National Pollutant Inventory

Emission Estimation Technique Manual

for

Meat Processing

Environment Australia

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EMISSION ESTIMATION TECHNIQUES
FOR
MEAT PROCESSING

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MEAT PROCESSING

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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 meat processing industries.

The meat processing activities covered by this Manual include facilities primarily engaged in:

- Abattoirs and Meat Processing
- Meat Rendering
- Poultry Slaughtering and Processing
- Smallgoods Manufacturing

EET MANUAL:	Meat Processing
HANDBOOK:	Meat & Meat Product Manufacturing
ANZSIC CODES :	- 2111 Meat Processing - 2112 Poultry Processing - 2113 Bacon, Ham and Smallgoods Manufacturing and all codes in the 211 ANZSIC code group.

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

2.0 Processes and Emissions

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

2.1 Process Description

The meat industry activities covered in this Manual include three main categories:

Abattoirs and Meat Processing

This class consists mainly of those facilities engaged in slaughtering animals (except poultry), boning, freezing, preserving or packaging meat (except poultry), canning meat (except bacon and ham), manufacturing meals from abattoir by-products, or rendering lard or tallow.

Poultry Slaughtering and Processing

This class consists of those facilities mainly engaged in slaughtering, dressing, freezing or packaging (except canning) poultry and game birds.

Bacon, Ham, and Smallgood Manufacturing

This class consists of those facilities mainly engaged in manufacturing bacon, ham (including canned bacon or ham), smallgoods, or prepared meat products not elsewhere classified.

2.2 Emission Sources and Control Technologies

The following table lists substances that may be used in the meat processing industry, therefore giving an indication of those substances that may be emitted.

Emissions of NPI-listed substances may also occur from the combustion of fuel at meat processing facilities.

The *Combustion in Boilers* EET Handbook is available to assist with estimating emissions from combustion processes.

Table 1 - Usage of NPI-Listed Substances in the Meat Processing Industry

NPI-Listed Substance	Meat Processing Industry	Meat Rendering	Comment (if applicable)
Ammonia (total)	✔	✔	For refrigeration, ammonia emissions may be estimated by the amount of ammonia required to 'top up' the refrigeration system.
Chlorine	✔	✔	If chlorine has undergone a reaction or is mixed with water or other substances, there will be no emissions of chlorine. It is only necessary to report emissions of chlorine if there is a spill or leak.
Acetic Acid	✔		May be used in animal decontamination.
Hydrochloric Acid	✔	✔	If hydrochloric acid has undergone a reaction there will be no emissions of acid. It is only necessary to report emissions of acids if there is a spill or leak of the acid.
Nitric Acid	✔	✔	As above
Phosphoric Acid	✔	✔	As above
Sulfuric Acid	✔	✔	As above
Total Nitrogen (to water)	✔	✔	Total Nitrogen is only reportable if it is discharged directly to a waterbody.
Total Phosphorus (to water)	✔	✔	Total Phosphorus is only reportable if it is discharged directly to a waterbody.

Source: Mike Johns, Meat Research Corporation, Personal Communication to Alison Wiltshire, Department of Environment and Heritage, 1998

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.

For the meat industry examples of fugitive emissions may be:

- loss of ammonia from refrigeration; or
- spills or leaks of acids or chlorine products.

Point Source Emissions

These emissions are exhausted into a vent or stack and emitted through a single point source into the atmosphere.

In the meat processing industry point source emissions may include emissions from fuel burning.

The *Combustion in Boilers* EET Handbook is available to assist with estimating emissions from combustion processes.

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_{10} emissions, (particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less ie. $\leq 10\mu m$), 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*.)

For the meat processing industry, the main discharges to water bodies, if any, will be total nitrogen, total phosphorus, and ammonia. Ammonia (total) is the sum of ammonia and ammonium forms. Wastewater from the meat processing industry is characteristically high in ammonia.

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
- unintentional leaks and spills.

For the meat processing industry land emissions will occur if wastewater is being used for irrigation. It is anticipated that ammonia will be the main NPI- listed constituent of the wastewater. Nitrogen and phosphorus compounds need not be reported as these substances are only reportable if discharged to a water body.

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 emission estimation techniques 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 Manual does not necessarily imply that an emission should not 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.

In general, direct measurement is the most accurate method for characterising emissions and, where available, such data should be used in preference to other EETs presented in this Manual. However, additional direct measurement is not required under the NPI Measure. Direct monitoring may be undertaken as an element of other EETs.

