



**National Pollutant Inventory**

# **Emission Estimation Technique Manual**

**for**

**Seafood Processing  
Industry**

*First published in June 1999*

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**EMISSION ESTIMATION TECHNIQUES  
FOR  
SEAFOOD PROCESSING INDUSTRY**

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# SEAFOOD PROCESSING INDUSTRY

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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 emissions from facilities engaged in seafood processing.

The seafood processing industry in this handbook will mainly refer to fish processing, but can be used as a guideline for the other forms of seafood processing.

EET MANUAL:           Seafood Processing

HANDBOOK:           Seafood Processing

ANZSIC CODES :     2173

This Manual was drafted by the NPI Unit of the Queensland Department of Environment & Heritage 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.

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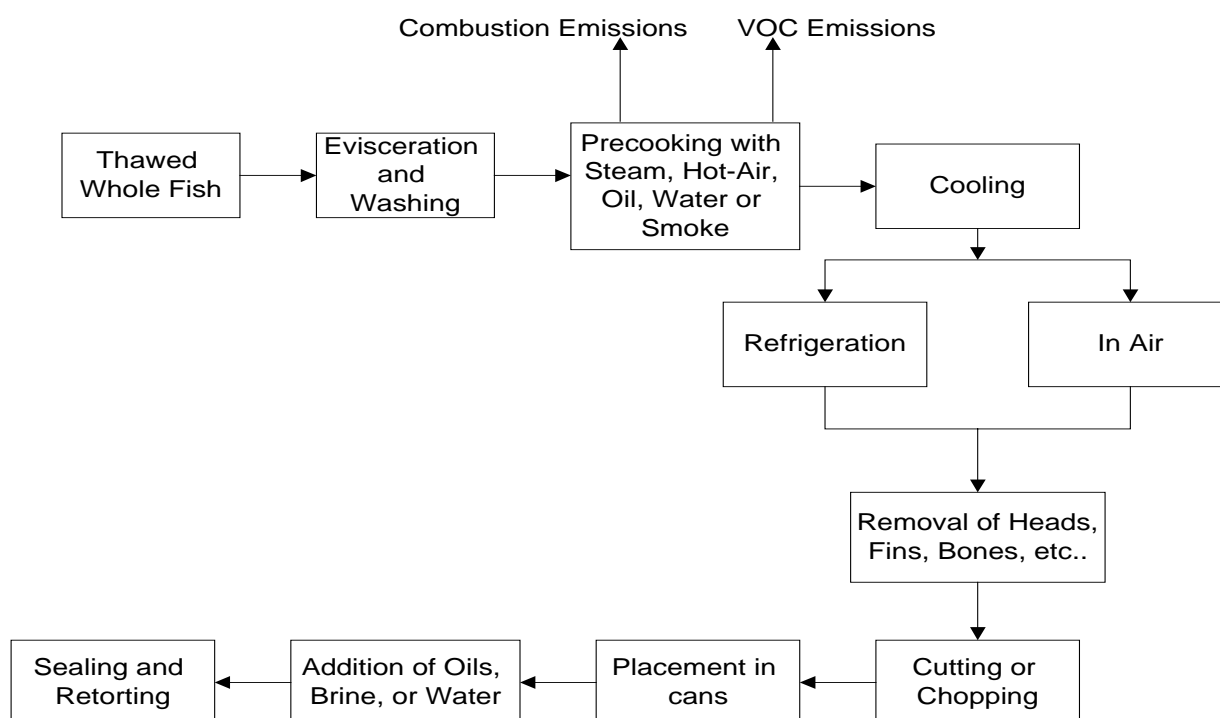
## 2.0 Processes and Emissions

The following section presents a brief description of the seafood processing industry and identifies likely sources of emissions.

