fabricated metal product manufacturing facilities are likely to be routed to sewer or sent for off-site treatment, recycling or disposal. This effluent is classed as a transfer under the National Pollutant Inventory (see **Section 3.3** below) and hence is not reportable.

In the unlikely event that wastewater is released to water (eg. after wastewater treatment), this release (and the NPI-listed substances contained in the wastewater) would be required to be reported.   If wastewater treatment occurs on-site it needs to be examined for potential emissions. Please refer to the *Emission Estimation Technique Manual for Sewage and Wastewater Treatment* for guidance on how to estimate these emissions.

There may be NPI reporting issues associated with stormwater run-off. If stormwater contains NPI-listed substances, most facilities are likely to be required by their relevant State or Territory environment agency to closely monitor and measure these emissions. These sampling data can be used to calculate annual emissions.

3.3   Emissions to Land

Under the NPI, the following are classed as transfers and are not reportable:

- Discharges of substances to sewer or tailings dam;
- Deposit of substances to landfill; and,
- Removal of substances from a facility for destruction, treatment, recycling, reprocessing, recovery, or purification.

The definition of transfer has been clarified by the NPI Implementation Working Group as:

"All emissions of listed substances, except those which are directed to, and contained by, purpose built facilities, are to be reported to the NPI. This applies irrespective of whether the substances' fate is within or outside a reporting facility boundary. With respect to receipt of NPI-listed substances, such receiving facilities are to be operating in accordance with any applicable State or Territory government requirements."

Emissions of substances to land on-site include solid wastes, slurries, sediments and leaks, storage and distribution of liquids. Such emissions may contain NPI-listed substances. It is expected that all of these substances will be sent to sewer, sent off-site for treatment or recycling or sent to landfill. As a consequence, there will be no requirement to report on these emissions. Therefore, it is likely that the only reporting requirements for releases to land will be associated with:

- Spills or accidental releases to land of NPI-listed substances (if spills occur, see the *Emission Estimation Technique Manual for Organic Chemical Processing Industries* (Section 9.2) for guidance on how to estimate these releases);

- Releases to groundwater of NPI-listed substances (see the *Emission Estimation Technique Manual for Organic Chemical Processing Industries* (Section 9.1) for guidance on how to estimate these releases); and

- On-site disposal, where the on-site disposal does not meet the definition provided above.

4.0   Glossary of Technical Terms and Abbreviations

ANZSIC   Australian and New Zealand Standard Industrial Classification

CEMS   Continuous Emission Monitoring System

CO   Carbon Monoxide

EEA   European Environment Agency

EET   Emission Estimation Technique

EFR   Emission Factor Rating

mg   Milligrams

NEPM   National Environment Protection Measure

NO_x Oxides of Nitrogen

NPI   National Pollutant Inventory

PM   Particulate Matter

PM_{10} Particles which have an aerodynamic diameter less than or equal to 10 micrometers ($\leq 10\mu m$).

ppmv   Parts per million by volume

SO_2 Sulphur Dioxide

STP   Standard Temperature & Pressure (T = 0°C, P = 1 atm)

TSP   Total Suspended Particulates

USEPA   United States Environmental Protection Agency

VOC   Volatile Organic Compound

5.0   References

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The following Emission Estimation Technique Manuals referred to in this Manual are available at the NPI Homepage (www.npi.gov.au), and from your
local environmental protection agency:

- *Emission Estimation Technique Manual for Combustion Engines;*
- *Emission Estimation Technique Manual for Combustion in Boilers;*
- *Emission Estimation Technique Manual for Electroplating and Anodising;*
- *Emission Estimation Technique Manual for Ferrous Foundries;*
- *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage;*
- *Emission Estimation Technique Manual for Fugitive Emissions;*
- *Emission Estimation Technique Manual for Galvanising;*
- *Emission Estimation Technique Manual for Non-Ferrous Foundries;*
- *Emission Estimation Technique Manual for Sewage and Wastewater Treatment;* and
- *Emission Estimation Technique Manual for Surface Coating.*

Appendix A - Emission Estimation Techniques

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

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

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

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

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

If you estimate your emission by using any of these EETs, your data will be displayed on the NPI database as being of 'acceptable reliability'. Similarly, if your relevant environmental authority has approved the use of 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 the NPI substances relevant to this industry. However, the absence of an EET for a substance in this handbook 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, ie. the quantity of the NPI reportable substance spilled, less the quantity recovered or consumed during clean up operations.

