



National Pollutant Inventory

Emission Estimation Technique Manual

for

Wool Scouring

First published in July 1999

**EMISSION ESTIMATION TECHNIQUES
FOR
WOOL SCOURING**

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WOOL SCOURING

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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 wool scouring processes.

This Manual covers facilities and processes engaged in the wool scouring industry.

EET MANUAL: Wool Scouring

HANDBOOK: Wool Scouring

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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 wool scouring Industry and identifies likely sources of emissions.

2.1 Process Description

Each tonne of raw wool contains approximately 150 kg of lanolin, 40 kg of suint, 150 kg of dirt, 20 kg of vegetable matter, leaving 640 kg of wool fibre. Suint is the natural grease in the sheep's wool. Wool scouring is a cleaning process for removing these contaminants. The effective scouring of raw wool is an essential step to remove contaminants from wool that would otherwise impede its further processing.

Wool is scoured in a series of hot aqueous detergent solutions. These solutions are contained in stainless steel tanks (bowls). In order to maintain continuous operation, contaminants must be removed from the system either through recovery loops or by flowdown in effluent streams.

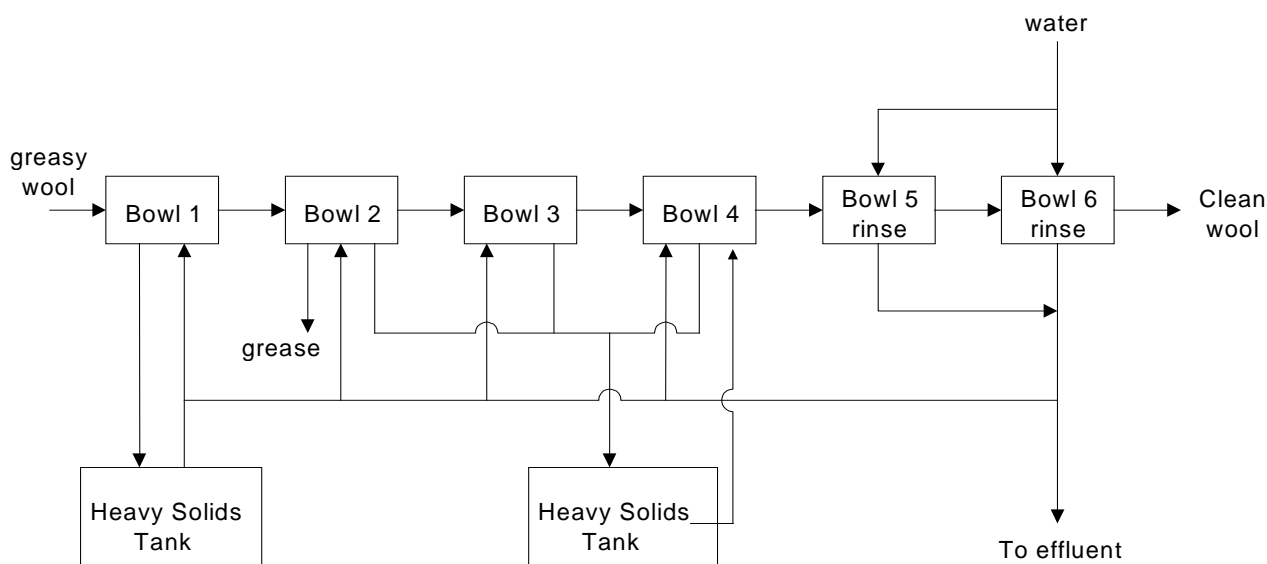


Figure 1 - Typical Wool Scouring Process Flow Diagram

Source: EnviroNET, 1996, Cleaner Production in Wool Scouring: ConAgra Pty Ltd.

2.1.1 Factors Improving Continuous Operations

The following are three ways that help to extend the life of a scouring bowl. These are countercurrent flow, improved bowl design and contaminant removal/recovery loops (IWS, undated, p29-31).

2.1.1.1 Countercurrent Flow

By definition wool scouring is a multi-stage countercurrent extraction process. There are two main flowdowns from a scouring line. These are low volume, high strength strong flow, and a high volume, weak rinse waterflow. Countercurrent flow from the last bowl back to the first bowl maintains these flowdowns.

2.1.1.2 Bowl Design

Woppen-bottom bowls enable the contents of a scouring bowl to be continuously discharged either to the contaminant recovery system or as an effluent. This keeps the levels of contaminants at manageable levels. The accumulation of contaminants, dirt in particular, will impede continuous flow.