### 2.1 Process Description

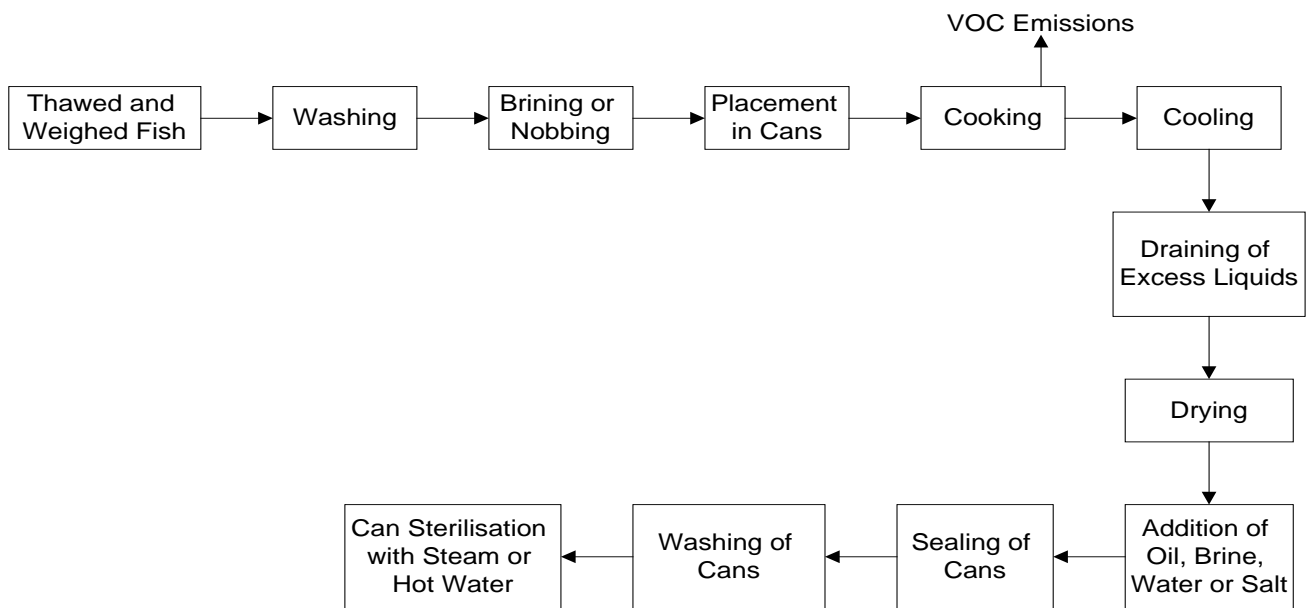
Fish processing includes both the canning of fish for human consumption and the production of fish by-products such as meal and oil. Either a precooking method or a raw pack method may be used in canning. In the pre-cooking method the raw fish are cleaned and cooked before being canned. In the raw pack method, the raw fish are cleaned and placed in cans before cooking. The precooking method is typically used for larger fish, while the raw pack is used for smaller fish. These two methods are illustrated in Figure 1 and Figure 2.

The by-product manufacturing segment of the fish industry, as shown in Figure 3, uses canning or filleting wastes and fish that are not suitable for human consumption to produce fish meal and fish oil. The processed crude fish oil is further polished through a hardening process. This process is shown in Figure 4.