The **usage**[a] 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.

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

A list of the variables and symbols used in this Manual may be found in **Appendix C**.

A.1   Direct Measurement

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

A.1.1 Sampling Data

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

An example of test results is summarised in Table 7. The table shows the results of three different sampling runs conducted during one test event. The source parameters measured as part of the test run include gas velocity and moisture content, which are used to determine exhaust gas flow rates in m^3/s. The filter weight gain is determined gravimetrically and divided by the volume of gas sampled, as shown in Equation 1, to determine the PM concentration in grams per m^3. Note that this example does not present the condensable PM emissions.

Pollutant concentration is then multiplied by the volumetric flow rate to determine the emission rate in kilograms per hour, as shown in Equation 2 and Example 2.

Equation 1

$$C_{PM} \quad = \quad C_f \, / \, V_{m,STP}$$

where:

C_{PM} = concentration of PM or gram loading, g/m^3
C_f = filter catch, g
$V_{m,STP}$ = metered volume of sample at STP, m^3

Equation 2

$$E_{PM} = C_{PM} * Q_d * 3.6 * [273 / (273 + T)]$$

where:

E_{PM}	=	hourly emissions of PM, kg/hr
C_{PM}	=	concentration of PM or gram loading, g/m^3
Q_d	=	stack gas volumetric flow rate at actual conditions, m^3/s, dry
3.6	=	3600 seconds per hour multiplied by 0.001 kilograms per gram
T	=	temperature of the gas sample, °C

Table 7 - Stack Sample Test Results

Parameter	Symbol	Test 1	Test 2	Test 3
Total sampling time (sec)		7200	7200	7200
Moisture collected (g)	g_{MOIST}	395.6	372.6	341.4
Filter catch (g)	C_f	0.0851	0.0449	0.0625
Average sampling rate (m^3/s)		$1.67 * 10^{-4}$	$1.67 * 10^{-4}$	$1.67 * 10^{-4}$
Standard metered volume (m^3)	$V_{m, STP}$	1.185	1.160	1.163
Volumetric flow rate (m^3/s), dry	Q_d	8.48	8.43	8.45
Concentration of particulate (g/m^3)	C_{PM}	0.0718	0.0387	0.0537

Example 2 - Using Stack Sampling Data

PM emissions calculated using Equation 1 and Equation 2 (above) and the stack sampling data for Test 1 (presented in Table 7, and an exhaust gas temperature of 150°C (423 K)).

C_{PM}	=	$C_f / V_{m, STP}$
	=	0.0851 / 1.185
	=	0.072 g/m^3

E_{PM}	=	$C_{PM} * Q_d * 3.6 * [273/(273 + T)]$
	=	0.072 * 8.48 * 3.6 * (273/423 K)
	=	1.42 kg/hr

The information from some stack tests may be reported in grams of particulate per cubic metre of exhaust gas (wet). Use Equation 3 below to calculate the dry particulate emissions in kg/hr.

