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Department of the Environment, Water, Heritage and the Arts



National Pollutant Inventory

**Emission estimation
technique manual
for**

**Maritime operations
Version 2.0**

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**EMISSION ESTIMATION TECHNIQUES
FOR
MARITIME OPERATIONS
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1 Introduction

The purpose of all emission estimation technique (EET) manuals 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 maritime operations.

Activities covered in this manual apply to facilities primarily engaged in the operation of ports (i.e. the loading and unloading of freight), maintenance and general upkeep of ocean going and inland water vessels. This manual does not cover facilities engaged in shipbuilding, refit, overhauls, and dry-docking activities.

EET MANUAL:		Maritime operations
ANZSIC CODE	2006	All applicable activities within the ANZSIC Groups 239, 261, 281, 291, 292, 310, 332, 349, 481, 482, 521,529, 530, and 771.

Note that the ANZSIC code is part of NPI reporting requirements. The *NPI Guide* contains an explanation of the ANZSIC code.

Pacific Air and Environment (PAE) drafted this manual on behalf of the Australian Government. It has been developed through a process of national consultation involving state and territory environmental authorities and key industry stakeholders.

NPI substances are those that when emitted at certain levels have the potential to be harmful. Australian, state and territory governments have agreed, in response to international requirements to provide information to the community, that industries will report these emissions on an annual basis. NPI substances are set out in the *NPI Guide* and are listed in categories which have a threshold; i.e. once annual 'use' of substances or fuels is above the threshold their emissions and transfers must be reported.

NPI emissions in the environmental context

It should be noted that the NPI reporting process accounts for emission estimates only. It does not attempt to relate emissions to potential environmental impacts, bioavailability of emissions, natural background levels etc.

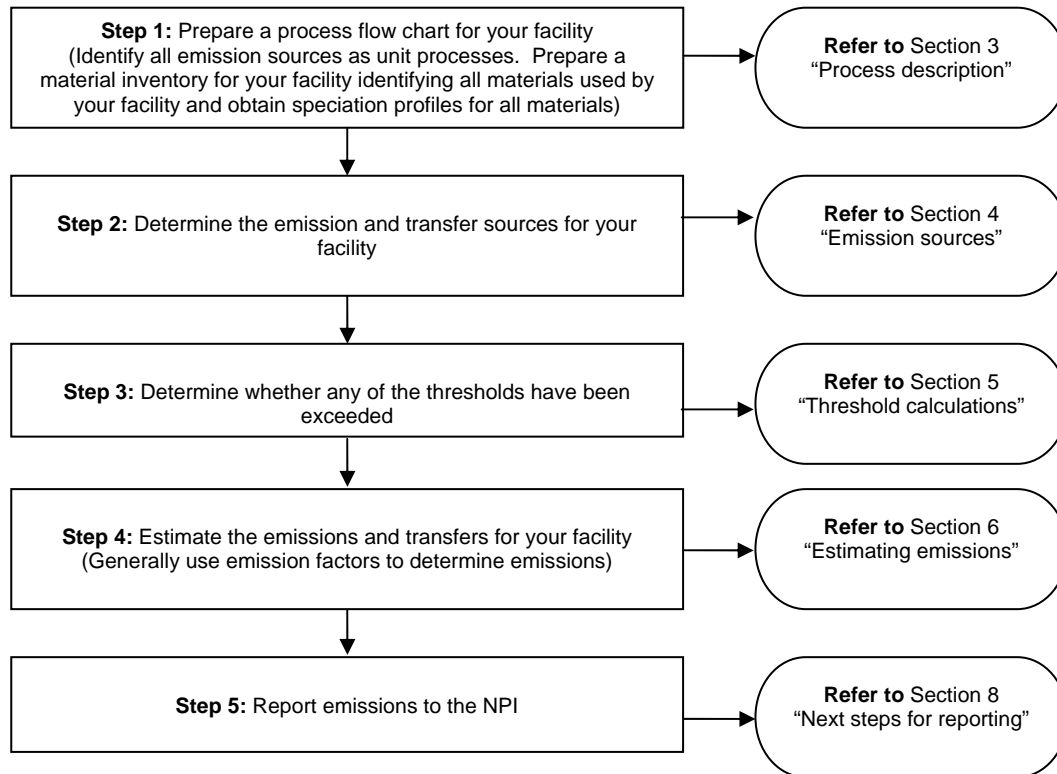
Facilities may undertake 'Ancillary activities', such as the production of substances, either as a process input or through processing of waste streams. When estimating emissions, a facility should ensure that emissions are not 'double accounted' and process maps should be used to minimise the potential for this.

This manual is structured to allow facilities to work through the manual addressing issues in a structured and coherent manner.

Likely emissions from maritime operations and the approach to emissions estimation are discussed in Section 4 of this manual.

1.1 The process for NPI reporting

The process for NPI reporting can be seen in the following flow chart below.



1.2 Information required to produce an annual NPI report

Typical data that will need to be collated for the reporting period is outlined in Table 1.

Table 1: Typical data required to produce an annual NPI report

Process	Data to collect each reporting year
Materials inventory	Mass of all materials that cross your facility boundary (e.g. coal, bauxite, diesel, petrol, crude oil, paints, solvents, alumina)
	Speciation profiles for all materials used at your facility. Locations of default material speciation profiles is provided in Table 4
Vessels at berth	Details of auxiliary engines and boilers, fuel use and the time in port for vessels at berth
Training fires	Type and amount of fuel used in training fire activities
Fuel storage	An inventory of fuel and organic liquid storage tanks at your facility showing the following: <ul style="list-style-type: none"> • tank type (e.g. horizontal fixed roof tank, vertical fixed roof tank) • material stored • tank capacity • throughput during the reporting year for each tank
Bulk dry material handling	Total amount of each material loaded to vessels in the reporting year
	Total amount of each material unloaded from vessels in the reporting year
	Surface area of bulk dry material stockpiles
	Number of conveyor transfer points at your facility for transferring bulk dry material
Bulk volatile material loading	Total amount of each volatile material loaded to vessels and the type of vessel loaded to (i.e. ocean vessel or barge)
Landside vehicle operation	Total amount of fuel combusted in landside vehicles used on-site
	Total vehicle kilometres travelled on site by landside vehicles on unpaved roads
Maintenance operations	Total amount of each surface coating type used on site during the reporting year
	Total amount of abrasive material used during the reporting year for abrasive blasting
	Total amount of each solvent type used on site during the reporting year
Ancillary equipment operation	Total amount of fuel combusted in each boiler/space heater type
	Type of boiler/space heater (e.g. output capacity, low NO _x , wall or tangentially fired)
	Total amount of fuel combusted in each stationary internal combustion engine
	Type of internal combustion engine (e.g. rated capacity, low NO _x)
Water emissions	Total amount of water discharged during the reporting year
	Concentration of NPI substances in water discharged
Spills	Total amount of each material spilled
	Total amount of material removed/recovered after each spill

1.3 Additional reporting materials

This manual is written to reflect the common processes employed in the maritime operations industry. In many cases, it will be necessary to refer to other EET manuals to ensure a complete report of the emissions for the facility can be made. Other applicable EET manuals may include, but are not limited to:

- Shipbuilding repair and maintenance
- Combustion in boilers
- Combustion engines
- Mining
- Fuel and organic liquid storage
- Surface coating
- Fugitive emissions
- Sewage sludge and biomedical waste incineration, and
- Other industry-specific emission estimation technique manuals.

2 Reporting requirements

The purpose of this EET manual is to provide guidance on the characterisation of emissions from those activities specifically associated with maritime operations. There may be certain activities which lead to emissions of NPI substances that are not covered by this manual. In this situation refer to Table 3 to determine which other NPI EET manuals are likely to assist you in estimating your emissions of NPI substances. If further advice is required contact your state or territory environment agency whose contact details are in the *NPI Guide* and on the NPI website at www.npi.gov.au.

This maritime operations manual applies to shore based facilities located at Australian ports, either privately owned or controlled by a Port Authority. Ports may be comprised of several facilities occupied by many individual tenants of a Port Authority who are separate from the Port Authority. Ports may also include power stations and other facilities not directly associated with the maritime industry. Some ports have only one occupier, the owner.

2.1 NPI facility occupier

The NPI NEPM defines ‘occupier’ as a person who is in occupation or control of a facility whether or not that person is the facility owner.

In the case of a port, the facility occupier could be, for example, a stevedoring company, a petroleum company, a mineral exporter, or a shipbuilding company. The Port Authority would also be regarded as the facility occupier for any activities directly under its control.

2.2 Operational control

Under the NPI, occupiers of facilities are required to report emissions of NPI substances if the relevant thresholds are exceeded.

At some facilities, sites or locations (such as ports, airports and mine sites), activities can be carried out by separate business entities and reporting responsibilities may not be obvious.

In the NPI, the definition of facility is as follows:

facility means any building or land together with any machinery, plant, appliance, equipment, implement, tool or other item used in connection with any activity carried out at the facility, and includes an offshore facility. The facility may be located on a single site or on adjacent or contiguous sites owned or operated by the same person.

Under this definition it is possible for the same site to have more than one occupier and thus be a ‘facility’ for more than one entity for the purposes of reporting.

To clarify reporting responsibilities in these instances, the NPI uses the concept of ‘operational control’. Operational control is a concept used internationally to allocate responsibility, for reporting data, to the entity with the greatest ability to influence the introduction and implementation of environmental policies. A business entity is deemed to have the reporting responsibility for an activity when it has operational control of that activity.

2.2.1 Who has operational control?

An occupier of a facility is considered to have operational control over an activity at a facility if it has the authority to introduce and implement the operating, health and safety and/or environmental policies for that activity at the facility.

2.2.2 What if it is uncertain who has control?

If there is uncertainty as to which business entity has operational control over an activity, the one with the greatest authority to introduce and implement operating and environmental policies will deem to be.

Occupiers of facilities often have differing and complex contractual arrangements in place and may need to seek further advice to determine operational control in their specific situation.

General guidance on how to determine operational control over a facility is contained in the following figures.

Figure 1. Determining whether your business entity has responsibility for reporting emissions for activities carried on a particular site