2.1.1.3 Recovery Loops

A recovery loop is a system used to connect recovery devices to each other, to and from the scouring line. There are few factors that govern the performance of such a system. These include the arrangement of the recovery devices, the liquor flows and the way it is operated in the mill (IWS, undated p. 31).

Some of the advantages of a recovery loop include:

1. The lives of the scouring bowls are extended, thereby increasing the production efficiency.
2. Water consumption is reduced.
3. A valuable by-product, wool wax, is recovered. Depending on the selling price of the recovered wool wax a substantial portion of the operating costs can be recovered.
4. The removal of elements that lead to lack of heterogeneity in the scouring liquor improves the control of the scouring process to produce a consistent, clean product.
5. The pollution load of effluent discharged to the external environment is reduced, hence decreasing the costs of discharge and the load to the subsequent wastewater treatment.

The wool wax and dirt recovery devices can be arranged either in series or in parallel.

The WRONZ loop (Figure 2) is an example of the former whereas the SIROSCOUR system (Figure 3) is an example of the latter.

The WRONZ Comprehensive Scouring System (Figure 2) incorporates both dirt and grease recovery devices. The feed, which is taken from the bottoms of the scouring bowls in a timer-controlled sequence, is pumped to the dirt recovery device—a settling tank. The overflow from the tank provides the feed to the primary grease centrifuge. The middle phase of the centrifuge is returned to the scour to complete the loop.

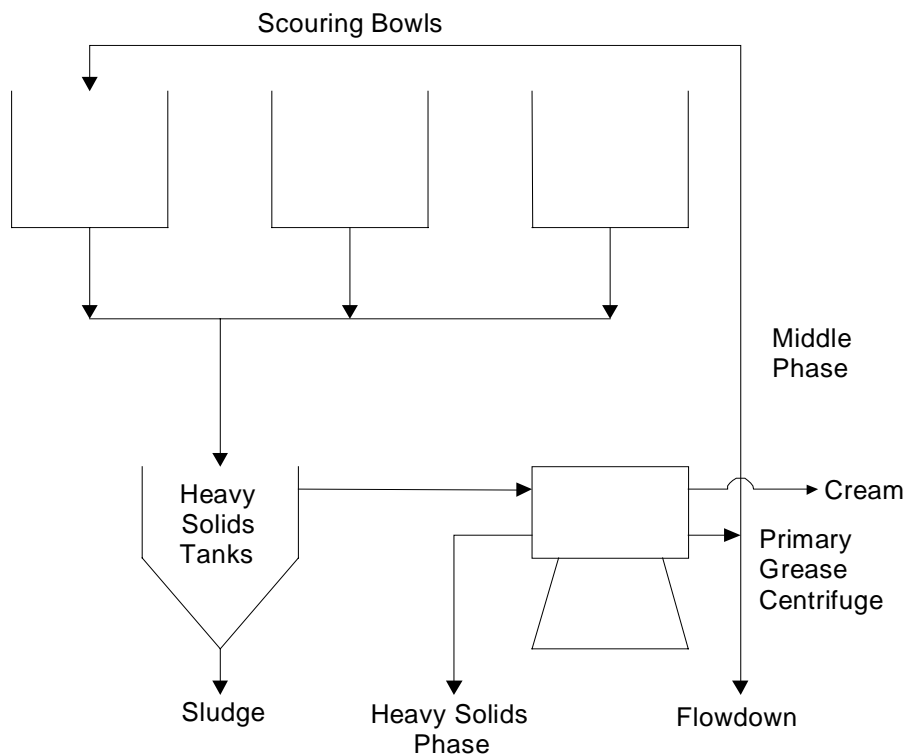


Figure 2 - Contaminant Recovery Loop for WRONZ Comprehensive Scouring System

Source: Christoe & Bateup, International Wool Secretariat: Wool Science Review, publication no. 64

In the recovery loop for the SIROSCOUR system the recovery loops for grease and dirt are completely separated, enabling both to be optimised, as shown in Figure 3. The feeds to the loops are taken from the top and bottom of the scouring bowls respectively. The primary dirt recovery device is a settling tank fitted with a lamella plate settler. A decanter centrifuge, which operates outside the recovery loops, dewateres the liquid sludges from the settling tanks and the primary grease centrifuge. Overall dirt recoveries, as a spadeable sludge vary from 40 - 60% on the amount originally present on the raw wool (IWS, undated, p. 33-p. 35).