Equation 3

$$E_{PM} = Q_a * C_{PM} * 3.6 * (1 - moist_R/100) * [273 / (273 + T)]$$

where:

E_{PM}	=	hourly emissions of PM in kilograms per hour, kg/hr
Q_a	=	actual (ie. wet) cubic metres of exhaust gas per second, m^3/s
C_{PM}	=	concentration of PM or gram loading, g/m^3
3.6	=	3600 seconds per hour multiplied by 0.001 kilograms per gram
$moist_R$ =		moisture content, %
273	=	273 K (0°C)
T	=	stack gas temperature, °C

Total suspended particulates (TSP) are also referred to as total particulate matter (total PM). To determine PM_{10} from total PM emissions, a size analysis may need to be undertaken. The weight PM_{10} fraction can then be multiplied by the total PM emission rate to produce PM_{10} emissions. Alternatively, it can be assumed that 100% of PM emissions are PM_{10}; ie assume that all particulate matter emitted to air has an equivalent aerodynamic diameter of 10 micrometres or less ie. ≤10μm. In most situations, this is likely to be a conservative assumption, but it may be a suitable technique to obtain a reasonable characterisation of emissions for the purposes of NPI reporting.

To calculate moisture content use Equation 4

Equation 4

Moisture percentage = 100 * weight of water vapour per specific volume of stack gas /total weight of the stack gas in that volume

$$moist_R = \frac{100 * \dfrac{g_{moist}}{(1000 * V_{m,STP})}}{\dfrac{g_{moist}}{(1000 * V_{m,STP})} + \rho_{STP}}$$

where:

$moist_R$ =		moisture content, %
g_{moist}	=	moisture collected, g
$V_{m,STP}$	=	metered volume of sample at STP, m^3
ρ_{STP}	=	dry density of stack gas sample, kg/m^3 at STP {if the density is not known a default value of 1.62 kg/m^3 may be used. This assumes a dry gas composition of 50% air, 50% CO_2}

Example 3 - Calculating Moisture Percentage

A 1.2m^3 sample (at STP) of gas contains 410g of water. To calculate the moisture percentage use Equation 4.

$$moist_R = \frac{100 * \left(\frac{g_{moist}}{(1000 * V_{m,STP})}\right)}{\left(\frac{g_{moist}}{(1000 * V_{m,STP})}\right) + \rho_{STP}}$$

$$
\begin{aligned}
g_{MOIST} / 1000 * V_{m,STP} &= 410 / (1000 * 1.2) \\
&= 0.342 \\
moist_R &= 100 * 0.342 / (0.342 + 1.62) \\
&= 17.4\%
\end{aligned}
$$

A.1.2 Continuous Emission Monitoring System (CEMS) Data

A continuous emission monitoring system (CEMS) provides a continuous record of emissions over time, usually by reporting pollutant concentration. Once the pollutant concentration is known, emission rates are obtained by multiplying the pollutant concentration by the volumetric gas or liquid flow rate of that pollutant.

Although CEMS can report real-time hourly emissions automatically, it may be necessary to estimate annual emissions from hourly concentration data Manually. This Section describes how to calculate emissions for the NPI from CEMS concentration data. The selected CEMS data should be representative of operating conditions. When possible, data collected over longer periods should be used.

It is important to note that, prior to using CEMS to estimate emissions, you should develop a protocol for collecting and averaging the data in order that the estimate satisfies the local environmental authority's requirement for NPI emission estimations.

To monitor SO_2, NO_x, VOC, and CO emissions using a CEMS, you use a pollutant concentration monitor that measures the concentration in parts per million by volume dry air (ppm_{vd} = volume of pollutant gas/10^6 volumes of dry air). Flow rates should be measured using a volumetric flow rate monitor. Flow rates estimated based on heat input using fuel factors may be inaccurate because these systems typically run with high excess air to remove the moisture out of the kiln. Emission rates (kg/hr) are then calculated by multiplying the stack gas concentrations by the stack gas flow rates.

Table 8 presents example CEMS data output for three periods for a hypothetical furnace. The output includes pollutant concentrations in parts per million dry basis (ppm_{vd}), diluent (O_2 or CO_2) concentrations in percent by volume dry basis (%v, d) and gas flow rates; and may include emission rates in kilograms per hour (kg/hr). This data represents a snapshot of a hypothetical boiler operation. While it is possible to determine total emissions of an individual pollutant over a given time period from this data, assuming the CEMS operates properly all year long, an accurate emission estimate can be made by adding the hourly emission estimates if the CEMS data is representative of typical operating conditions.