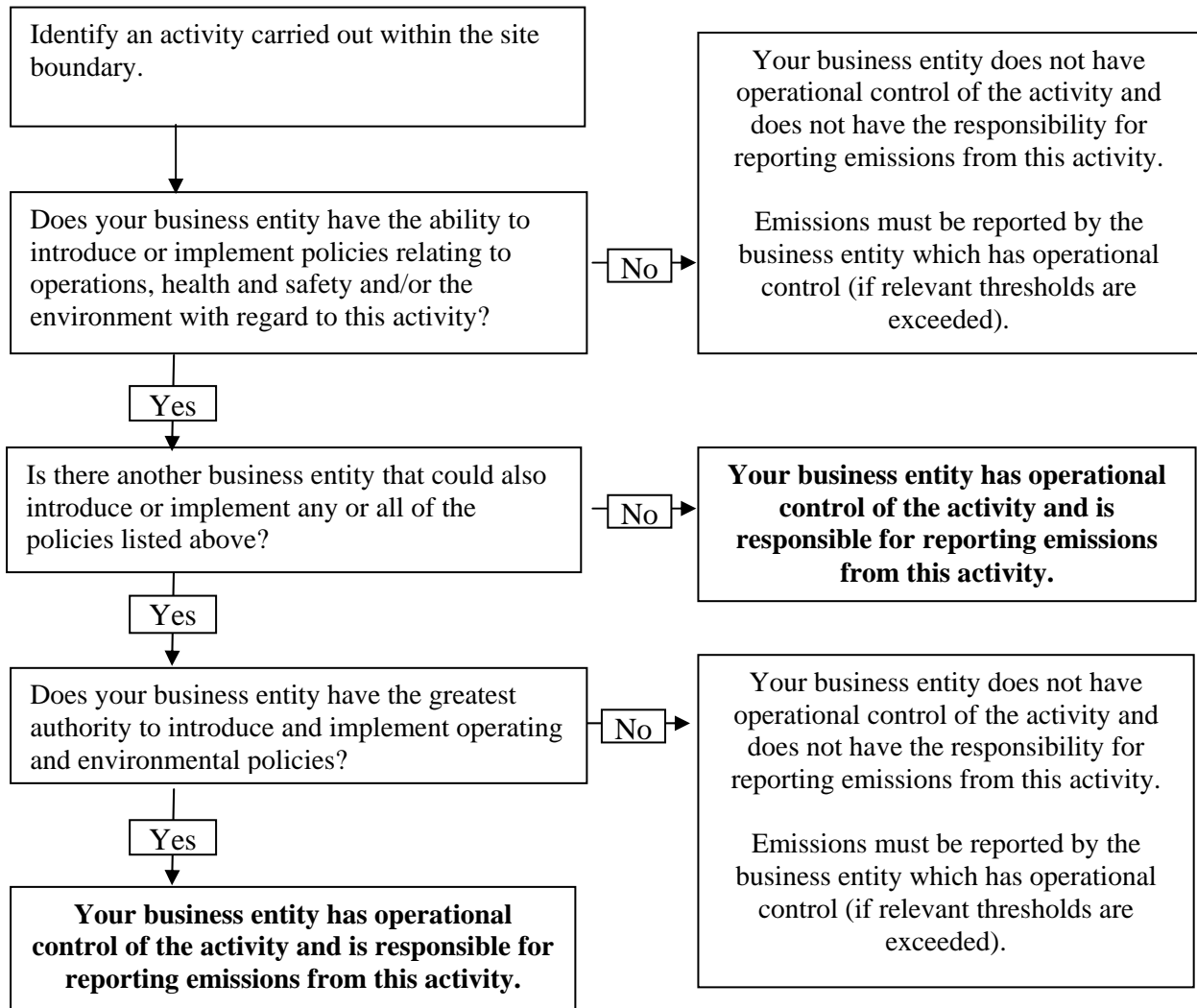
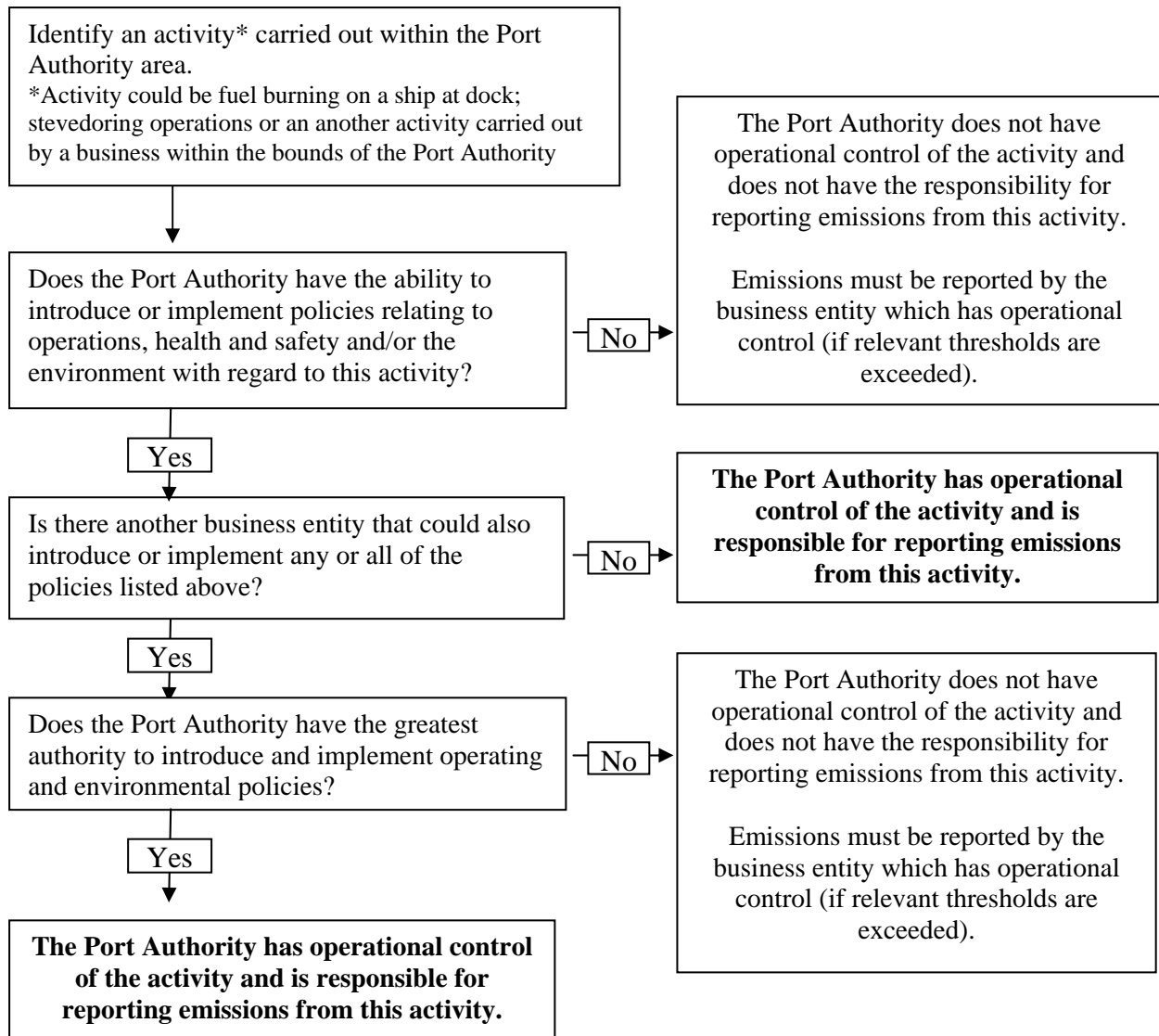


Figure 2. Determining whether a Port Authority has responsibility for reporting emissions for activities carried out within the Port Authority area



The following table provides a summary of reporting requirements based on activities which are likely to occur at a port.

Table 2: Reporting requirements for maritime operations

Activity	Emission source	Reporting responsibilities
Vessels at berth	Auxiliary engines	Occupier
	Auxiliary boilers	Occupier
Training fires	Training fires	Occupier
Fuel storage	Fuel storage	Occupier
Bulk dry material handling (including use of equipment such as loaders)	Loading of dry material	Occupier
	Unloading of dry material	Occupier
	Wind erosion of dry material in storage	Occupier
Bulk volatile material loading	Bulk volatile material loading	Occupier
Landside vehicle operation	Exhaust emissions	Occupier
	Wheel generated dust	
Maintenance operations	Painting	Occupier
	Abrasive blasting	Occupier
	Equipment cleaning	Occupier
Ancillary equipment operation	Boilers and space heaters	Occupier
	Emergency generators	Occupier
	Incinerators	Occupier
Ship	Standing off-shore	Environmental agency
	Underway in channel	Environmental agency
	Oil spillage from vessel in berth	Occupier ^a
	Oil spillage from vessel in channel	Environmental agency
Sub-threshold tenants		Environmental agency

^a If facility disputes ownership of the spill the issue is to be considered as a 'disputed data' issue.

3 Process description and emissions

The following section presents a brief description of the activities that occur in the maritime industry, and identifies the likely sources of emissions. Even though this manual describes processes at a typical facility in the industry, you should develop a process flow diagram specific to your site.

Australian ports range in size from a couple of hectares to over a thousand hectares and their activities encompass a wide range of processes. Many port facilities may be the equivalent of a small industrial estate and display the entire infrastructure - such as wastewater treatment plants, roads, vehicle maintenance and repair workshops, and other aspects - associated with any such environment. Much of the support activity associated with this infrastructure is commercial and industrial in nature and involves many individual tenants who are often quite separate from the operations responsible for overall port management. Accordingly, these operations can be seen as analogous to an industrial estate and treated as such for NPI reporting.

The majority of the raw materials and wastes associated with a marine facility are related to maintenance services provided to vessels. The *EET* manual for *Shipbuilding repair and maintenance* covers these aspects in detail. A considerable amount of diesel powered equipment, such as forklifts, tractors and front-end loaders, is used at a typical marine facility. EETs for air emissions from on-site vehicles are included in the *EET* manual for *Combustion engines*.

Bulk storage of liquid materials in above- or below-ground tanks and transfers of such materials provide a potential for emissions to air, water and land from leaks and spills. Dry bulk cargo handling generates dust emitted to air or deposited on land and subsequently discharged to water by storm or wash-down water. For estimating total suspended particulate material emissions, including the NPI substance PM₁₀, refer to the most recent version of the *EET* manual for *Mining*.

The first step in working out emissions of NPI substances from your facility is to create a process flow diagram and highlight points in the process where emissions may occur.

Generally, the following emission sources exist at facilities undertaking maritime operations.

Vessels at berth

Typical activities include the use of auxiliary engines and boilers while a ship is at berth.

Training fires

Conducting training fires leads to emissions of combustion products. Typically, fuels such as JP4, JP5, JP8, propane or Tekflame are used for fire training.

Fuel storage

The storage of fuels and organic liquids leads to emissions of volatile organic compounds (VOCs). These emissions may contain a number of NPI substances, including polycyclic aromatic hydrocarbons (PAHs).

VOC emissions from storage tanks occur as a result of both standing and working losses. Standing loss is the expulsion of vapour from a tank through vapour expansion and contraction, which are the result of changes in temperature and atmospheric pressure. This loss occurs without any liquid level change in the tank. The combined loss from filling and emptying is called working loss. Evaporation during filling operations is a result of an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapours are expelled from the tank. Evaporative loss during emptying occurs when air drawn into the tank during liquid removal becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space (USEPA, 2006).

Bulk dry material handling

Handling of bulk dry material (e.g. coal, bauxite, alumina, aluminium fluoride, coke) leads to emissions of particulate matter (PM₁₀) and emissions of trace compounds contained in the bulk material to air. Runoff from stockpiles can also lead to emissions of NPI substances to water and transfers to wastewater treatment facilities.

Handling emissions are generated from material transfers (e.g. conveyor to conveyor, conveyor to stockpile, front end loaders handling material and ship loading).

Furthermore, wind erosion of bulk dry materials will lead to emissions of particulate matter and trace compounds contained in the bulk material to air.

Bulk volatile material loading

Loading of petroleum liquids to ships/ocean vessels and barges results in emissions to air as organic vapours in 'empty' cargo tanks are displaced by the liquid being loaded into the tanks (USEPA, 2001). Vapours displaced from vessel tanks are a composite of vapours formed in three ways (USEPA, 2001):

- vapours which are formed in the 'empty' tank by evaporation of residual product from previous loads
- vapours transferred to the tank from a vapour balance system that was used when the previous load was being unloaded, and
- vapours generated in the tank as the new product is being loaded.

Loading losses are usually the largest source of evaporative emissions from petroleum vessels. This activity usually only occurs at refineries or at the terminal at the end of the pipeline where the product is loaded for distribution.

Landside vehicle operation

The operation of landside vehicles on-site leads to emissions to air of combustion products. Furthermore, particulate matter is generated from wheel generated dust caused by brake wear and disturbance of road material from vehicle movements.

Maintenance operations

Typical maintenance operations that occur at maritime facilities include:

- painting
- abrasive blasting, or
- equipment cleaning.

Maintenance operations lead to emissions to air of Total VOCs and speciated VOCs from solvent evaporation and emissions of particulate matter and trace metals from abrasive blasting. Spills of paints and solvents can lead to emissions to water of Total VOCs and speciated VOCs. Disposal of waste solvents and paints to hazardous waste facilities is considered a mandatory transfer of reportable NPI substances.

Ancillary equipment operation

Other ancillary equipment commonly found at maritime operation facilities include:

- boilers and space heaters for electricity generation or heating
- emergency generators for electricity supply, or
- incinerators for waste disposal.

The use of this equipment leads to emissions to air of combustion products that are reportable to the NPI.

4 Emission sources

General information regarding emission sources can be obtained from the *NPI Guide*.

Expected emission sources and substances released from each emission source are provided in Table 3. It is noted that additional sources may exist at some facilities and that Table 3 provides information on common sources at port facilities.

4.1 Emissions to air

Air emissions may be categorised as fugitive emissions or point source emissions.

4.1.1 Point source emissions

Point source emissions are directed into a vent or stack and emitted through a single stationary point source into the atmosphere. Examples of point source emissions include operation of vessels in port (auxiliary engine exhaust and operation of the auxiliary boiler) and emissions from on-site power generation (e.g. stationary diesel generator).

