

**SNAP CODE:** 040104

**SOURCE ACTIVITY TITLE:** **PROCESSES IN PETROLEUM INDUSTRIES**  
*Storage and Handling of Products in Refinery*

**NOSE CODE:** 105.08.04

**NFR CODE:** 1 B 2 a iv

**1 ACTIVITIES INCLUDED**

Only the emissions of NMVOC from the storage and handling of volatile intermediates and products are considered in this chapter. These intermediates and products are categorised as follows:

**Table 1.1: Categories of Products**

Category	Product
Liquid fuels	motor gasoline
	aviation gasoline
	aviation turbine fuel
	illuminating gasoline
	high-speed diesel
	distillate heating fuel
By product Fuels	Naphtha
	liquefied petroleum gases
	white oils
Primary petrochemicals	Ethylene
	Propylene
	Butadiene
	Benzene
	Toluene
	Xylene

The storage and handling of crude oil, the raw material of refineries, is dealt with in SNAP sub-sector 0502.

The storage and handling of refinery products outside a refinery is dealt with in SNAP codes 0504 and 0505.

**2 CONTRIBUTION TO TOTAL EMISSIONS**

Emissions from the storage and handling of intermediates and products typically contribute to between 1% and 6% of a country’s total NMVOC emissions from anthropogenic sources. Table 2.1 and 2.2 summarise emissions of NMVOC from these sources.

**Table 2.1: Contribution to total emissions of the CORINAIR90 inventory (28 countries)**

Source-activity	SNAP-code	Contribution to total emissions [%]							
		SO <sub>2</sub>	NO <sub>x</sub>	NMVOG	CH <sub>4</sub>	CO	CO <sub>2</sub>	N <sub>2</sub> O	NH <sub>3</sub>
Storage and Handling of Products in Refinery	040104	-	-	0.4	-	-	-	0.1	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)

- = no emissions are reported

**Table 2.2: Emissions of NMVOG from Petroleum Product Storage at Petroleum Refineries in Canada**

Country	NMVOG	
	Emissions (Mg)	% Total Anthropogenic
Canada (1988)	25280	5.16
Canada (1995)		

This activity is not believed to be a significant source of PM<sub>2.5</sub> (as of December 2006).<sup>1</sup>

### 3 GENERAL

#### 3.1 Description

Storage and handling of intermediates and products in a refinery is one part of the refining process.

Emissions arise as a result of evaporation from storage tanks, the displacement of vapour during volume changes, loading and unloading and spillage.

Intermediates and products may be stored in a variety of tanks. This chapter considers the following categories of tanks:

- fixed roof tanks
- external floating roof
- internal floating roof
- other tank types such as variable vapour space

Pressure tanks are considered to be minor sources and are not included in this chapter.

#### 3.2 Definitions

#### 3.3 Techniques

**Fixed Roof Tanks** - A typical vertical fixed roof tank consists of a cylindrical steel shell with a permanently affixed roof, which may vary in design from cone- or dome-shaped to flat. These tanks are either freely vented or equipped with a pressure/vacuum vent, which prevent the release of vapours during very small changes in temperature, pressure, or liquid level. This tank is considered the minimum acceptable equipment for storing organic liquids.

<sup>1</sup> Updated with particulate matter details by: Mike Woodfield, AEA Technology, UK, December 2006

Horizontal fixed roof tanks are constructed for both above-ground and underground service. These are generally small storage tanks with capacities with capacities of less than 40,000 gallons. Horizontal tanks are usually equipped with pressure-vacuum vents, gauge hatches and sample wells, and manholes. For underground storage tanks, emissions are associated mainly with changes in the liquid level in the tank.

External Floating Roof Tanks - An external floating roof tank typically consists of an open-topped cylindrical steel shell equipped with a roof that floats on the surface of the storage liquid. These tanks are equipped with a seal system, which is attached to the roof perimeter and contacts the tank wall. The floating roof system and seal act to reduce evaporative losses of the contents. Evaporative losses from the external floating roof design are limited to losses from the seal system and roof fittings (standing storage loss) and any exposed liquid on the tank walls (withdrawal loss).

Internal Floating Roof Tanks - An internal floating roof tank has a permanent fixed roof as well as an internal floating deck. Fixed roof tanks that have been retrofitted with an internal deck typically have the roof supported by vertical columns within the tank. Converted external floating roof tanks typically have a self-supporting roof. A newly constructed internal floating roof tank may have either. The deck may be a contact deck (floats directly on the liquid) or non-contact (floats on pontoons which float on the liquid surface). Both types incorporate rim seals and deck fittings. Evaporation losses from decks may come from deck fittings, non-welded deck seams, and the annular space between the deck and the wall. Circulation vents on the fixed roof allows these emissions to freely vent.

Variable Vapour Space Tanks - These tanks are equipped with expandable vapour reservoirs to accommodate vapour volume fluctuations due to temperature and barometric pressure changes. These are normally connected to the vapour space of one, or more, fixed roof tanks. Lifter roof tanks (a telescoping roof) and flexible diaphragm tanks are the two most common types of variable vapour space tanks. Losses occur from these tanks during tank filling when vapour is displaced by liquid.