Table 8 - Example of CEMS Output for a Hypothetical Furnace Firing Waste Fuel Oil

Time	O$_2$ content	Concentration				Gas Flow Rate (Q)	Production Rate of Product (A)
	% by volume	SO$_2$ (ppm$_{vd}$)	NO$_x$ (ppm$_{vd}$)	CO (ppm$_{vd}$)	VOC (ppm$_{vd}$)	m^3/s	tonnes/hour
1	10.3	150.9	142.9	42.9	554.2	8.52	290
2	10.1	144.0	145.7	41.8	582.9	8.48	293
3	11.8	123.0	112.7	128.4	515.1	8.85	270

Hourly emissions can be based on concentration measurements as shown in Equation 5.

Equation 5

$$E_i = (C * MW * Q * 3600) / [22.4 * ((T + 273)/273) * 10^6]$$

where:

E_i = emissions of pollutant i, kg/hr
C = pollutant concentration, ppm$_{v,d}$
MW = molecular weight of the pollutant, kg/kg-mole
Q = stack gas volumetric flow rate, m^3/s
3600 = conversion factor, s/hr
22.4 = volume occupied by one mole of gas at standard temperature and pressure (0°C and 101.3 kPa), m^3/kg-mole
T = temperature of gas sample, °C
10^6 = conversion factor, ppm.kg/kg

Actual annual emissions can be calculated by multiplying the emission rate in kg/hr by the number of actual operating hours per year (OpHrs) as shown in Equation 6 for each typical time period and summing the results.

Equation 6

$$E_{kpy,i} = \Sigma (E_i * OpHrs)$$

where:

$E_{kpy,i}$ = annual emissions of pollutant i, kg/yr
E_i = emissions of pollutant i, kg/hr (from Equation 5).
OpHrs = operating hours, hr/yr

Emissions in kilograms of pollutant per tonne of product produced can be calculated by dividing the emission rate in kg/hr by the activity rate (production rate (tonnes/hr) during the same period. This is shown in Equation 7 below.

It should be noted that the emission factor calculated below assumes that the selected time period (ie. hourly) is representative of annual operating conditions and longer time periods should be used for NPI reporting where they are available. Use of the calculation is shown in Example 5.

Equation 7

$$E_{kpt,i} = E_i / A$$

where:

$E_{kpt,i}$	=	emissions of pollutant i per tonne of product produced, kg/t
E_i	=	hourly emissions of pollutant i, kg/hr
A	=	production, t/hr

Example 4 illustrates the application of Equation 5, Equation 6 and Equation 7.

Example 4 - Using CEMS Data

This example shows how SO_2 emissions can be calculated using Equation 5 based on the CEMS data for Time Period 1 shown in Table 8, and an exhaust gas temperature of 150°C (423 K).

$E_{SO2,1}$	=	$(C * MW * Q * 3600) / [(22.4 * (T + 273/273) * 10^6]$
	=	$(150.9 * 64 * 8.52 * 3600) / [22.4 * (423/273) * 10^6]$
	=	$296\ 217\ 907 / 34\ 707\ 692$
	=	8.53 kg/hr

For Time Period 2, also at 150°C

$E_{SO2,2}$	=	8.11 kg/hr

For Time Period 3, also at 150°C

$E_{SO2,3}$	=	7.23 kg/hr

Say representative operating conditions for the year are:

Period 1	=	1500 hr
Period 2	=	2000 hr
Period 3	=	1800 hr

Total emissions for the year are calculated by adding the results of the three Time Periods using Equation 6:

$E_{kpy,SO2}$	=	$E_{SO2,1} * OpHrs + E_{SO2,2} * OpHrs + E_{SO2,3} * OpHrs$
	=	$(8.53 * 1500) + (8.11 * 2000) + (7.23 * 1800)$ kg
	=	$42\ 021$ kg/yr

Emissions, in terms of kg/tonne of product produced when operating in the same mode as time period 1, can be calculated using Equation 7

$E_{kpt,SO2}$	=	E_{SO2} / A
	=	8.53 / 290
	=	$2.94 * 10^{-2}$ kg SO_2 emitted per tonne of product produced

When the furnace is operating as in time periods 2 or 3, similar calculations can be undertaken for emissions per tonne.