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 processing off-gases before emission through a stack. The collection efficiency of the abatement equipment needs to be considered where such equipment has been installed, and where emission factors from uncontrolled sources have been used in emission estimations.

4.1.2 Fugitive emissions

These are emissions not released through a vent or stack. Examples of fugitive emissions include emissions from vehicles, dust from stockpiles, volatilisation of vapour from vats and open vessels, or spills and materials handling. Emissions emanating from ridgeline roof-vents, louvers, and open doors of a building as well as equipment leaks, such as from valves and flanges are also examples of fugitive emissions. Estimating emissions using emission factors is the usual method for determining losses from fugitive emission sources.

4.2 Emissions to water

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

- surface waters (lakes, rivers, dams, estuaries)
- coastal or marine waters, and
- stormwater runoff.

Emissions of substances to waterways may pose environmental hazards. Most facilities emitting NPI listed substances are required by their state or territory environment agency to closely monitor and measure these emissions. These existing sampling data can be used to calculate annual emissions to the NPI.

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

Discharge of listed substances to a sewer or tailings dam is not regarded as an emission but is reportable as a transfer. Further guidance on reporting transfers is provided in the *NPI Guide* and in Section 7 of this manual.

4.3 Emissions to land

Emissions of substances to land include solid wastes, slurries, sediments, spills and leaks, storage and distribution of liquids, and such emissions may contain NPI listed substances. Emission sources can be categorised as:

- surface impoundments of liquids and slurries, or
- unintentional leaks and spills.

Some facilities may use treated wastewater for irrigation. This wastewater need only be considered for NPI reporting (emissions to land) if it contains NPI listed substances.

Table 3: List of possible emission sources at port facilities

Operation	Unit process	NPI substances potentially emitted	Destination and emission estimation technique		
			Air	Land	Water
Vessels at berth	Auxiliary engines and boilers	Combustion products	Section 6.2.2.2.2 of this manual		
Training fires	Training fires	Combustion products	Section 6.2.2.2.2 of this manual	NA	NA
Fuel storage	Fuel storage	Total VOCs and speciated VOCs	EETs are outlined in the NPI EET Manual for <i>Fuel and organic liquid storage</i>	Potential for spills. See Section 6.3.1.3.1	Potential for spills. See Section 6
Bulk dry material handling	Loading of dry bulk material	Particulates	EETs are outlined in the <i>NPI EET Manual for Mining</i>	NA	NA
	Unloading of dry bulk material	Particulates	EETs are outlined in the NPI EET Manual for <i>Mining</i>	NA	NA
	Storage of dry bulk materials	Particulates	EETs are outlined in the NPI EET Manual for <i>Mining</i>	NA	Potential for diffuse runoff due to rain. See Section 6.
Bulk volatile material loading	Bulk volatile material loading	Total VOCs and speciated VOCs	Section 6.2.5.2.5 of this manual	Potential for spills. See Section 6.	Potential for spills. See Section 6.
Landside vehicle operation	Exhaust emissions from vehicles	Combustion products	EETs are outlined in the NPI EET Manual for <i>Combustion engines</i>	NA	NA

Operation	Unit process	NPI substances potentially emitted	Destination and emission estimation technique		
			Air	Land	Water
Maintenance operations	Painting	Total VOCs and speciated VOCs	EETs are outlined in the NPI EET Manual for <i>Surface coating</i>	NA	NA
	Abrasive blasting	Particulates	EETs are outlined in the NPI EET Manual for <i>Shipbuilding and maintenance</i>	NA	NA
	Equipment cleaning	Total VOCs and speciated VOCs	EETs are outlined in the NPI EET Manual for <i>Shipbuilding and maintenance</i>	NA	NA
Ancillary equipment operation	Boilers and space heaters	Combustion products	EETs are outlined in the NPI EET Manual for <i>Boilers</i>	Potential for fuel leakage and spills. See Section 6.	Potential for fuel leakage and spills. See Section 6.
	Emergency generators	Combustion products	EETs are outlined in the NPI EET Manual for <i>Combustion engines</i>	Potential for fuel leakage and spills. See Section 6.	Potential for fuel leakage and spills. See Section 6.
	Incinerators	Combustion products	EETs are outlined in the NPI EET Manual for <i>Sewage sludge and biomedical waste incineration</i>	NA	NA

5 Threshold calculations

The NPI has six different threshold categories, and each NPI substance has at least one reporting threshold. If an NPI substance exceeds a threshold all emissions of that substance from the facility must be reported. For Category 1 substances this will mean reporting any substance where the use exceeds the threshold. For Category 2 substances this will mean reporting either Category 2a and/or 2b substances depending on which of the thresholds have been exceeded. If emissions or transfers of either Total Nitrogen or Total Phosphorus exceed the threshold then emissions of both must be reported.

If the ‘use’ of any NPI substance or fuel exceeds the threshold, all of the emissions of that substance from the facility must be reported. In the case of maritime operations, the main ‘uses’ are:

- use and transfer of fuel in vessels
- use of fuel in landside vehicles and stationary engines, and
- use of substances contained in materials transferred to and from vessels (e.g. trace metals in coal and iron ore (for instance arsenic and mercury)).

Other on-site operations may also result in threshold exceedences, including the transfer of NPI substances in waste.

The *NPI Guide* outlines detailed information on thresholds and identifying emission sources. The method involves identifying any NPI substances that may be used by your facility, or are components of materials used by your facility, and then calculating whether the quantity used exceeds the NPI threshold. The NPI thresholds that are applicable to facilities within the maritime operations sector include Categories 1, 1a, 1b, 2a and 2b substances. In the case of Category 1, 1a and 1b substances they must be reported if use exceeds the threshold. In the case of Category 2 substances, if burning exceeds the threshold then all Category 2a and 2b substances must be reported.

The thresholds for substances that are expected to be tripped for maritime operations are:

- Category 1 thresholds from the receipt of materials containing NPI substances
- Category 2a or 2b threshold from the combustion of fuel.

The following flowchart (Figure 3) outlines the process the user should work through to determine whether the facility has tripped a threshold for reporting Category 1, Category 1a and Category 1b substances.

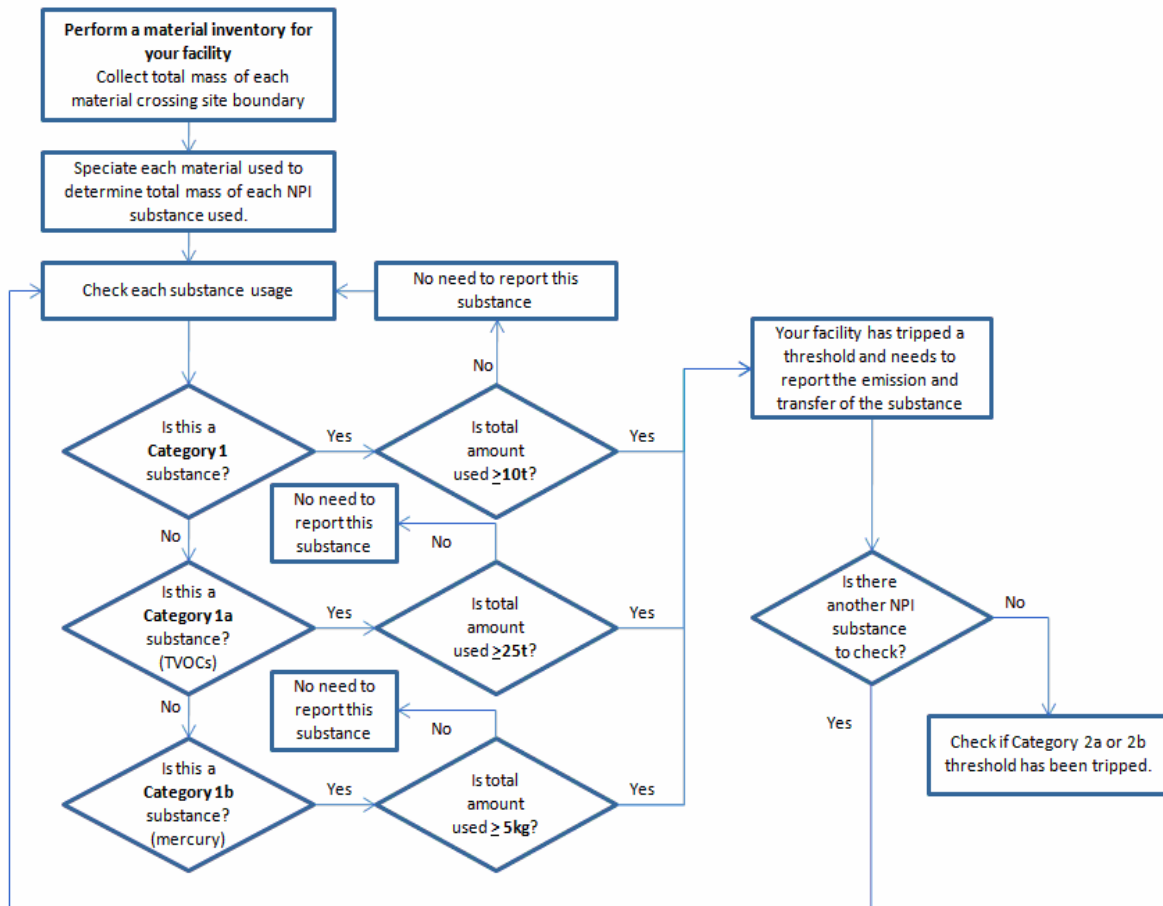


Figure 3: Determining whether the Category 1, Category 1a or Category 1b reporting thresholds have been tripped

The first step in determining whether Category 1, 1a or 1b reporting thresholds have been tripped is preparing a materials inventory for your facility.

When preparing a materials inventory, you should record the mass of all materials that have been used at your site including materials that are unloaded at your facility and loaded onto vessels. For example, the mass of

- coal
- iron ore
- bauxite, and
- other mineral ores.

Also, the mass of fuels that cross your site boundary needs to be recorded including:

- diesel
- petrol, and
- residual oil.

Furthermore, the mass of substances used for ancillary activities such as maintenance works and equipment cleaning is required to be included to determine the total mass of each NPI substance used at the facility. These materials could include paints and solvents.

The next step is to determine the amount of each NPI substance in each material used during the reporting year. This process is called **material speciation**. Material speciation profiles are profiles that detail the concentration of each substance (or species) within each material. Material speciation profiles can be obtained from Material Safety Data Sheets (MSDSs) or from the supplier of the material. If site specific material speciation profiles are not available, use the speciation profiles detailed in Table 4.

Table 4: Location of material speciation profiles

Material	Location of material speciation profile
Coal	NPI EET Manual for <i>Mining</i> NPI EET Manual for <i>Fossil fuel electric power generation</i>
Bauxite	NPI EET Manual for <i>Alumina refining</i>
Petrol	NPI EET Manual for <i>Fuel and organic liquid storage</i>
Diesel	
Residual oil	
Fuel oil	
Crude oil	
Naphtha	
Paints	NPI EET Manual for <i>Surface coating</i>
Solvents	

Example 1– Calculating the total mass of Category 1 substances used

This example shows how the usage of manganese and compounds is calculated from a facility that handles coal and bauxite. The following data are available:

Mass of coal used = 100,000 tonnes/year
 Mass of bauxite used = 2,540,000 tonnes/year

Concentration of manganese and compounds in coal handled = 41 g/tonne

Concentration of manganese and compounds in bauxite handled = 70 g/tonne

Mass of manganese and compounds used in reporting period
 = (100,000 x 41/1000 + 2,540,000 x 70/1000)/1000
 = 182 tonnes

In this example, the total mass of manganese and compounds used by the facility is 182 tonnes. Therefore, the Category 1 threshold for manganese and compounds has been triggered and all emissions and transfers to mandatory reporting destinations of manganese and compounds must be reported to the NPI.

The following flowchart (Figure 4) outlines the process the user should work through to determine whether the facility has tripped a threshold for reporting Category 2 substances.