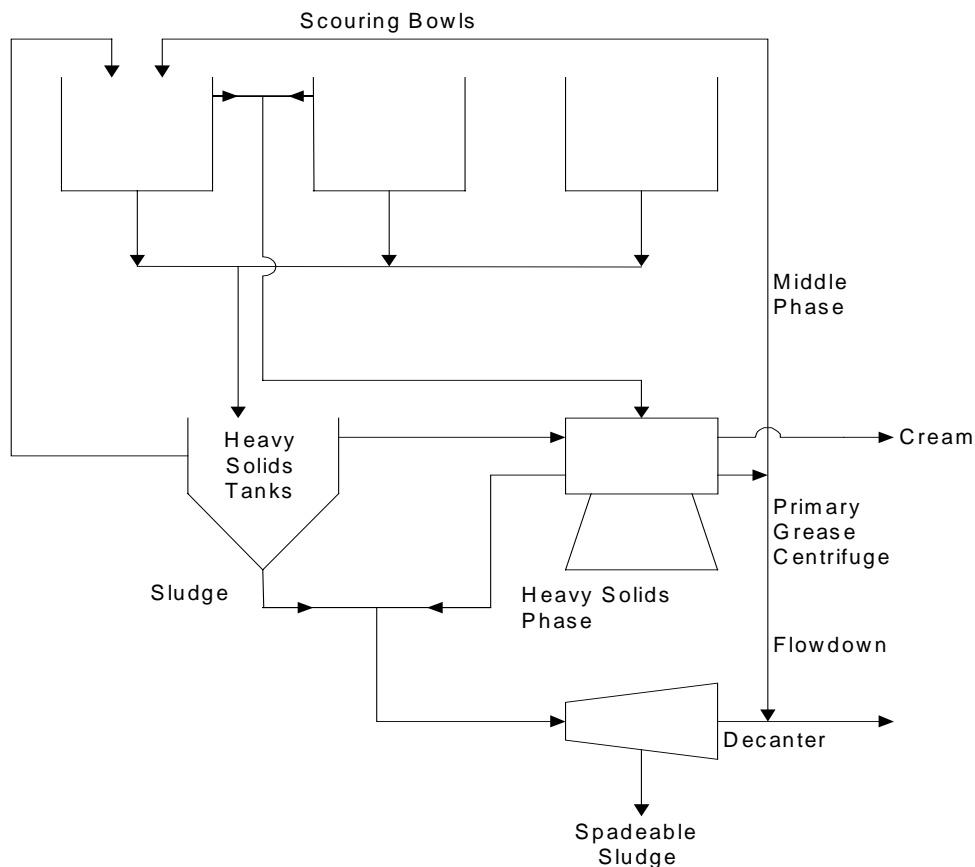


Figure 3 - Contaminant Recovery Loops for SIROSCOUR Scouring System

Source: Christoe & Bateup, International Wool Secretariat: Wool Science Review, publication no. 64

2.1.2 Wool Scouring Effluent Treatment Methods

Effluent from wool scouring is extremely polluting to the environment, containing high levels of organic wastes in addition to mineral dirt, making it very difficult to treat. Virtually every method for treating industrial effluent has been used with wool scouring effluent.

2.1.2.1 Biological Method

According to J. Christoe, 'biological treatments use microorganisms to convert the organic matter in an effluent into more microorganisms (by cell-growth) and respiration products. Aerobic treatments, which need oxygen to function, form carbon dioxide and water. Anaerobic treatments which exclude oxygen form carbon dioxide, methane and other reduction products, such as hydrogen sulfide' (Christoe, 1986)

2.1.2.2 Chemical Treatment

According to J. Christoe, 'with wool scouring effluent, chemicals are added to destabilise the extremely stable grease-dirt particles which remain suspended after centrifugation. Chemical destabilisation can be achieved in a number of ways, including acid cracking, chemical flocculation, emulsion destabilisation and solvent-extraction'.

'*Acid cracking* disrupts the ability of the detergent to stabilise the emulsion. It is more effective for soap than for the alkyl and alcohol ethoxylates currently used to scour wool. At pHs less than 8 (but preferably 2-3) the acid (sulfuric acid) reacts with the soap to produce free acid, which is then boiled and filtered through a plate filter press. On heating the press, the hot filtered grease appears as low quality acid cracked grease.'

'Most solid particles in solution have an electrical charge, which is usually negative. These charges cause particles to repel each other, preventing mutual attraction between them. *Coagulation* reduces these electrical charges so that the attractive forces can dominate to join the particles together and encourage their sedimentation.'