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. To be adequate, sampling data used for NPI reporting purposes would need to be collected over a period of time representative of the whole year.

3.1.1 Sampling Data

Stack sampling test reports often provide emissions data in terms of kg/hr or g/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 to be taken under maximum emissions rating, where emissions are likely to be higher than when operating under normal operating conditions.

For those meat processing facilities discharging to a water body, sampling data that may have been undertaken for regulatory requirements may be used for NPI reporting.

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 of that pollutant.

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.

In the meat processing industry, continuous emission monitoring data may be available from stack monitoring or from water monitoring, depending on the sampling regime at individual facilities.

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_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, which may be converted into other compounds during the combustion process.

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

Equation 1

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

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

For instance, SO_2 emissions from coal combustion can be calculated based on the concentration of sulfur in the coal. 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 1.

Example 1 - Using Fuel Analysis Data

This example illustrates how SO_2 emissions can be calculated from coal combustion based on fuel analysis results and the fuel flow information. The facility is assumed to operate 1500 hours per year.

E_{SO2} = may be calculated using Equation 1.

Fuel flow = 2 000 kg/hr
Weight percent sulfur in fuel = 0.5

$$E_{kpy,SO2} = Q_f * \text{pollutant concentration in fuel} * (MW_p / EW_f) * OpHrs$$
$$= (2\,000) * (0.5 / 100) * (64 / 32) * 1\,500$$
$$= 20 \text{ kg/hr} * 1\,500 \text{ hr/yr}$$
$$= 30\,000 \text{ kg/yr}$$

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 (eg. kilograms of formaldehyde emitted per tonne of sawdust used).

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

Equation 2

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

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. You are required to have the emission factor reviewed and approved by State or Territory environment agencies prior to its use for NPI estimations.

3.4.1 Industry-Wide Emission Factors

The following emission factors provide information to assist in estimating emissions from wastewater treatment and meat smoking.

Table 2 - Emissions of Ammonia from Irrigation

Treatment Level Before Irrigation	Ammonia (total) Concentration (mg/L) in Water
Raw, or primary treated wastewater (undosed)	130
Primary treated with chemically dosed DAF	80
Primary and anaerobic pond treated only	180
Primary, anaerobic and aerobic pond treated (no aerated ponds)	150
Treatment including aerated ponds, or biological nutrient removal process	must be measured

Source: Mike Johns, Meat Research Corporation, Personal Communication to Alison Wiltshire, Department of Environment and Heritage, 1998

Note: If a low temperature rendering process is operated, the ammonia (total) concentration value in the table should be doubled for treatment processes, including anaerobic, or aerobic ponds.

Table 3 - Emission Factors for Batch and Continuous Meat Smokehouses[a]

Process	PM_{10} (kg/tonne of wood or sawdust used)[b]	VOC (kg/tonne of wood or sawdust used)	Formaldehyde (kg/tonne of wood or sawdust used)	Acetic Acid (kg/tonne of wood or sawdust used)	Emission Factor Rating
Batch smokehouse, smoking cycle	26.5	22	ND	ND	E
Continuous smokehouse, smoke zone	70	8.5	0.65	2.25	E
Continuos smokehouse, smoke zone, with vortex wet scrubber and demister	14.5	2.2	0.31	1.4	E

[a] USEPA 1995
Factor units are kg of substance emitted per tonne of fuel burnt.
[b] Figure is the sum of filterable and condensible PM_{10}
ND = no data available
NA = not applicable

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.

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 meat 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. 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 one 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 meat processing facility using mass balance appears to be a straightforward approach to emissions estimations. 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 often accumulate into large deviations of 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 emissions estimations.

4.3 Engineering Calculations

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

Use of emission equations to estimate emissions from meat 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

5.0 References

Griffith University. 1996. *Industrial Water and Waste Water Treatment* - Study Guide Part Two, Brisbane, Queensland.

National Pollutant Inventory Homepage
http://www.npi.gov.au

USEPA. September 1995. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, fifth edition, AP-42. Section 9.5.3 Meat Rendering Plants.* United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
http://www.epa.gov/ttn/chief/ap42.html

USEPA. September 1995. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, fifth edition, AP-42. Section 9.5.2 Meat Smokehouses* United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.

Personal Communication from Mike Johns, Meat Research Corporation, Brisbane, Australia, to Alison Wiltshire, National Pollutant Inventory Unit, Queensland Department of Environment and Heritage, 10 June 1998.

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;
- Emission Estimation Technique Manual for Combustion Engines; and
- Emission Estimation Technique Manual for Sewage and Wastewater Treatment.