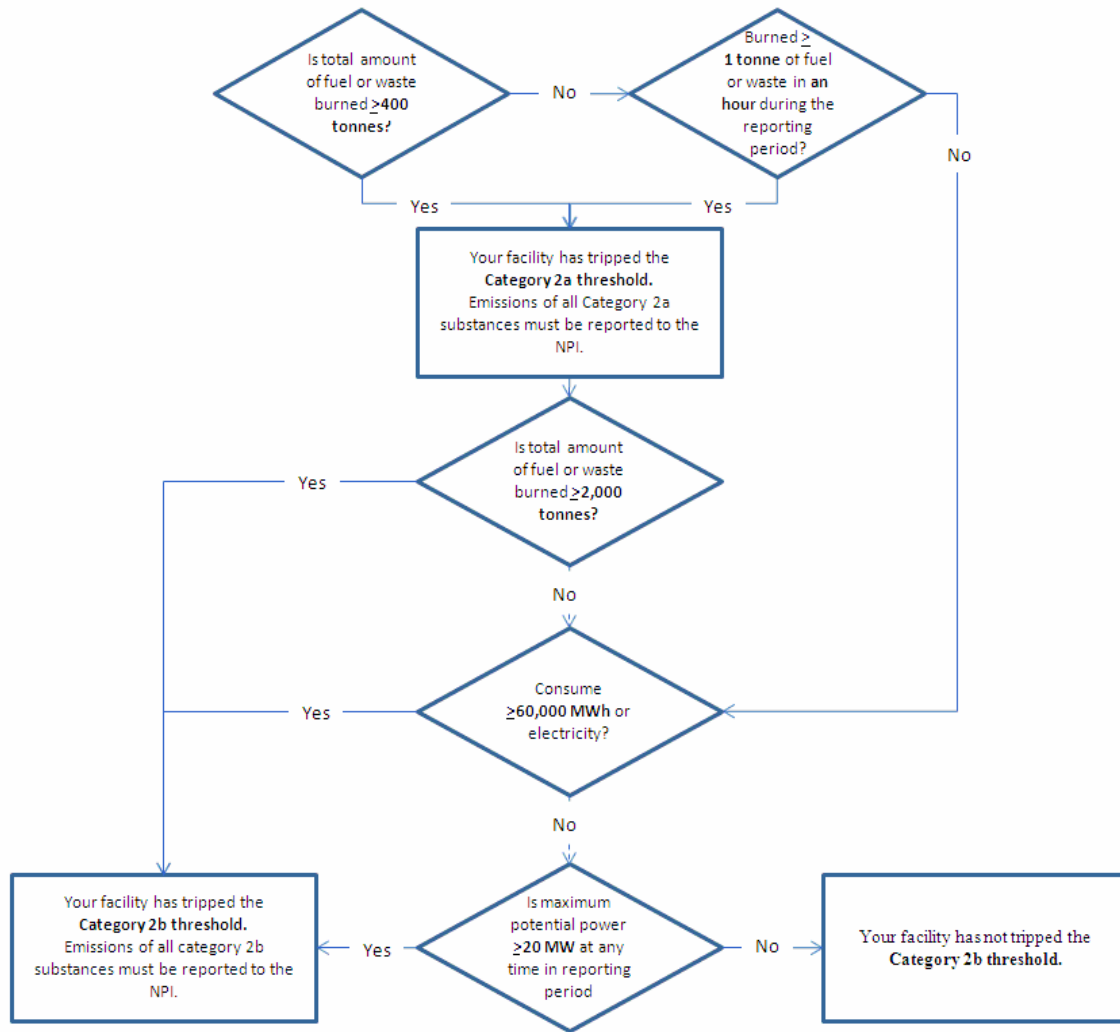


Figure 4: Determining whether the Category 2a and Category 2b reporting thresholds have been tripped

Note that electricity use is for other than lighting or motive purposes.

Category 2a substances and thresholds

This category contains a group of substances that are common products of combustion or other thermal processes. The NPI reporting thresholds for this category are:

- burning of 400 tonnes or more of fuel or waste in a year, or
- burning of 1 tonne or more of fuel or waste in an hour at any time during the reporting year.

Category 2b substances and thresholds

This category also contains substances that are common products of combustion or other thermal processes and includes all Category 2a substances. It also includes metals and compounds emitted when fuels (especially coal and oil) are burnt. The NPI thresholds for this category of substances are:

- burning 2,000 tonnes or more of fuel or waste in the reporting year
- consuming 60,000 megawatt hours or more of electrical energy for other than lighting or motive purposes in the reporting year, or

-
- a facility that has maximum potential power consumption of 20 megawatts or more for other than lighting or motive purposes in the reporting year.

If your facility trips any of the Category 2 thresholds you must estimate and report any emissions of the substances listed under these categories. Note, apart from PM_{2.5}, emissions from all sources, not just combustion sources, need to be estimated.

Transfers of Category 2 substances are not reportable. However, many Category 2 substances are also Category 1 or Category 1b substances. If the Category 1 or 1b threshold has been exceeded then transfers to mandatory transfer destinations must be reported.

6 Emission estimation techniques

If you have established under Section 5 that your facility exceeds NPI thresholds, you will need to estimate the total mass of NPI substances emitted.

There are five types of emission estimation techniques (EETs) that may be used to calculate emissions from your facility. These are:

- sampling data or direct measurement
- mass balance
- fuel analysis or engineering calculations
- emission factors, and
- an approved alternative.

Generally, maritime operations facilities estimate emissions using the emission factor, direct measurement or mass balance methods that are described in this section. Descriptions of the other emission estimation techniques can be found in the *NPI Guide*.

Select the EET (or mix of EETs) that is most appropriate for your purposes. For example, you might choose mass balance to 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 the relevant environmental agency has approved the use of EETs that are not outlined in this manual, your data will also be displayed as being of acceptable reliability.

This manual seeks to provide the most effective emission estimation technique for the NPI substances relevant to the maritime operations industry. However, the absence of an EET for a substance in the manual does not 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 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 (e.g. spills) will also need to be estimated. The emission resulting from a spill is the net emission, i.e. the quantity of the NPI reportable substance spilled, less the quantity recovered or consumed immediately (within 24 hours) during clean up operations.

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

independently of the applied EET, then there would be little gain in applying a different EET which requires significant additional sampling.

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

- for Category 1, 1a and 1b substances, identify which reportable NPI substances are used (or handled by way of their incidental presence in ore or materials), and determine whether the amounts used or handled are above the 'threshold' values and therefore trigger reporting requirements
- for Category 2a and 2b substances, determine the amount and rate of fuel (or waste) burnt each year, the annual power consumption and the maximum potential power consumption, and assess whether the threshold limits are exceeded
- for Category 3 substances, determine the annual emissions to water and assess whether the either threshold limit is exceeded, and
- 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 method.

6.1 Direct measurement

You may wish to use direct measurement in order to report to the NPI, particularly if you already do so in order to meet other regulatory requirements. If this is the case, the NPI does not require you to undertake additional sampling and measurement.

Monitoring data can be expressed in a range of units. The following discussion may be of assistance when converting monitoring results into annual emission estimates for the purposes of the NPI. It is important to remember that the calculation of annual emissions must also take into account the number of hours per year the source is discharging to the environment.

Stack data is commonly presented in terms of either actual flow, or a 'normalised' flow. The difference is that normalised data is standardised to a particular temperature and pressure, typically 0°C and 1 atm respectively. However, sometimes it may be referenced to 25°C and 1 atm. The following terms may be used when presenting data:

- Acm or Am³– actual cubic metre (at actual temperature and pressure),
- Scm or Sm³– standard cubic metre (at 25°C and 1 atm), and
- Nm³ - normal cubic metre (at 0°C and 1 atm).

It is essential to know the conditions under which the source test data is collected before determining annual emission estimates. You should note that the measured concentrations and flue gas flows are usually presented on source test reports at the same conditions (i.e. temperature and pressure).

Provided below are two examples of the use of sampling data to characterise annual emissions.

Example 2 – Emissions determined by direct measurement: concentration units are the same as the process flow units

The following example relates to a situation where the concentration of oxides of nitrogen (NO_x) is presented at the same conditions as the measured flow rate.

The following data is known:

- the flue gas flow from a stack is measured at 30 Nm³/s
- the measured concentration of NO_x in the flue gas is 351 mg/Nm³
- the stack operates 24 hours per day for 156 days per year

Therefore the calculation to determine the amount of NO_x released is as follows:

$$\begin{aligned}\text{Emission} &= 351 \text{ [mg/Nm}^3\text{]} \times 1/1,000,000 \text{ [kg/mg]} \times 30 \text{ [Nm}^3\text{/s]} \times \\ & 156 \text{ [days/year]} \times 24 \text{ [hours/day]} \times 3,600 \text{ [s/hour]} \\ &= 141,900 \text{ kg of NO}_x \text{ released per year.}\end{aligned}$$

Example 3 – Emissions determined by direct measurement: concentration units are the different from the process flow units

If the concentration and flue gas flows are measured under different conditions then additional calculations are required. For this example, the following data is known:

- the flue gas flow from a stack is measured at 100 Am³/s
- the conditions at the stack sampling plane are approximately 150°C and 1 atm
- the measured concentration of NO_x in the flue gas is 351 mg/Nm³
- the stack operates 24 hours per day for 156 days per year

The ‘actual’ flue gas flow needs to be converted to a normalised flow using a ratio of temperatures. You should note that the temperatures must be presented using the absolute temperature scale of Kelvin (i.e. 0°C = 273 K). The conversion is then performed as follows (noting that the actual stack conditions are 150 + 273 = 423 K):

$$\begin{aligned}\text{Flue gas flow rate [Nm}^3\text{/s]} &= 100 \text{ Am}^3 \times (273/423) \\ &= 64.5 \text{ Nm}^3\text{/s}\end{aligned}$$

Therefore the calculation to determine the amount of NO_x released is as follows:

$$\begin{aligned}\text{Emission} &= 351 \text{ [mg/Nm}^3\text{]} \times 1/1,000,000 \text{ [kg/mg]} \times 64.5 \text{ [Nm}^3\text{/s]} \times \\ & 156 \text{ [days/year]} \times 24 \text{ [hours/day]} \times 3,600 \text{ [s/hour]} \\ &= 305,100 \text{ kg of NO}_x \text{ released per year.}\end{aligned}$$

Furthermore, discharges to waterways through licensed discharge points are a common source of emissions to water. Direct measurement is typically the only way to estimate emissions to water that requires you to know the volume of water discharged and the concentration of NPI pollutants within it.

Example 4 illustrates the method you should use to estimate emissions of NPI pollutants to water from monitored licence discharge points.

Example 4 – Emissions determined by direct measurement: estimating emissions to water

A facility monitors a water discharge point for total volume discharged and the concentration of arsenic and compounds in the discharge once a fortnight.

The monitoring data for the year is presented below:

Week	Measured flow (kL/day)	Arsenic concentration (mg/L)	Emission (kg/day)
2	350	0.918	0.32
4	394	0.7	0.28
6	417	0.815	0.34
8	440	0.683	0.30
10	364	0.787	0.29
12	340	0.84	0.29
14	457	0.865	0.40
16	424	0.643	0.27
18	463	0.958	0.44
20	414	0.681	0.28
22	476	0.68	0.32
24	431	0.628	0.27
26	369	0.807	0.30
28	392	0.729	0.29
30	323	0.964	0.31
32	302	0.722	0.22
34	358	0.566	0.20
36	322	0.51	0.16
38	330	0.63	0.21
40	322	0.63	0.20
42	408	0.652	0.27
44	442	0.649	0.29
46	356	0.695	0.25
48	390	0.758	0.30
50	423	0.658	0.28
52	487	0.97	0.47
Average discharge			0.29

In this example, the daily discharge needs to be calculated for every discrete monitoring point by multiplying the measured flow rate by the measured concentration of arsenic in the outfall. From these calculated data the average arsenic discharge can be determined.

To estimate the annual emission to water, you must multiply the average daily emission by the number of days water was discharged to the environment.

6.2 Emission factors

An emission factor is a tool that is used to estimate emissions to the environment. In this manual, it relates to the quantity of substances emitted from a source to some common activity associated with those emissions. Emission factors are usually expressed as the weight of a substance emitted multiplied by the unit weight, volume, distance or duration of the activity emitting the substance (e.g. kilograms of substance per tonne of product).