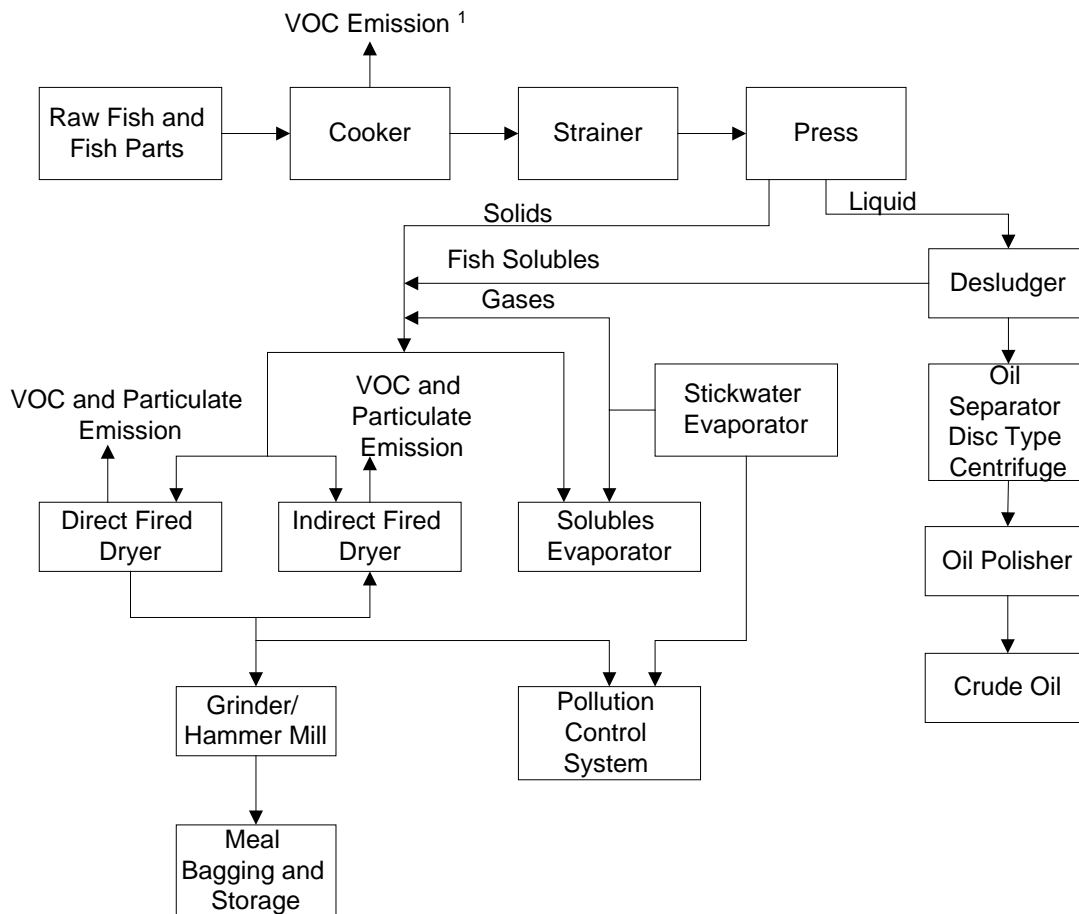
**Figure 1 - Flow Diagram of Precooking Method**

Source: USEPA, AP-42, Section 9.13.1, 1995



**Figure 2 - Flow Diagram of Raw Pack Method**

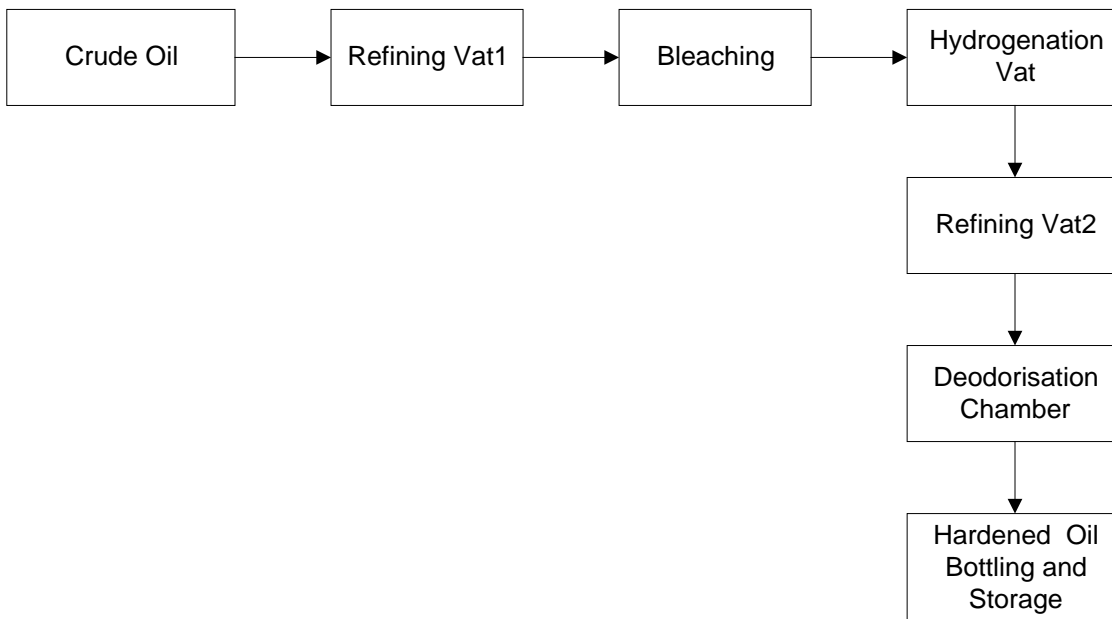
Source: USEPA, AP-42, Section 9.13.1, 1995



**Figure 3 - Flow Diagram of Fish Meal and Crude Oil Processing**

Source: USEPA, AP-42, Section 9.13.1, 1995

<sup>1</sup> VOC emissions consist of H<sub>2</sub>S and (CH<sub>3</sub>)<sub>3</sub>N, but no particulate matter.