'*Flocculation* involves aggregating particles together using a chemical containing a number of functional groups. Electrical repulsion need not be reduced for flocculation to be successful. Polymeric flocculants having molecular weight of about 10 million Daltons, and a positive charge are usually used to improve the settling of scouring sludges in settling tanks.'

'If sufficient solvent is added to a scouring liquor, the detergent can no longer stabilise the organic phase. This causes the emulsion to break giving a grease-rich solvent phase. Solvents that have been used include alcohols such as butanol, pentanol and hexanol.' (Christoe, 1986)

2.1.2.3 Evaporation/Pyrolysis

According to J. Christoe, 'Wool grease has a calorific value (40 MJ/kg) which is comparable to fuel oil (43 MJ/kg). However, injecting a normal scour liquor into a furnace would be uneconomical because of the large quantities of water that are present.'

The usual method involves firstly increasing the solids content of the effluent to about 60-70% by passing it through a series of evaporators. The concentrate is then incinerated at 1200°C to produce heat. The only waste is ash from the furnace.' (Christoe, 1986)

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 (excluding roof vents) or stack and emitted through a single point source into the atmosphere.

Table 1 - Common Air Emissions of NPI-Listed Substances from Wool Scouring Processes

Substance		
Arsenic	Cobalt	Nickel
Boron	Copper	Oxides of Nitrogen (NO _x)
Cadmium	Lead	PM ₁₀
Carbon Monoxide (CO)	Manganese	Zinc
Chromium	Mercury	

Source: Queensland Environmental Protection Agency, 1999 Mercury

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. (Refer to the methods and procedures outlined in the *Combustion in Boilers EET Manual*).

With regards to emission controls for PM₁₀ 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 or tailings dam does not require you to report to the NPI (See also Section Three of *The NPI Guide*). Discharges to a tailings dam from this industry are unlikely.

2.2.3 Emissions to Land

It is normal practice for wool scour effluent to be applied to land, causing emissions to land. Other emissions of substances to land on-site include solid wastes, slurries, sediments, spills and leaks, storage and distribution of liquids. Emissions to land may contain listed substances. These additional emission sources can be broadly categorised as:

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

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.

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

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.

Table 2 is an example of a typical analysis of a suint concentrate.

Table 2 - Typical Analysis of Trace Heavy Metal Concentrate in Suint^{a,b}

Listed Pollutant	Concentration (mg/litre)
zinc	41
manganese	45
boron	42
lead	9
copper	3
nickel	2.5
chromium	1
cobalt	0.9
arsenic	0.4
cadmium	0.1
mercury	>0.1

Source: Bateup et al, *Effluent Management*, CSIRO Division of Wool Technology

^a Suint represents approximately 4% of effluent.

^b A normal suint concentrate has around 40% total solids concentration and 60% water.

In the event where analysis data is available, emissions to water can be calculated using the Equation 1. The application of this equation is shown in Example 1. It should be noted that Table 2 only represents data based on a typical case study.

Equation 1

$$E_{kpy,i} = C_i * V / 10^6$$

where:

$E_{kpy,i}$ = emissions of pollutant i (kg/yr)
 C_i = concentration of substance i in wastewater (mg/L)
 V = volume of wastewater (L/yr)
 10^6 = conversion of mg to kg (mg/kg)

Example 1 - Using Direct Measurement

A scouring facility discharges its wastewater to land. The scourer wants to calculate the annual wastewater emissions of lead in suint. This facility consumes an average of 300 000 litres/day over an assumed 300 working days/year. Table 2 lists an analysis of a typical suint concentrate of NPI-listed substances. Hence, the total amount of lead can be calculated using Equation 1 (for suint solids) and multiplying by the proportion of lead in suint.

$$\begin{aligned} V \text{ (Volume of wastewater)} &= 300\,000 \text{ L/day} * 300 \text{ day/yr} \\ &= 90 * 10^6 \text{ L/yr} \end{aligned}$$

From Table 2:

$$\text{Percentage of suint in the effluent} = 4 \%$$

$$\begin{aligned} E_{\text{kpy,suint}} \text{ (Emissions of suint in the effluent)} &= (C_{\text{suint}}) * V \\ &= (4/100) * (90 * 10^6) \\ &= 3.6 * 10^6 \text{ L / yr} \end{aligned}$$

To calculate E_{Pb} we first need the proportion of lead in suint:

$$\begin{aligned} (C_{\text{lead}}) \text{ Concentration of Pb in Suint} &= 9 \text{ mg/L of concentrate (Table 2)} \\ E_{\text{kpy,i}} &= C_i * V / 10^6 \\ &= (9 * 3.6 * 10^6) / 10^6 \\ &= 32.4 \text{ kg lead(Pb) per year} \end{aligned}$$

3.1.1 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.