When using emission factors, you should be aware of the associated emission factor rating (EFR) code and what the rating implies. An A or B rating indicates a greater degree of certainty than a D or E rating. 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:

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

Emission factors applicable to this manual are listed in Appendix B. You must ensure that you estimate emissions for all substances relevant to your process.

Emission factors developed from measurements for a specific process may sometimes be used to estimate emissions at other sites. For example, a company may have several units of similar model and size, if emissions were measured from one facility, an emission factor could be developed and applied to similar sources. If you wish to use a site-specific emission factor, you should first seek approval from your state or territory environment agency before its use for estimating NPI emissions.

6.2.1 Ships at berth – auxiliary engines and boilers

Emissions from the operation of auxiliary engines while vessels are in port can be estimated using Equation 1 and emission factors presented in Appendix B.

Equation 1

$$E_i = N \times EF_i \times P \times TIW$$

where:

E_i	= Emissions from auxiliary power engines	(kg/year)
N	= Number of ships visiting port each year	(ships/year)
EF_i	= Emission factor for NPI substance i from auxiliary engines	(kg/kWh)
P	= Auxiliary power (assume 600 kW for all vessels)	(kWh)
TIW	= Average time in wharf per ship	(hours/ship)

Emission factors to estimate emissions from auxiliary engines are presented in Table 7 to Table 10 of Appendix B. The emission factors are given for each fuel type used to operate auxiliary engines. If the fuel type is unknown, emission factors presented in Table 7 should be used to estimate emissions.

In addition to the auxiliary engines that are used to generate electricity onboard ships, most vessels also have boilers used to heat residual oil to make it fluid enough to use in diesel engines and to produce hot water (USEPA, 2006). Auxiliary boiler emission factors are provided in Appendix B (Table 11) and are given in terms of fuel usage, rather than power, so the fuel consumption rate needs to be determined. If the fuel consumption rate is unknown, it is recommended that a fuel consumption rate of 0.0125 tonnes of fuel per hour is used to estimate emissions from auxiliary boilers (USEPA, 2006).

To estimate emissions from auxiliary boilers, use Equation 2 and emission factors presented in Table 11 in Appendix B.

Equation 2

$$E_i = FC \times N \times EF_i \times TIW$$

where:

- E_i = Emissions from auxiliary boilers (kg/year)
- FC = Estimated fuel consumption in auxiliary boilers (assume 0.0125 tonnes per hour if unknown) (tonnes/hour)
- N = Number of ships visiting port each year (ships/year)
- EF_i = Emission factor for NPI substance i from auxiliary engines (kg/kWh)
- TIW = Average time in wharf per ship (hours/ship)

Example 5 shows how to calculate emissions from auxiliary engines and Example 6 shows how to calculate emissions from auxiliary boilers.

Example 5 – Estimating emissions from auxiliary engines while ships are in port

This example illustrates the steps for estimating emissions from auxiliary engines while ships are in port. 350 ships berth in the reporting period. The average time for each ship in berth is 50 hours. The fuel used to power auxiliary engines for each ship is unknown and the power rating for each ship’s auxiliary engines is unknown.

Step 1

Determine the number of ships visiting the port in the reporting period. The number of ships visiting the port is 350 ships.

Step 2

Estimate the auxiliary engine power. The auxiliary engine power for each ship is unknown. Therefore, it is assumed that the auxiliary engine power is 600 kW.

Step 3

Estimate the average time in port for each ship. It is estimated that the average time in port for each ship is 50 hours.

Step 4

Select the appropriate EF values for auxiliary engines where the specific fuel type is unknown. The appropriate EF values are presented in Table 7 in Appendix B. The emission factors assume that 71% of ships operate auxiliary engines on residual fuel

and 29% of ships run auxiliary engines on marine diesel fuel.

Step 5

Calculate emissions using Equation 1.

Substance	Number of ships	Emission factor	Auxiliary engine power	Average time in wharf per ship	=	Emissions
(i)	(-)	(kg/kWh)	(kW)	(h/y)	=	(kg/y)
	N	\times EF_i	\times P	\times TIW	=	E_i
NO _x	350	\times 1.45E-02	\times 600	\times 50	=	1.52E+05
CO	350	\times 1.10E-03	\times 600	\times 50	=	1.16E+04
VOCs	350	\times 3.80E-04	\times 600	\times 50	=	3.99E+03
PM _{2.5}	350	\times 8.60E-04	\times 600	\times 50	=	9.03E+03
PM ₁₀	350	\times 1.00E-03	\times 600	\times 50	=	1.05E+04
SO ₂	350	\times 9.70E-03	\times 600	\times 50	=	1.02E+05
Benzene	350	\times 7.60E-06	\times 600	\times 50	=	7.98E+01
Toluene	350	\times 7.60E-06	\times 600	\times 50	=	7.98E+01
Xylenes	350	\times 3.90E-06	\times 600	\times 50	=	4.10E+01
Formaldehyde	350	\times 3.50E-07	\times 600	\times 50	=	3.68E+00
Ethylbenzene	350	\times 2.50E-07	\times 600	\times 50	=	2.63E+00
PAHs	350	\times 0.00E+00	\times 600	\times 50	=	0.00E+00
PCDD/F	350	\times 6.65E-14	\times 600	\times 50	=	6.98E-07

Example 6 – Estimating emissions from auxiliary boilers while ships are in port

This example illustrates the steps for estimating emissions from auxiliary boilers from a port where 350 ships berth in the reporting period. The average time for each ship in berth is 50 hours. The fuel consumption for each ship is unknown.

Step 1

Determine the number of ships visiting the port in the reporting period. The number of ships visiting the port is 350 ships.

Step 2

Estimate the fuel consumption by each ship for operation of the auxiliary boiler. The fuel consumption by the auxiliary boiler is unknown. Therefore, the estimated fuel consumption is 0.0125 tonnes/hour.

Step 3

Estimate the average time in port for each ship. It is estimated that the average time in port for each ship is 50 hours.

Step 4

Select the appropriate EF values for auxiliary boilers. The appropriate EF values are presented in Table 1 in Appendix B.

Step 5

Calculate emissions using Equation 2.

Substance	Number of ships	Emission factor	Fuel burn rate	Average time in wharf per ship	=	Emissions
(i)	(-)	(kg/t)	(t/h)	(h/y)	=	(kg/y)
	N	x EF _i	x FC	x TIW	=	E _i
NO _x	350	x 1.23E+01	x 0.0125	x 50	=	2.69E+03
CO	350	x 4.60E+00	x 0.0125	x 50	=	1.01E+03
VOCs	350	x 3.63E-01	x 0.0125	x 50	=	7.94E+01
PM _{2.5}	350	x 1.04E+00	x 0.0125	x 50	=	2.28E+02
PM ₁₀	350	x 1.30E+00	x 0.0125	x 50	=	2.84E+02
SO ₂	350	x 5.40E+01	x 0.0125	x 50	=	1.18E+04
Benzene	350	x 7.24E-03	x 0.0125	x 50	=	1.58E+00
Toluene	350	x 7.21E-03	x 0.0125	x 50	=	1.58E+00
Xylenes	350	x 3.69E-03	x 0.0125	x 50	=	8.07E-01
Formaldehyde	350	x 3.35E-04	x 0.0125	x 50	=	7.33E-02
Ethylbenzene	350	x 2.35E-04	x 0.0125	x 50	=	5.14E-02
PAHs	350	x 0.00E+00	x 0.0125	x 50	=	0.00E+00
PCDD/F	350	x 4.00E-09	x 0.0125	x 50	=	8.75E-07

6.2.2 Fire training and emergency situations

Emissions from fire training can be estimated using Equation 1 and emissions factors presented in Appendix B.

Equation 3:

$$E_i = A \times EF_i$$

where:

E_i	=	Emissions from training fires	(kg/year)
EF_i	=	Emission factor for NPI substance i from training fire	(kg/kL)
A	=	Amount of fuel burned in training fires during the reporting period	(kL/year)

Example 7 illustrates how to estimate emissions from fire training activities.

Example 7 – Estimating emissions from fire training activities

This example illustrates the steps for estimating pollutant emissions from fire training activities from a port where 12 fire training sessions are held each year (once per month). During each fire training activity it is estimated that 200 L of Tekflame is used.

Step 1

Determine the amount of fuel used for fire training activities. The amount of fuel used for fire training activities is equal to:

12 training sessions per year x 200 L per training session = 2,400 L per year

The amount of Tekflame used for fire training is 2.4 kL per year.

Step 2

Select the appropriate EF values for fire training emissions using Tekflame. The appropriate EF values are presented in Table 16 in Appendix B.

Step 3

Calculate emissions using Equation 3.

Susbtance	Emission factor		Amount of fuel used	=	Emissions
(i)	(kg/kL)		(kL/y)		(kg/y)
NO _x	0.45	x	2.4	=	1.08
CO	8.19	x	2.4	=	19.7
VOCs	5.9	x	2.4	=	14.2
PM _{2.5}	3.86	x	2.4	=	9.3
PM ₁₀	3.99	x	2.4	=	9.6
SO ₂	0.0053	x	2.4	=	0.013

6.2.3 Fuel storage

EETs for the storage of organic liquids (e.g. fuels) can be found in the EET manual for *Fuel and organic liquid storage*.

6.2.4 Bulk dry material handling

EETs for the handling and storage of bulk dry materials (e.g. coal, bauxite, alumina) can be found in the EET manual for *Mining*.

6.2.5 Bulk volatile material loading

Emissions from loading volatile organic liquids to ships can be estimated using Equation 2 and emissions factors presented in Appendix B.

Equation 4:

$$E_i = A \times EF_i$$

where:

E_i	=	Emissions from loading volatile material to ship	(kg/year)
EF_i	=	Emission factor for NPI substance i from loading ships with volatile material	(kg/kL)
A	=	Amount of volatile material loaded to ships in the reporting period	(kL/year)

Example 8 illustrates how to estimate emissions from loading volatile material to ships.

Example 8– Estimating emissions from bulk volatile material loading

This example illustrates the steps for estimating emissions from loading volatile material to ships from a port where 265,000 kL of diesel (distillate) and 350,000 kL of petrol are loaded to ocean vessels.

Step 1

Determine the amount of volatile material loaded to vessels during the reporting period. 265,000 kL of diesel and 350,000 kL of petrol are loaded to vessels in the reporting period.

Step 2

Select the appropriate EF values for volatile material loading. The appropriate EF values are presented in Table 18 (diesel) and Table 19 (petrol) for ocean vessels.

Step 3

Calculate emissions from diesel loading using Equation 4.

Susbtance	Amount of fuel loaded		Emission factor	=	Emissions
(i)	(kL/y)		(kg/kL)		(kg/y)
VOCs	265,000	x	5.99×10^{-04}	=	159
Benzene	265,000	x	5.86×10^{-08}	=	0.016
Cumene	265,000	x	1.28×10^{-07}	=	0.034
Cyclohexane	265,000	x	1.91×10^{-08}	=	0.005

Ethylbenzene	265,000	x	2.63×10^{-08}	=	0.007
n-Hexane	265,000	x	2.96×10^{-08}	=	0.008
Toluene	265,000	x	6.20×10^{-08}	=	0.016
Xylenes	265,000	x	7.09×10^{-08}	=	0.019
PAHs	265,000	x	ND	=	ND

Calculate emissions from petrol loading using Equation 4.

Substance	Amount of fuel loaded		Emission factor	=	Emissions
(i)	(kL/y)		(kg/kL)		(kg/y)
VOCs	350,000	x	2.16×10^{-01}	=	75,600
Benzene	350,000	x	6.56×10^{-04}	=	230
Cumene	350,000	x	4.71×10^{-06}	=	2
Cyclohexane	350,000	x	5.25×10^{-04}	=	184
Ethylbenzene	350,000	x	1.32×10^{-04}	=	46
n-Hexane	350,000	x	1.95×10^{-03}	=	683
Toluene	350,000	x	1.25×10^{-03}	=	438
Xylenes	350,000	x	5.73×10^{-04}	=	201
PAHs	350,000	x	ND	=	ND

6.2.6 Landside vehicle operation

EETs for exhaust emissions from landside vehicle operation can be found in the EET manual for *Combustion engines*.