**Figure 4 - Oil Hardening Process**

Source: USEPA, AP-42, Section 9.13.1, 1995

## 2.2 Emission Sources and Control Technologies

### 2.2.1 Emissions to Air

Air emissions may be categorised as:

#### Fugitive Emissions

These are emissions that are not released through a vent or stack. Examples of fugitive emissions include dust from stockpiles, volatilisation of vapour from vats, open vessels, or spills and materials handling. Emissions emanating from ridgeline roof-vents, louvres, and open doors of a building as well as equipment leaks, and leaks from valves and flanges are also examples of fugitive emissions. Emission factor EETs are the usual method for determining losses through fugitive emissions.

#### Point Source Emissions

These emissions are exhausted into a vent or stack and emitted through a single point source into the atmosphere. Table 1 highlights common air emissions from seafood processing. The *Combustion in Boilers* EET Manual, along with other Manuals in this series, is available from State and Territory environment agencies. The *Combustion in Boilers* EET Manual is designed to provide guidance on estimating emissions from combustion sources such as combustion of natural gas and combustion from wood burning, which may be of particular relevance to the seafood industry.

**Table 1 - Common Air Emissions from Seafood Processing**

Substances	
Volatile Organic Compounds (VOCs)	Oxide of Nitrogen (NO <sub>x</sub> )
Particulate Matter (PM <sub>10</sub> )	Sulfur Dioxide (SO <sub>2</sub> )
Hydrogen Sulfide (H <sub>2</sub> S)	Ammonia (NH <sub>3</sub> )*
Carbon Monoxide (CO)	Chlorine (Cl <sub>2</sub> )*

Source: Queensland Department of Environment and Heritage, 1998

\* Ammonia and Chlorine are common substances used for refrigeration and disinfecting/cleaning purposes, hence a possible emission source.

Air emission control technologies, such as electrostatic precipitators, fabric filters or baghouses, and wet scrubbers, are commonly installed to reduce the concentration of particulates in process off-gases before stack emission. Where such emission abatement equipment has been installed, and where emission factors from uncontrolled sources have been used in emission estimation, the collection efficiency of the abatement equipment needs to be considered. Guidance on applying collection efficiencies to emission factor equations is provided in later sections.

With regards to emission controls for PM<sub>10</sub> emissions (particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less ie.  $\leq 10\mu\text{m}$ ), in the absence of measured data, or knowledge of the collection efficiency for a particular piece of equipment, an efficiency of 90% should be used in the emission factor equation to calculate actual mass emissions. This default should only be used if there is no other available control efficiency.

### 2.2.2 Emissions to Water

Emissions of substances to water can be categorised as discharges to:

- Surface waters (eg. lakes, rivers, dams, and estuaries);
- Coastal or marine waters; and
- Stormwater.

Because of the significant environmental hazards posed by emitting toxic substances to water, most facilities emitting NPI-listed substances to waterways are required by their relevant State or Territory environment agency to closely monitor and measure these emissions. This existing sampling data can be used to calculate annual emissions.

If no wastewater monitoring data exists, emissions to process water can be calculated based on a mass balance or using emission factors.

The discharge of listed substances to a sewer does not require you to report to the NPI. However, leakage and other emissions (including dust) from a tailings storage facility are reportable. (See also Section Three of *The NPI Guide*.)



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### **2.2.3 Emissions to Land**

Emissions of substances to land on-site include solid wastes, slurries, sediments, spills and leaks, storage and distribution of liquids and may contain listed substances. These emission sources can be broadly categorised as:

- surface impoundments of liquids and slurries; and
- unintentional leaks and spills.

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### 3.0 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* at the front of this Handbook.

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 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 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 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** 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.

### 3.1 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.

#### 3.1.1 Sampling Data

Stack sampling test reports often provide emissions data in terms of parts per million (ppm) or grams per cubic metre ( $\text{g}/\text{m}^3$ ) (dry standard). 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.