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.

3.2.1 Emissions to Water and Air

Mass balance calculations for estimating emissions to air of NPI-listed substances can be represented conceptually by Equation 2.

Equation 2

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

where:

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

“Amount out_i” 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 air, or the amount of material transferred off-site as hazardous waste or to landfill. A thorough knowledge of the different destinations 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. By using this concentration data, Equation 3 can be applied as a practical extension of Equation 2 to estimate emissions of solvents and other volatile compounds that wool scouring facilities will emit to air.

The use of this equation should provide a reasonably accurate estimate in most cases, especially if other emissions are small compared with air emission losses. However, individual emissions of organic chemicals from storage tanks should be estimated using the methods and procedures outlined in the *Fuel and Organic Liquid Storage* EET Manual.

Equation 3

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

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 annually (generally expressed in kg for solids, L 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 (generally expressed in mg/kg for solids, mg/L for liquids)
10^6	=	conversion from milligrams to kilograms.

3.2.2 Emissions to Land

Where a facility uses a listed mineral acid or base, with this acid or base being effectively neutralised in use or during wastewater treatment (to a pH of 6 to 8, as required by most State and Territory effluent standards), no emission quantities should be reported. If the acid or base is itself transformed into another listed substance, however, the quantity of this substance coincidentally produced must be determined to assess if a threshold value has been reached. For example, sulfuric acid often yields hydrogen sulfide in effluent streams, which is itself a listed substance and require reporting where annual emissions total 10 tonnes or more.

Wastewater treatment may precipitate the reportable chemical in a 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. Alternatively, the loss in the sludge can be estimated by Equation 4. 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.

Equation 4

$$AS_{kgy, i} = (PL_i - WL_i) * OpHrs$$

where:

$AS_{kgy, i}$	=	amount of pollutant i in sludge (kg/yr)
PL_i	=	process losses of pollutant i (kg/hr)
WL_i	=	losses from wastewater of pollutant i (kg/hr)
$OpHrs$	=	operational hours (hr/yr)

For many chemicals used and emitted during chemical processes, some degradation in treatment may occur so that not all the chemical is 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.

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 SO₂, 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 *Combustion in Boilers* EET Manual can be used to calculate other combustion emissions.

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

Equation 5

$$E_{kpy,i} = Q_f * \text{pollutant concentration in fuel}/100 * (MW_p / EW_f) * \text{OpHrs}$$

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
		Concentration of pollutant i in fuel expressed as weight percent, %

For instance, SO₂ 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 SO₂. Therefore, for every kilogram of sulfur (EW = 32) burned, two kilograms of SO₂ (MW = 64) are emitted. The application of this EET is shown in Example 2.

Example 2 - Using Fuel Analysis

This example illustrates how SO₂ emissions can be calculated from oil combustion based on fuel analysis results and the fuel flow information from a wool scourer. The wool scourer is assumed to operate 1500 hr/yr.

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

Fuel flow (Q_f) = 2000 kg/hr
Weight percent sulfur in fuel = 1.17 %
OpHrs = 1500 hr/yr

$$\begin{aligned} E_{kpy,SO_2} &= Q_f * \text{pollutant concentration in fuel}/100 * (MW_p / EW_f) * \text{OpHrs} \\ &= (2000) * (1.17/100) * (64 / 32) * 1500 \\ &= 46.8\text{kg/hr} * (1500 \text{ hr/yr}) \\ &= 70\,200\text{kg/yr} \end{aligned}$$

3.4 Emission Factors

An emission factor is a tool that is used to estimate emissions to the environment. Emission factors 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

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

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, (%)

Presently, there are no existing emission factors available for the wool scouring industry. However, emissions can be developed specifically for specific processes. 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 your State or Territory environment agencies prior to its use for NPI estimations.

3.4.1 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 which 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 wool scouring 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.

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 wool scouring 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 wool scouring processes.

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 wool scouring facility using mass balance appears to be a straightforward approach to emission estimations. However, it is likely that few Australian wool scouring 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 often 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 ± 5 percent in any one step of the operation can significantly skew emission estimations.

4.3 Engineering Calculations

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

Use of emission equations to estimate emissions from wool scouring 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

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The following Emission Estimation Technique Manuals are available at the NPI Homepage (<http://www.npi.gov.au>) and from your local environmental protection agency (see the front of the NPI Guide for details):

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