If vehicles operate on unpaved roads at your facility, emissions are required to be estimated for wheel generated dust. EETs for estimating emissions from wheel generated dust can be found in the EET manual for *Mining*.

6.2.7 Maintenance operations

EETs for painting and surface coating operations can be found in the EET manual for *Surface coating*.

EETs for abrasive blasting can be found in the EET manual for *Shipbuilding and maintenance*.

EETs for equipment cleaning (i.e. use of degreasers and solvents) can be found in the EET manual for *Shipbuilding and maintenance*.

6.2.8 Ancillary equipment operation

EETs for operation of boilers and space heaters can be found in the EET manual for *Combustion in Boilers*.

EETs for operation of emergency generators can be found in the EET manual for *Combustion engines*.

EETs for operation of on-site incinerators can be found in the EET manual for *Sewage sludge and biomedical waste incineration*.

6.3 Mass balance

Mass balances involve examining a process to determine whether emissions can be characterised based on an analysis of operating parameters, material composition, and total material usage. Mass balance involves the quantification of total materials into and out of a process with the difference between inputs and outputs being accounted for as an emission to the environment (to air, water, land), or as part of the facility's waste. Mass balance is particularly useful when the input and output streams can be readily characterised, and this is most often the case for small processes and operations.

Mass balances can be undertaken for a whole facility or the individual process steps that make up the facility.

Information about mass balances in relation to the NPI is provided in the *NPI Guide*.

6.3.1 Spills

A mass balance approach is an ideal method to estimate emissions to land or water from spills.

For many facilities the primary source of emissions to land and water will be spills, including intentional spillage due to vessel wash down. Accidental spills can contribute to emissions to land directly, to water through runoff, and to air.

Unless spilled material is routed to a secure containment facility, the quantity of material spilled, less any material that is collected, must be reported to the NPI. In practical terms, a log of spillages could be maintained detailing quantities spilled and the composition of the spill (in particular the quantities of NPI substances spilled). This log could then provide the basic information for NPI reporting.

You should note that if the spill is a volatile liquid, it is reasonable to assume that the entire light end fraction is volatilised and the remaining liquid is released into the ground (if the spill occurs on land). However, if the liquid is not volatile and no material is collected, it is reasonable to assume that all material is released into the ground (i.e. emission to land).

If the spill occurs in the water, it is the facilities responsibility to report the total mass of the spill and the quantities of NPI substances within the spill as an emission to water.

To estimate emissions to land from spills of volatile liquids that occur on land, you should use Equation 5.

To estimate emissions from spills of non volatile liquids on land and spills of volatile and non-volatile liquids over water you should use Equation 6.

Equation 5:

$$E_i = ((Q_{\text{SPILL}} - mf_{\text{VOC}} \times Q_{\text{SPILL}}) - Q_{\text{REMOVED}}) \times mf_i$$

Equation 6:

$$E_i = (Q_{\text{SPILL}} - Q_{\text{REMOVED}}) \times mf_i$$

where:

E_i	=	Emissions to land or water of NPI substance i	(kg)
Q_{SPILL}	=	Quantity of material spilled	(kg)
Q_{REMOVED}	=	Quantity of material cleaned up	(kg)
mf_{VOC}	=	Mass fraction of volatile compounds in material spilled (see Table 5)	(kg VOC/kg material)
mf_i	=	Mass fraction of NPI substance i in material spilled (refer to site specific speciation profiles or speciation profiles detailed in Table 5).	(kg i/kg material)

To estimate emissions to atmosphere from spills on land of volatile materials, you should use Equation 7.

Equation 7:

$$E_i = (Q_{\text{SPILL}} \times mf_{\text{VOC}}) \times mf_i$$

where:

E_i	=	Emissions to land or water of NPI substance i	(kg)
Q_{SPILL}	=	Quantity of material spilled	(kg)
Q_{REMOVED}	=	Quantity of material cleaned up	(kg)
mf_{VOC}	=	Mass fraction of volatile compounds in material spilled (see Table 5)	(kg VOC/kg material)
mf_i	=	Mass fraction of NPI substance i in material spilled (refer to site specific speciation profiles or speciation profiles detailed in Table 5),	(kg i/kg material)

Table 5: Typical fraction of volatile compounds in Australian fuels

Volatile liquid	Mass fraction of volatile compounds (kg VOC/kg material)
Diesel	0.076
Fuel oil	0.03
Heating oil	0.12
Petrol	1.0

^a Source: NPI EET manual for Fuel and organic liquid storage

Example 9 illustrates how to estimate emissions to air of Total VOCs and to land of lead from a diesel spill.

Example 9 – Estimating emissions from spills

This example illustrates the steps for estimating emissions from heating oil spills in an uncontained location at a port facility. 1,200 kg of heating oil was spilt at the port facility during the reporting period. 500 kg of heating oil was removed from the site and disposed. It is estimated that heating oil contains 0.0042 kg lead per kilogram heating oil.

Step 1

Determine the amount of heating oil spilt during the reporting period. 1,200 kg of heating oil was spilt.

Step 2

Determine the amount of heating oil cleaned up after the spill. 500 kg of heating oil was removed from the spill site and transferred to a secure containment facility.

Step 3

Determine the volatile fraction of heating oil. The volatile fraction of heating oil is 0.12 kg VOCs/kg heating oil.

Step 4

Estimate the emission to air of Total VOCs from the spill.

$$\begin{aligned} \text{Total VOC emissions to air} &= 1,200 \text{ kg heating oil} \times 0.12 \text{ kg VOCs/kg} \\ &= 144 \text{ kg VOCs} \end{aligned}$$

Step 5

Estimate the emission to land of lead from the heating oil spill using Equation 7.

$$\begin{aligned} \text{Lead emission to land} &= ((1,200 \text{ kg heating oil} - 0.12 \text{ kg VOCs/kg heating oil} \times \\ &\quad 1,200 \text{ kg heating oil}) - 500 \text{ kg heating oil}) \times 0.0042 \text{ kg} \\ &\quad \text{lead/kg heating oil} \\ &= 2.3 \text{ kg lead} \end{aligned}$$

6.4 Approved alternative

You are able to use emission estimation techniques that are not outlined in this document. You must, however, seek the consent of your state or territory environmental agency. For example, if your company has developed site-specific emission factors, you may use these if they have been approved by your local environmental agency.

7 Transfers of NPI substances in waste

The NPI requires the mandatory reporting of NPI substances that are transferred in waste to a final destination. Transfers are required to be reported if a Category 1, Category 1b or Category 3 reporting threshold is exceeded. For example, if the threshold has been exceeded for the Category 1 substance - lead and compounds - as a result of use of this substance on site, transfers to final destination of lead as well as the emissions are reportable. Both emissions and transfers are reportable in kilograms.

There is no requirement to report transfers of:

- substances that are exclusively Category 2a or Category 2b
- substances which are both Category 2a or Category 2b and Category 1 or Category 1b (e.g. copper and compounds), in the event that the substance has tripped the Category 2 threshold only, or
- Total VOC (Category 1a and Category 2a).

Transfers are also not reportable if they are contained in overburden, waste rock, uncontaminated soil or rock removed in construction or road building, or soil used in capping of landfills.

Transfers are required to be reported if they are transported to a destination for containment or destruction which includes:

- a destination for containment including landfill, tailings storage facility, underground injection or other long term purpose-built waste storage facility
- an off-site destination for destruction
- an off-site sewerage system, and
- an off-site treatment facility which leads solely to one or more of the above.

A containment destination may be on-site, for example a tailings storage facility on a mine site, or off-site, for example waste going to landfill. The transport or movement of substances contained in waste to a sewerage system is also included.

In the specific context of maritime operations, the quantities of NPI substances contained in waste moved on-site or off-site to landfill or other final destination will need to be reported as a transfer. For example, NPI substances in wastewater, such as arsenic, cadmium, boron and fluoride, would be reportable as transfers. Also NPI substances contained in waste oil that are transferred to a hazardous waste facility would need to be reported to the NPI (if none gets recycled).

The transfer of NPI substances to a destination for reuse, recycling, reprocessing, purification, partial purification, immobilisation, remediation or energy recovery can be reported voluntarily. This is an opportune way for facilities to promote good news stories to their local community.

Further information regarding transfers of waste, including how to estimate and report transfers, can be found in the *NPI Guide*.

8 Next steps for reporting

This manual has been written to reflect the common processes employed in the maritime operations industry. To ensure a complete report of the emissions for your facility, it may be necessary to refer to other EET manuals. These are listed in Section 1.3.

When you have a complete report of substance emissions from your facility, report these emissions according to the instructions in the *NPI Guide*.

9 References

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Appendix A: Definitions and abbreviations

Table 6: Glossary of technical terms and abbreviations used in this manual

Term	Definition
°C	Degrees Celsius
Acm or Am ³	Actual cubic metres of gas i.e. at stack conditions
ANZSIC	Australian and New Zealand Standard Industrial Classification
atm	Atmosphere, in terms of pressure. 1 atm = 101.3 kPa
CARB	California Air Resources Board
CEMS	Continuous emission monitoring systems
CO	Carbon monoxide
Combustion products	CO, NO _x , SO ₂ , PM ₁₀ , PM _{2.5} , VOCs, speciated VOCs (e.g. benzene, toluene, xylenes, ethylbenzene, formaldehyde), speciated particulates (e.g. antimony, arsenic, chromium, copper, selenium)
DEH	Department of the Environment and Heritage
DEWHA	Department of the Environment, Water, Heritage and the Arts
EET	Emission estimation technique
EF	Emission factor
EFR	Emission factor rating
E _i	Emission of pollutant i per year
h	Hour
i	Pollutant component of which emission level is being determined
JP4	Jet Propellant (JP4) is a jet fuel, specified in 1951 by the U.S. government (MIL-J-5624E). JP4 is a mixture of aliphatic and aromatic hydrocarbons. It is a flammable transparent liquid with clear or straw colour, with a kerosene-like smell. It evaporates easily. Its freeze point is at -60°C and its flash point temperature is -18 °C
JP5	Jet Propellant (JP5) is a jet fuel weighs 6.8 pounds per gallon and has a high flash point (min. 60 °C). It was developed in 1952 for use in aircraft stationed aboard aircraft carriers where the risk from fire is particularly great
JP8	Jet Propellant (JP8) is a jet fuel, specified in 1990 by the U.S. government. It is kerosene-based
K	Kelvin
kg	Kilograms
kL	Kilolitre (i.e. 1,000 litres)
kWh	Kilowatt hour (unit of energy). 1 kWh = 3,600 kilojoules
L	Litre
mf _i	Mass fraction of NPI substance in material spilled
mf _{VOV}	Mass fraction of volatile compounds in material spilled
Mn	Manganese and compounds
MSDSs	Material safety data sheets

Term	Definition
NA	Not applicable
ND	No data
Nm ³	Normalised cubic metre i.e. at 0°C and 1 atm pressure
NO _x	Oxides of nitrogen
NPI	National Pollutant Inventory
P	Auxiliary power (use 600 kW if unknown)
PAHs	Polycyclic aromatic hydrocarbons.
PCDD/Fs	Polychlorinated dioxins and furans
PM _{2.5}	Particulate matter with an aerodynamic diameter of less than 2.5 µm
PM ₁₀	Particulate matter with an aerodynamic diameter of less than 10 µm
Q _{SPILL}	Quantity of material spilled
Q _{REMOVED}	Quantity of material cleaned up
Scm or Sm ³	Standard cubic metres of gas, i.e. at 25°C and 1 atm pressure
SO ₂	Sulfur dioxide
t	Tonnes
Tekflame	Tekflame fuel is purposefully manufactured fuel for fire fighting training. It produces less smoke and reduces fuel consumption when compared to comparative fuels used in fire fighting training
TOC	Total organic compounds
TSP	Total suspended particulate
Total VOCs	Total volatile organic compounds
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
y	Year

Appendix B: Emission factors

B.1 Auxiliary engines

Table 7: Emission factors (kg/kWh) for auxiliary engines (weighted average fuel burn)

Substance	Emission factor (kg/kWh)	Emission factor scientific notation (kg/kWh)	Rating
Oxides of nitrogen ^a	0.0145	1.45E-02	U
Carbon monoxide ^a	0.0011	1.10E-03	U
Total volatile organic compounds ^b	0.00038	3.82E-04	U
Particulate matter 2.5 µm ^a	0.00086	8.62E-04	U
Particulate matter 10.0 µm ^a	0.0010	1.03E-03	U
Sulfur dioxide ^a	0.0097	9.67E-03	U
Benzene ^b	0.0000076	7.62E-06	U
Toluene (methylbenzene) ^b	0.0000076	7.59E-06	U
Xylenes (individual or mixed isomers) ^b	0.0000039	3.88E-06	U
Formaldehyde (methyl aldehyde) ^b	0.00000035	3.53E-07	U
Ethylbenzene ^b	0.00000025	2.47E-07	U
Polycyclic aromatic hydrocarbons (B[a]Peq) ^b	0	0.00E+00	U
Polychlorinated dioxins and furans (TEQ) ^c	6.65E-14	6.65E-14	U

^a Source: Emission factors sourced from Table 2-10, USEPA, 2006.