This Section shows how to calculate emissions in kg/hr based on stack sampling data, and how to convert this to an annual emissions figure. Calculations involved in determining particulate emissions are used as an example, although the same calculations are applicable for most of the substances listed on the NPI. Use Equation 1 to calculate the concentration of  $\text{PM}_{10}$  in  $\text{g}/\text{m}^3$  and use Equation 2 to calculate the hourly emission of  $\text{PM}_{10}$  in kg/hr.

#### Equation 1

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

where:

$$\begin{aligned} C_{\text{PM}} &= \text{concentration of PM or gram loading (g/m}^3\text{)} \\ C_f &= \text{filter catch (g)} \\ V_{\text{m,STP}} &= \text{metered volume of sample at STP (m}^3\text{)} \end{aligned}$$

#### Equation 2

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

where:

$$\begin{aligned} E_{\text{PM}} &= \text{hourly emissions of PM (kg/hr)} \\ C_{\text{PM}} &= \text{concentration of PM or gram loading (g/m}^3\text{)} \\ Q_d &= \text{stack gas volumetric flow rate (m}^3\text{/s)} \\ T &= \text{stack gas temperature (C)} \end{aligned}$$

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

### Equation 3

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

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 <sup>3</sup> /s
$C_{PM}$	=	concentration of PM or gram loading, g/m <sup>3</sup>
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<sub>10</sub> from total PM emissions, a size analysis may need to be undertaken. The weight PM<sub>10</sub> fraction can then be multiplied by the total PM emission rate to produce PM<sub>10</sub> emissions. Alternatively, assume that 100% of PM emissions are PM<sub>10</sub>; ie assume that all particulate matter emitted to air has an equivalent aerodynamic diameter of 10 micrometres or less ie. ≤10µm.

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.

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

where

$moist_R$	=	moisture content, %
$g_{moist}$	=	moisture collected, g
$V_{m,STP}$	=	metered volume of sample at STP, m <sup>3</sup>
$\rho_{STP}$	=	dry density of stack gas sample, kg/m <sup>3</sup> at STP {if the density is not known a default value of 1.62 kg/m <sup>3</sup> may be used. This assumes a dry gas composition of 50% air, 50% CO <sub>2</sub> }

### Example 1 – Calculating Moisture Percentage

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

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

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

### 3.1.2 Continuous Emission Monitoring System (CEMS) Data

A continuous emission monitoring system 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.

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 your relevant environmental authority's requirement for NPI emission estimations.

Most food processing industries however, will not require to use this method of EET for the reporting of substances.

## 3.2 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.

### 3.3 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).

#### 3.3.1 Fuel Analysis

Fuel analysis is an example of an engineering calculation and can be used to predict SO<sub>2</sub> and metal 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, which may be converted into other compounds during the combustion process.

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

#### Equation 5

$$E_{kpy,i} = Q_f * \text{pollutant concentration in fuel} * (MW_p / EW_f) * \text{OpHrs}$$

where:

$E_{kpy,i}$	=	emissions of pollutant i, kg/yr
$Q_f$	=	fuel use, kg/hr
$MW_p$	=	molecular weight of pollutant emitted, kg/kg-mole
$EW_f$	=	elemental weight of pollutant in fuel, kg/kg-mole
OpHrs	=	operating hours, hr/yr

For instance, SO<sub>2</sub> emissions from oil combustion can be calculated based on the concentration of sulfur in the 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

This example illustrates how SO<sub>2</sub> emissions can be calculated from oil combustion based on fuel analysis results and the fuel flow information from a processing facility. The facility is assumed to operate 1500 hours per year.

$E_{kpy,SO_2}$  = may be calculated using Equation 5.

$$\text{Fuel flow} = 2\,000 \text{ kg/hr}$$

$$\text{Weight percent sulfur in fuel} = 1.17$$

$$\begin{aligned} E_{kpy,SO_2} &= Q_f * \text{pollutant concentration in fuel} * (MW_p / EW_f) * \text{OpHrs} \\ &= (2\,000) * (1.17 / 100) * (64 / 32) * 1\,500 \\ &= 46.8 \text{ kg/hr} * 1\,500 \text{ hr/yr} \\ &= 70\,200 \text{ kg/yr} \end{aligned}$$

### 3.4 Emission Factors

An emission factor is a tool that is 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.

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

#### Equation 6

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

where :

$E_{kpy,i}$	=	emission rate of pollutant i (kg/yr)
A	=	activity rate (t/hr)
OpHrs	=	operating hours (hr/yr)
EF	=	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. You are required to have the emission factor reviewed and approved by State or Territory environment agencies prior to its use for NPI estimations.