A.2 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 (e.g. if any chemical reaction occurs that changes a pollutant into another substance)

Mass balance calculations for estimating emissions to air of NPI-listed substances can be represented conceptually by Equation 8.

Equation 8

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

where:

$E_{kpy,i}$ = emissions of pollutant i, kg/yr
Amount in$_i$ = amount of pollutant i entering the process, kg/yr
Amount out$_i$ = amount of pollutant i leaving the process as a waste stream, article or product, kg/yr

The term "Amount out$_i$" 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 9 can be applied as a practical extension of Equation 8.

Equation 9

$$E_{kpy,i} = [(Q_{in} * C_{in}) - (Q_{pr} * C_{pr}) - (Q_{rec} * C_{rec}) - (Q_{waste} * C_{waste})] / 10^6$$

where:

$E_{kpy,i}$ = emissions of pollutant i, kg/yr
$Q_{in}, Q_{pr}, Q_{rec}, Q_{waste}$ = quantity of raw material, product, recycled material or waste respectively, that is processed (generally expressed in kg/yr for solids, L/yr for liquids)
$C_{in}, C_{pr}, C_{rec}, C_{waste}$ = concentration of substance i in the raw material, product, recycled material or waste respectively, that is processed annually (usually mg/kg for solids, mg/L for liquids)
10^6 = conversion from milligrams to kilograms.

Wastewater treatment may precipitate the reportable chemical in sludge. Facilities are often required to obtain data on the concentration of metals or other substances in sludges as part of their licensing requirement and this data can be used to calculate the emissions as kilograms of sludge multiplied by the concentrations of the substance in the sludge. Although listed substances in sludges transferred off-site do not require reporting, determining this loss can assist with determining other process losses or may require reporting if the sludge is disposed of on-site.

For many chemicals used and emitted during chemical processes, some degradation in treatment may occur so that the entire chemical is not transferred to the sludge. Facilities can estimate the amount of reportable compounds in the sludge by using measured data, or by subtracting the amount biodegraded from the total amount removed in treatment. The amount of removal can be determined from operating data, and the extent of biodegradation might be obtained from published studies. If the biodegradability of the chemical cannot be measured or is not known, reporting facilities should assume that all removal is due to absorption to sludge.

A.3   Engineering Calculations

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

A.3.1 Fuel Analysis

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

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

Equation 10

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

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, weight percent, %

For instance, SO$_2$ 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$_2$. Therefore, for every kilogram of sulfur (EW = 32) burned, two kilograms of SO$_2$ (MW = 64) are emitted. The application of this EET is shown in Example 5.

Example 5 - Using Fuel Analysis Data

This example shows how SO$_2$ emissions can be calculated from fuel combustion based on fuel analysis results, and the known fuel flow of the engine. $E_{kpy,SO2}$ may be calculated using Equation 10 and given the following:

Fuel flow (Q_f)	=	20 900 kg/hr
Weight percent sulfur in fuel	=	1.17 %
Operating hours	=	1500 hr/yr

$$E_{kpy,SO2} = Q_f * C_i/100 * (MW_p / EW_f) * OpHrs$$
$$= (20\ 900) * (1.17/100) * (64 / 32) * 1500$$
$$= 733\ 590 \text{ kg/yr}$$

A.4   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:

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

For example, if the emission factor has units of '*kg pollutant/m^3 of fuel burned*', then the activity data required would be in terms of '*m^3 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).

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

Equation 11

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

where :

$E_{kpy,i}$ = emission rate of pollutant i, kg/yr
A = activity rate, t/hr
$OpHrs$ = operating hours, hr/yr
EF_i = uncontrolled emission factor of pollutant i, kg/t
CE_i = overall control efficiency 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. It is necessary to have the site-specific emission factor reviewed and approved by State or Territory environment agencies prior to its use for NPI estimations.