^b Speciated hydrocarbons emission factors are estimated using the HC emission factor presented in Table 2-10, USEPA, 2006 and the organic speciation profile for “external combustion boilers – distillate or residual” (CARB, 2003)

^c Source: Table 50 and 51, UNEP (2005). Assuming 30% thermal efficiency, heat values of 40.1 MJ/L for residual oil and 38.6 MJ/L for marine diesel oil and densities of 0.86 kg/L for residual oil and marine diesel oil.

^d The weighted average emission factors are calculated based on the assumption that 71% of vessels use residual oil and 31% of vessels use marine diesel fuel as recommended in USEPA (2006).

Table 8: Emission factors (kg/kWh) for auxiliary engines (residual oil)

Substance	Emission factor (kg/kWh)	Emission factor scientific notation (kg/kWh)	Rating
Oxides of nitrogen ^a	0.0147	1.47E-02	U
Carbon monoxide ^a	0.0011	1.10E-03	U
Total volatile organic compounds ^b	0.00038	3.82E-04	U
Particulate matter 2.5 µm ^a	0.0011	1.10E-03	U
Particulate matter 10.0 µm ^a	0.00114	1.14E-03	U
Sulfur dioxide ^a	0.0111	1.11E-02	U
Benzene ^b	0.0000076	7.62E-06	U
Toluene (methylbenzene) ^b	0.0000076	7.59E-06	U
Xylenes (individual or mixed isomers) ^b	0.0000039	3.88E-06	U
Formaldehyde (methyl aldehyde) ^b	0.00000035	3.53E-07	U
Ethylbenzene ^b	0.00000025	2.47E-07	U
Polycyclic aromatic hydrocarbons (B[a]P _{eq})	0	0.00E+00	U
Polychlorinated dioxins and furans (TEQ)	9.26E-14	9.26E-14	U

^a Source: Emission factors sourced from Table 2-10, USEPA, 2006.

^b Speciated hydrocarbons emission factors are estimated using the HC emission factor presented in Table 2-10, USEPA, 2006 and the organic speciation profile for “external combustion boilers – distillate or residual” (CARB, 2003)

^c Source: Table 51, UNEP (2005). Assuming 30% thermal efficiency, heat value of 40.1 MJ/L and density of 0.86 kg/L.

Table 9: Emission factors (kg/kWh) for auxiliary engines (marine diesel oil)

Substance	Emission factor (kg/kWh)	Emission factor scientific notation (kg/kWh)	Rating
Oxides of nitrogen ^a	0.0139	1.39E-02	U
Carbon monoxide ^a	0.0011	1.10E-03	U
Total volatile organic compounds ^b	0.00038	3.82E-04	U
Particulate matter 2.5 µm ^a	0.00028	2.80E-04	U
Particulate matter 10.0 µm ^a	0.00075	7.50E-04	U
Sulfur dioxide ^a	0.00616	6.16E-03	U
Benzene ^b	0.0000076	7.62E-06	U
Toluene (methylbenzene) ^b	0.0000076	7.59E-06	U
Xylenes (individual or mixed isomers) ^b	0.0000039	3.88E-06	U
Formaldehyde (methyl aldehyde) ^b	0.00000035	3.53E-07	U
Ethylbenzene ^b	0.00000025	2.47E-07	U
Polycyclic aromatic hydrocarbons (B[a]Peq) ^b	0	0.00E+00	U
Polychlorinated dioxins and furans (TEQ) ^c	2.41E-15	2.41E-15	U

^a Source: Emission factors sourced from Table 2-10, USEPA, 2006.

^b Speciated hydrocarbons emission factors are estimated using the HC emission factor presented in Table 2-10, USEPA, 2006 and the organic speciation profile for “external combustion boilers – distillate or residual” (CARB, 2003)

^c Source: Table 50, UNEP (2005). Assuming 30% thermal efficiency, heat value of 38.6 MJ/ and density of 0.86 kg/L.

Table 10: Emission factors (kg/kWh) for auxiliary engines (marine gas oil)

Substance	Emission factor (kg/kWh)	Emission factor scientific notation (kg/kWh)	Rating
Oxides of nitrogen ^a	0.0139	1.39E-02	U
Carbon monoxide ^a	0.0011	1.10E-03	U
Total volatile organic compounds ^b	0.00038	3.82E-04	U
Particulate matter 2.5 µm ^a	0.00023	2.30E-04	U
Particulate matter 10.0 µm ^a	0.00042	4.20E-04	U
Sulfur dioxide ^a	0.00205	2.05E-03	U
Benzene ^b	0.0000076	7.62E-06	U
Toluene (methylbenzene) ^b	0.0000076	7.59E-06	U
Xylenes (individual or mixed isomers) ^b	0.0000039	3.88E-06	U
Formaldehyde (methyl aldehyde) ^b	0.00000035	3.53E-07	U
Ethylbenzene ^b	0.00000025	2.47E-07	U
Polycyclic aromatic hydrocarbons (B[a]Peq) ^b	0	0.00E+00	U
Polychlorinated dioxins and furans (TEQ)	NA	NA	NA

^a Source: Emission factors sourced from Table 2-10, USEPA, 2006.

^b Speciated hydrocarbons emission factors are estimated using the HC emission factor presented in Table 2-10, USEPA, 2006 and the organic speciation profile for “external combustion boilers – distillate or residual” (CARB, 2003)

B.2 Auxiliary boilers

Table 11: Emission factors (kg/tonne) for auxiliary boilers (residual oil)

Substance	Emission factor (kg/tonne)	Emission factor scientific notation (kg/tonne)	Rating
Oxides of nitrogen ^a	12.3	1.23E+01	U
Carbon monoxide ^a	4.6	4.60E+00	U
Total volatile organic compounds ^b	0.36	3.63E-01	U
Particulate matter 2.5 µm ^a	1.04	1.04E+00	U
Particulate matter 10.0 µm ^a	1.3	1.30E+00	U
Sulfur dioxide ^a	54	5.40E+01	U
Benzene ^b	0.0072	7.24E-03	U
Toluene (methylbenzene) ^b	0.0072	7.21E-03	U
Xylenes (individual or mixed isomers) ^b	0.0037	3.69E-03	U
Formaldehyde (methyl aldehyde) ^b	0.00034	3.35E-04	U
Ethylbenzene ^b	0.00023	2.35E-04	U
Polycyclic aromatic hydrocarbons (B[a]Peq) ^b	0	0.00E+00	U
Polychlorinated dioxins and furans (TEQ) ^c	4.00E-09	4.00E-09	U

^a Source: Emission factors sourced from Table 2-10, USEPA, 2006.

^b Speciated hydrocarbons emission factors are estimated using the HC emission factor presented in Table 2-10, USEPA, 2006 and the organic speciation profile for "external combustion boilers – distillate or residual" (CARB, 2003)

^c Source: Table 51, UNEP (2005). Assuming 30% thermal efficiency, heat value of 40.1 MJ/L and density of 0.86 kg/L.

B.3 Training fires

Table 12: Emission factors (kg/kL) for training fires (JP4)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Oxides of nitrogen ^a	3.2	3.22x10 ⁺⁰⁰	U
Carbon monoxide ^a	429	4.29x10 ⁺⁰²	U
Total volatile organic compounds ^a	15.3	1.53x10 ⁺⁰¹	U
Particulate matter 2.5 µm ^{a,b}	111	1.11x10 ⁺⁰²	U
Particulate matter 10.0 µm ^a	115	1.15x10 ⁺⁰²	U
Sulfur dioxide ^a	0.45	4.54x10 ⁻⁰¹	U

^a Source: Adapted from Energy and Environmental Analysis Inc., September 1995 and FAA (2007)

^b Emission factor for PM_{2.5} is calculated using PM profile ID 110 from the California Emission Inventory and Reporting System.

Table 13: Emission factors (kg/kL) for training fires (JP5)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Oxides of nitrogen ^a	0.32	3.17x10 ⁻⁰¹	U
Carbon monoxide ^a	14.8	1.48x10 ⁺⁰¹	U
Total volatile organic compounds ^a	23.7	2.37x10 ⁺⁰¹	U
Particulate matter 2.5 µm ^{a,b}	11.2	1.12x10 ⁺⁰¹	U
Particulate matter 10.0 µm ^a	11.6	1.16x10 ⁺⁰¹	U
Sulfur dioxide ^a	1.8	1.79x10 ⁺⁰⁰	U

^a Source: Adapted from Energy and Environmental Analysis Inc., September 1995 and FAA (2007)

^b Emission factor for PM_{2.5} is calculated using PM profile ID 110 from the California Emission Inventory and Reporting System.

Table 14: Emission factors (kg/kL) for training fires (JP8)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Oxides of nitrogen ^a	4.0	4.03x10 ⁺⁰⁰	U
Carbon monoxide ^a	538	5.38x10 ⁺⁰²	U
Total volatile organic compounds ^a	16.2	1.62x10 ⁺⁰¹	U
Particulate matter 2.5 µm ^{a,b}	117	1.17x10 ⁺⁰²	U
Particulate matter 10.0 µm ^a	122	1.22x10 ⁺⁰²	U
Sulfur dioxide ^a	0.81	8.14x10 ⁻⁰¹	U

^a Source: Adapted from Energy and Environmental Analysis Inc., September 1995 and FAA (2007)

^b Emission factor for PM_{2.5} is calculated using PM profile ID 110 from the California Emission Inventory and Reporting System.

Table 15: Emission factors (kg/kL) for training fires (Propane)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Oxides of nitrogen ^a	0.77	7.66x10 ⁻⁰¹	U
Carbon monoxide ^a	4.2	4.17x10 ⁺⁰⁰	U
Total volatile organic compounds ^a	3.8	3.81x10 ⁺⁰⁰	U
Particulate matter 2.5 µm ^{a,b}	13.6	1.36x10 ⁺⁰¹	U
Particulate matter 10.0 µm ^a	14.0	1.40x10 ⁺⁰¹	U
Sulfur dioxide ^a	0.0024	2.38x10 ⁻⁰³	U

^a Source: Adapted from Energy and Environmental Analysis Inc., September 1995 and FAA (2007)

^b Emission factor for PM_{2.5} is calculated using PM profile ID 110 from the California Emission Inventory and Reporting System.

Table 16: Emission factors (kg/kL) for training fires (Tekflame)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Oxides of nitrogen ^a	0.45	4.49x10 ⁻⁰¹	U
Carbon monoxide ^a	8.19	8.19x10 ⁺⁰⁰	U
Total volatile organic compounds ^a	5.9	5.94x10 ⁺⁰⁰	U
Particulate matter 2.5 µm ^{a,b}	3.86	3.86x10 ⁺⁰⁰	U
Particulate matter 10.0 µm ^a	3.99	3.99x10 ⁺⁰⁰	U
Sulfur dioxide ^a	0.0053	5.28x10 ⁻⁰³	U

^a Source: Adapted from Energy and Environmental Analysis Inc., September 1995 and FAA (2007)

^b Emission factor for PM_{2.5} is calculated using PM profile ID 110 from the California Emission Inventory and Reporting System.