Emission factors for the Seafood Processing Industry from fish canning and by-product manufacturing can be found in Table 2.

#### 3.4.1 Industry-Wide Emission Factors

**Table 2 - Emission Factors for Fish Canning and By-Product Manufacture<sup>a</sup>**

Process	Total Particulate Matter <sup>c</sup> (kg/t)	Hydrogen Sulfide (H <sub>2</sub> S) (kg/t)	Trimethylamine ((CH <sub>3</sub> ) <sub>3</sub> N) (kg/t)	Emission Factor Rating Code
Cookers, crap: <i>Fresh Fish</i>	Neg	0.005	0.15	C
<i>Stale Fish</i>	Neg	0.1	1.75	C
Steam tube dryer	2.5	0.05 <sup>b</sup>	no data	C & U(H <sub>2</sub> S)
Direct-fired dryer	4	0.05 <sup>b</sup>	no data	C & U(H <sub>2</sub> S)

Source: USEPA, AP-42, Section 9.13.1, 1995

<sup>a</sup> Factors are in terms of raw fished processed. Neg = negligible

<sup>b</sup> Data Obtained from Economopoulos A.P., 1993

<sup>c</sup> Utilisation of these emission factors will over-estimate the calculation of PM<sub>10</sub> emission for your facility (a conservative estimate, as PM<sub>10</sub> would probably account for 30-50% of total particulate matter).

### Example 3 - Using Emission Factors

Table 2 shows that 2.5 kg of particulate matter (PM<sub>10</sub>) is emitted from a steam tube dryer in a canning and by-product manufacturing facility, for each tonne of raw fish processed. The overall control efficiency of the pollutant is 40%. If it is assumed that the facility operates 10 hrs/d and 260 days/year, then PM<sub>10</sub> emissions can be calculated as,

$$\begin{aligned} \text{EF}_{\text{PM}} &= 2.5 \text{ kg/t} \\ \text{Activity rate} &= 5 \text{ t/hr} \\ \text{OpHrs} &= 10 \text{ hr/d} * 260 \text{ d/yr} \\ &= 2600 \text{ hr/yr} \\ \text{CE} &= 40\% \\ \\ \text{E}_{\text{kpy, PM}} &= [\text{A} * \text{OpHrs}] * \text{EF} * [1 - (\text{CE}_i/100)] \\ &= [5 \text{ t/hr} * 2600 \text{ hr/yr}] * 2.5 \text{ kg/t} * [1 - (40/100)] \\ &= 13\,000 \text{ t/yr} * 2.5 \text{ kg/t} * 0.6 \\ &= 19\,500 \text{ kg/yr} \end{aligned}$$

### 3.4.2 Predictive Emission Monitoring (PEM)

Predictive emission monitoring is based on developing a correlation between pollutant emission rates and process parameters. A PEM allows facilities to develop site-specific emission factors, or emission factors more relevant to their particular process.

Based on test data, a mathematical correlation can be developed that predicts emissions using various parameters.



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## **4.0 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 seafood processing facilities. The technique chosen is dependent on available data, 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 3.4.1 of this Manual.

### **4.1 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 seafood processing 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.

### **4.2 Mass Balance**

Calculating emissions from a seafood processing facility using mass balance appears to be a straightforward approach to emission estimations. However, it is likely that few Australian seafood processing 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 of 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 emission estimations.

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### 4.3 Engineering Calculations

Theoretical and complex equations or *models* can be used for estimating emissions from seafood processes.

Use of emission equations to estimate emissions from seafood processing 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.

### 4.4 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 Section 5.0 of this Manual. 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

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## 5.0 References

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<http://www.epa.gov/ttn/chief/ap42.html>

USEPA, October 1992, *VOC / PM Speciation Data System - Version 1.50*, United States Environmental Protection Agency, Office of Air Quality, Planning and Standards, Research Triangle Park, NC, USA.

The following Emission Estimation Technique Manuals referred to in this Manual are available at the NPI Homepage and from your local environmental protection agency (see the front of the NPI Guide for details):

- Emission Estimation Technique Manual for Combustion in Boilers; and
- Emission Estimation Technique Manual for Sewage & Wastewater Treatment.