Appendix B - Emission Estimation Techniques: Acceptable Reliability and Uncertainty

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

Several techniques are available for calculating emissions from structural and fabricated metal product manufacturing facilities. The technique chosen is dependent on available data, and available resources, and the degree of accuracy sought by the facility in undertaking the estimate.

B.1   Direct Measurement

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

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

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

B.2   Mass Balance

Calculating emissions from structural and fabricated metal product manufacturing facilities using mass balance appears to be a straightforward approach to emission estimation. However, it is likely that few Australian facilities consistently track material usage and waste generation with the overall accuracy needed for application of this method. Inaccuracies associated with individual material tracking, or other activities inherent in each material handling stage, can 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 ± 5 percent in any one step of the operation can significantly skew emission estimations.

B.3   Engineering Calculations

Theoretical and complex equations, or models, can be used for estimating emissions from structural and fabricated metal product manufacturing processes. Use of engineering calculations to estimate emissions from these facilities 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

B.4   Emission Factors

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

Appendix C - List of Variables and Symbols

Variable	Symbol	Units
Conversion from kilograms to tonnes	10^3	kg/tonne
Conversion from milligrams to kilograms	10^6	mg/kg
Density of air	ρ_a	kg/m^3
Density of material	ρ_m	kg/L
Dry density of stack gas sample	ρ_{STP}	kg/m^3 at STP
Activity rate	A	units/hr, eg. t/hr
Surface area	area	m^2
Overall control efficiency	CE_i	% reduction in emissions of pollutant i
Filter Catch	C_f	grams
Concentration of pollutant i	C_i	kg/L
Concentration of pollutant i in material	C_i	kg/L
Concentration of substance i in the raw material, product, recycled material or waste respectively, that is processed annually	C_{in}, C_{pr}, C_{rec}, C_{waste}	(usually mg/kg for solids, mg/L for liquids)
Concentration of PM$_{10}$	C_{PM10}	grams/m^3
Uncontrolled emission factor for pollutant i	EF_i	kg of pollutant/tonne
Total emissions of pollutant i per hour	E_i	kg/hr
Emissions per tonne	$E_{kpt,i}$	kilograms of pollutant i per tonne of fuel consumed
Annual emissions of pollutant i	$E_{kpy,i}$	kg/yr
Elemental weight of pollutant in fuel	EW_f	kg/kg-mole
Molecular Weight of pollutant i	MW_i	kg/kg-mole
Operating hours	OpHrs	hr/yr
Pollutant concentration	ppm_{vd}	volume of pollutant gas/10^6 volume of dry air
Saturation vapour pressure of pollutant i	$P_{sat,i}$	kilopascals (kPa)
Total pressure	P_t	kPa
Vapour pressure of pollutant i	$P_{vap,i}$	kPa
Volumetric flow rate,	Q	m^3/s
Volumetric flow rate of stack gas	Q_a	actual cubic metres per second (m^3/s)
Volumetric flow rate of stack gas	Q_d	dry cubic metres per second (m^3/s)
Fuel used	Q_f	t/hr
Material entering the process	Q_{in} or Amount in$_i$	kg/hr
Material leaving the process	Q_{out} or Amount out$_i$	kg/hr
Ideal gas constant	R	kPa.m^3 /(kgmol).K
Standard Temperature & Pressure	STP	0°C (273 K) and 1 atmosphere 101.3 kPa
Temperature	T	°Celsius (°C) or Kelvin (K)
Total suspended particulates or Total particulate matter (total PM)	TSP or PM	mg/m^3
Metered volume at STP	$V_{m,STP}$	m^3
Total VOC emissions	E_{VOC}	kg/L
Moisture collected	g_{moist}	grams
Moisture content	$moist_R$	%
Percentage weight of pollutant i	$Wt\%_i$	%