B.4 Bulk volatile material loading

Table 17: Emission factors (kg/kL) for vessel loading – ship/ocean vessel (crude oil)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.073	7.31x10 ⁻⁰²	U
Benzene ^b	0.000021	2.14x10 ⁻⁰⁵	U
Cumene ^b	0.00000064	6.38x10 ⁻⁰⁷	U
Cyclohexane ^b	0.00018	1.77x10 ⁻⁰⁴	U
Ethylbenzene ^b	0.0000047	4.66x10 ⁻⁰⁶	U
n-Hexane ^b	0.00075	7.45x10 ⁻⁰⁴	U
Toluene ^b	0.000031	3.10x10 ⁻⁰⁵	U
Xylenes ^b	0.000018	1.78x10 ⁻⁰⁵	U
Polycyclic aromatic hydrocarbons (B[a]Peq)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for crude oil presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Table 18: Emission factors (kg/kL) for vessel loading – barge (crude oil)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.12	1.20x10 ⁻⁰¹	U
Benzene ^b	0.000035	3.52x10 ⁻⁰⁵	U
Cumene ^b	0.0000010	1.05x10 ⁻⁰⁶	U
Cyclohexane ^b	0.00029	2.90x10 ⁻⁰⁴	U
Ethylbenzene ^b	0.0000076	7.64x10 ⁻⁰⁶	U
n-Hexane ^b	0.0012	1.22x10 ⁻⁰³	U
Toluene ^b	0.000051	5.09x10 ⁻⁰⁵	U
Xylenes ^b	0.000029	2.92x10 ⁻⁰⁵	U
Polycyclic aromatic hydrocarbons (B[a]Peg)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for crude oil presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Table 19: Emission factors (kg/kL) for vessel loading – ship/ocean vessel (petrol)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.22	2.16x10 ⁻⁰¹	U
Benzene ^b	0.00066	6.56x10 ⁻⁰⁴	U
Cumene ^b	0.0000047	4.71x10 ⁻⁰⁶	U
Cyclohexane ^b	0.00053	5.25x10 ⁻⁰⁴	U
Ethylbenzene ^b	0.00013	1.32x10 ⁻⁰⁴	U
n-Hexane ^b	0.0020	1.95x10 ⁻⁰³	U
Toluene ^b	0.0013	1.25x10 ⁻⁰³	U
Xylenes ^b	0.00057	5.73x10 ⁻⁰⁴	U
Polycyclic aromatic hydrocarbons (B[a]Peg)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for unleaded petrol presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Table 20: Emission factors (kg/kL) for vessel loading – barge (petrol)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.41	4.07x10 ⁻⁰¹	U
Benzene ^b	0.0012	1.24x10 ⁻⁰³	U
Cumene ^b	0.0000089	8.90x10 ⁻⁰⁶	U
Cyclohexane ^b	0.00099	9.92x10 ⁻⁰⁴	U
Ethylbenzene ^b	0.00025	2.49x10 ⁻⁰⁴	U
n-Hexane ^b	0.0037	3.69x10 ⁻⁰³	U
Toluene ^b	0.0024	2.36x10 ⁻⁰³	U
Xylenes ^b	0.0011	1.08x10 ⁻⁰³	U
Polycyclic aromatic hydrocarbons (B[a]Peq)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for unleaded petrol presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Table 21: Emission factors (kg/kL) for vessel loading – ship/ocean vessel (jet naphtha/other)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.060	5.99x10 ⁻⁰²	U
Benzene ^b	0.000072	7.17x10 ⁻⁰⁵	U
Cumene ^b	0.000037	3.70x10 ⁻⁰⁵	U
Cyclohexane ^b	0.00023	2.29x10 ⁻⁰⁴	U
Ethylbenzene ^b	0.000012	1.23x10 ⁻⁰⁵	U
n-Hexane ^b	0.0014	1.38x10 ⁻⁰³	U
Toluene ^b	0.000011	1.12x10 ⁻⁰⁵	U
Xylenes ^b	0.000039	3.86x10 ⁻⁰⁵	U
Polycyclic aromatic hydrocarbons (B[a]Peq)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for jet kerosene presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Table 22: Emission factors (kg/kL) for vessel loading – barge (jet naphtha/other)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.14	1.44x10 ⁻⁰¹	U
Benzene ^b	0.00017	1.72x10 ⁻⁰⁴	U
Cumene ^b	0.000089	8.88x10 ⁻⁰⁵	U
Cyclohexane ^b	0.00055	5.49x10 ⁻⁰⁴	U
Ethylbenzene ^b	0.000030	2.96x10 ⁻⁰⁵	U
n-Hexane ^b	0.0033	3.31x10 ⁻⁰³	U
Toluene ^b	0.000027	2.68x10 ⁻⁰⁵	U
Xylenes ^b	0.000093	9.27x10 ⁻⁰⁵	U
Polycyclic aromatic hydrocarbons (B[a]Peq)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for jet kerosene presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Table 23: Emission factors (kg/kL) for vessel loading – ship/ocean vessel (distillate/kerosene)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.00060	5.99x10 ⁻⁰⁴	U
Benzene ^b	0.000000059	5.86x10 ⁻⁰⁸	U
Cumene ^b	0.00000013	1.28x10 ⁻⁰⁷	U
Cyclohexane ^b	0.000000019	1.91x10 ⁻⁰⁸	U
Ethylbenzene ^b	0.000000026	2.63x10 ⁻⁰⁸	U
n-Hexane ^b	0.000000030	2.96x10 ⁻⁰⁸	U
Toluene ^b	0.000000062	6.20x10 ⁻⁰⁸	U
Xylenes ^b	0.000000071	7.09x10 ⁻⁰⁸	U
Polycyclic aromatic hydrocarbons (B[a]Peq)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for diesel presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Table 24: Emission factors (kg/kL) for vessel loading – barge (distillate/kerosene)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.0014	1.44x10 ⁻⁰³	U
Benzene ^b	0.00000014	1.41x10 ⁻⁰⁷	U
Cumene ^b	0.00000031	3.06x10 ⁻⁰⁷	U
Cyclohexane ^b	0.000000046	4.58x10 ⁻⁰⁸	U
Ethylbenzene ^b	0.000000063	6.30x10 ⁻⁰⁸	U
n-Hexane ^b	0.000000071	7.12x10 ⁻⁰⁸	U
Toluene ^b	0.00000015	1.49x10 ⁻⁰⁷	U
Xylenes ^b	0.00000017	1.70x10 ⁻⁰⁷	U
Polycyclic aromatic hydrocarbons (B[a]Peg)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for diesel presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Table 25: Emission factors (kg/kL) for vessel loading – ship/ocean vessel (residual oil)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.0000048	4.79x10 ⁻⁰⁶	U
Benzene ^b	0.00000000016	1.56x10 ⁻¹⁰	U
Cumene ^b	0.00000000022	2.25x10 ⁻¹⁰	U
Cyclohexane ^b	0	0.00x10 ⁺⁰⁰	U
Ethylbenzene ^b	0.00000000019	1.91x10 ⁻¹¹	U
n-Hexane ^b	0.00000000024	2.37x10 ⁻¹⁰	U
Toluene ^b	0.00000000015	1.49x10 ⁻¹⁰	U
Xylenes ^b	0.00000000016	1.64x10 ⁻¹⁰	U
Polycyclic aromatic hydrocarbons (B[a]Peg)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for fuel oil presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Table 26: Emission factors (kg/kL) for vessel loading – barge (residual oil)

Substance	Emission factor (kg/kL)	Emission factor scientific notation (kg/kL)	Rating
Total volatile organic compounds ^a	0.000011	1.08x10 ⁻⁰⁵	U
Benzene ^b	0.00000000035	3.52x10 ⁻¹⁰	U
Cumene ^b	0.00000000051	5.06x10 ⁻¹⁰	U
Cyclohexane ^b	0	0.00x10 ⁺⁰⁰	U
Ethylbenzene ^b	0.00000000043	4.30x10 ⁻¹¹	U
n-Hexane ^b	0.00000000053	5.34x10 ⁻¹⁰	U
Toluene ^b	0.00000000034	3.35x10 ⁻¹⁰	U
Xylenes ^b	0.00000000037	3.70x10 ⁻¹⁰	U
Polycyclic aromatic hydrocarbons (B[a]Peg)	ND	ND	NA

^a Source: Table 12.4-5 Marine Vessel Loading, Ballasting and Transit, Emissions Inventory Improvement Program (USEPA, 2001)

^b Derived based on Total VOC emission factor presented in USEPA, 2001 and speciation profile for fuel oil presented in the NPI EET Manual for Fuel and Organic Liquid Storage (DEWHA, 2008)

Appendix C: Modifications to the maritime operations manufacturing emission estimation technique (EET) manual (Version 2.0 July 2008)

Page	Outline of alteration
1	ANZSIC codes were updated to reflect changes between ANZSIC 1993 and ANZSIC 2006.
5	Table outlining reporting requirements for maritime operations was simplified.
5	New report section added: The Process for NPI Reporting.
6	Added a table outlining typical data required to estimate emissions from all emission sources likely to exist at a facility conducting maritime operations.
11 – 13	Modified the typical emission sources described in the Process Description and Typical emissions section so that emission sources, match, source names where there are available emission estimation technique published in NPI manuals.
14	Included emissions from stacks whilst ships are in port in the example for point source emissions (i.e. emissions from auxiliary engines and auxiliary boilers as an example of a point source likely to occur at facilities conducting maritime operations).
16	Included Table 3 which shows all likely emission sources, the likely emission destination (air, water or land) and where a user can find published emission estimation techniques in NPI manuals (either within the manual or in other manuals).
19	Included a flowchart showing how facilities should determine whether they have tripped any Category 1, Category 1a or Category 1b thresholds.
19 – 20	Included text describing how to perform a materials inventory over a facility and how to estimate the mass of NPI substances within each material in order to determine whether Category 1 or Category 1b thresholds have been tripped.
20	Included a table showing location of useful material speciation profiles to determine substance usage.
21	Included a flow chart to show users how to determine whether the Category 2a or Category 2b threshold has been tripped.
21 – 22	Included text to explain which substances are required to be reported if either the Category 2a or Category 2b threshold is tripped.
25 – 26	Included a discussion on sampling data and the differences between Am ³ and Nm ³ . Also included an example showing how to calculate emissions from direct measurement results when the data is on the same gas basis and when the data (flow and concentration) are on a different basis.
28	Included an example showing how to calculate water emissions from fortnightly grab samples of concentration and flow rate.
29	Changed the emission estimation technique for “operation of vessels in port” as recommended in <i>Current Methodologies and Best Practices in Preparing Port Emission Inventories</i> (USEPA, 2006). The previous emission estimation technique was incorrect and did not estimate emissions of SO ₂ correctly. The emission factors for other substances were also updated.
27	Included an emission estimation technique to estimate emissions from auxiliary boilers used on vessels to heat residual oil to make it fluid enough to use in diesel engines to produce hot water.

Page	Outline of alteration
30	Included an example showing users how to estimate emissions from training fires
26 - 36	This section is completely changed.
32	Included an example showing users how to estimate emissions from volatile material loading onto vessels.
33-34	Included the spills section under mass balance. This section details how users could estimate emissions to air, water and land from spills.
35	Included the table on typical fraction of volatile compounds in Australian fuels.
36	Included an example showing users how to calculate emissions to land and to air from a diesel spill.
37	Included the section on transfers.
43 – 44	Emission factors for JP-5 and Tekflame were included in emission factors for training fires. These emission factors were sourced from FAA (2007). Emission factors for PM _{2.5} were included in emission factors provided for training fires.
45	Included emission factors for speciated organics based upon published VOC emission factors and speciation profile for crude oil published in the NPI EET Manual for <i>Fuel and organic liquid storage</i> .
46	Included emission factors for speciated organics based upon published VOC emission factors and speciation profile for petrol published in the NPI EET Manual for <i>Fuel and organic liquid storage</i> .
47	Included emission factors for speciated organics based upon published VOC emission factors and speciation profile for naphtha published in the NPI EET Manual for <i>Fuel and organic liquid storage</i> .
48	Included emission factors for speciated organics based upon published VOC emission factors and speciation profile for diesel published in the NPI EET Manual for <i>Fuel and organic liquid storage</i> .
49	Included emission factors for speciated organics based upon published VOC emission factors and speciation profile for fuel oil published in the NPI EET Manual for <i>Fuel and organic liquid storage</i> .