### **3.4 Emissions**

For all tanks, the total emission of NMVOC is the result of two types of losses. The first is the breathing or standing loss, which is the release of overhead vapours in the tank, due to changes in meteorological conditions such as temperature and pressure, without any appreciable change in the liquid level of the tank. The second is working or withdrawal loss resulting from the displacement of tank vapours occurring during filling or emptying. (CPPI and Environment Canada 1991)

### **3.5 Controls**

All intermediates and final products should be stored in the appropriate container: pressure vessels for gases, floating roof tanks for volatile liquids, fixed roof tanks for heavy fuel oils and non-volatile liquids.

Improved operational procedures are an important part of a NMVOC emission control program. This may include such items as ensuring roof hatches etc are not opened unnecessarily; keeping storage temperatures as low as possible, frequent inspections and painting all tanks a light shade.

Vapour balancing, in which the vapours displaced during handling are collected and recovered or control, can have control efficiencies of 90 to 98 percent. Vapour recovery methods include vapour/liquid absorption, vapour compression, vapour cooling and/or vapour/solid adsorption. Efficiencies as high as 90 to 98 percent may be achieved, depending on the methods used, the design of the unit, the composition of vapours recovered, and the mechanical condition of the system. Control will involve thermal oxidation. Typically the air/vapour mixture is injected into an incinerator, with control efficiencies ranging from 96 to 98 percent. (U.S. EPA 1992)

Other control programs involve design changes and are more specific to the tank in question, as summarised, by tank type, below.

Fixed Roof Tanks - Fixed roof tank emissions vary as a function of vessel capacity, vapour pressure of the contents, utilisation rate of the tank and atmospheric conditions. Emissions can be controlled by the installation of an internal roof and seals, with a control efficiency of 60 to 99 percent. The control efficiency depends on the type of roof and seals installed as well as on the type of organic liquid being stored.

External Floating Roof Tanks - Efficiencies of primary seals may be improved through the used of weather shields. Additional control may be added through a secondary seal. External floating roof tanks may also be retrofitted with a fixed roof. Losses from roof fittings can be minimised through proper design, installation, maintenance and use.

Internal Floating Roof Tanks - Additional control of standing losses can be achieved through the installation of secondary seals. As for external floating roof tanks, losses from roof fittings can be minimised through proper design, installation, maintenance and use.

#### 4 SIMPLER METHODOLOGY

The simplest methodology is to combine the crude oil throughput of each refinery with an emission factor. Emission estimates should be calculated for each refinery in the country and the emission factor used will depend on the type of tanks used to store volatile materials.

The storage and handling emission from each refinery may then be reported and assigned to a grid reference.

#### 5 DETAILED METHODOLOGY

The detailed methodology requires each refinery to calculate the emission from each tank according to techniques developed by the American Petroleum Institute (API, 2002; 2003) (<http://www.api.org/>) or better. This methodology requires considerable input data and should

be carried out by qualified engineers. The methodology allows typical diurnal and monthly variations to be reported.

The U.S. EPA has issued a new section for AP-42 which outlines all of the methods for estimating emissions from storage of organic liquids (Section 7, <http://www.epa.gov/ttn/chief/>). This may be more accessible for some people than API reports. API and the U.S. EPA have worked together to develop these modules.

## 6 RELEVANT ACTIVITY STATISTICS

For the simpler methodology, the crude oil throughput of each refinery is required, together with the proportion of different types of storage tanks used for volatile products.

For the detailed methodology, specific data on the throughput of the intermediates and products via each tank is required together with the physical properties of the intermediate or product. Other data required include such average meteorological data as the temperature, wind speed, barometric pressure and data specific to the tank such as type, dimensions, colour, seal type and condition of the tank.

## 7 POINT SOURCE CRITERIA

Each refinery should be considered as a point source.

## 8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

### 8.1 Simpler Methodology

The Corinair1990 Default Emission Factor Handbook (CEC, 1992) proposed default emission factors of 0.25 g/kg crude oil throughput for a modern refinery (Data quality C) and 1.00 g/kg for an old refinery (Data Quality E).

The following emission factors are for the storage and handling of materials and are obtained by combining the Corinair Data with information obtained from Canada and the UK on proportion of losses from Storage and Handling.

**Table 8.1: Canadian and UK Storage and Handling Losses**

Refinery Type	Emission Factor (% of feedstock)	Quality
“Modern” Corinair	0.03	(Unknown)
Typical	0.05	(Unknown)
“Old” Corinair	0.12	(Unknown)

The following emission factors, together with conditions under which they should be used, have been developed by the U.S. EPA. However, they are considered dated and have a high uncertainty:

**Table 8.2: EPA Emission Factors for Storage and Handling Losses**

<b>Emission Factor</b>	<b>Condition</b>	<b>Quality</b>
0.17 g/kg	where the majority of volatile products are stored in floating roof tanks with secondary seals	(E)
0.67 g/kg	where the majority of volatile products are stored in floating roof tanks with only primary seals	(E)
4.9 g/kg	where the majority of volatile products are stored in fixed roof tanks	(E)

These emissions are intended to account for evaporative losses during storage and the displacement losses resulting from the loading and unloading of storage tanks.

**8.2 Detailed Methodology**

The CONCAWE Air Quality Management Group (Concawe, 2006) has identified a lot of issues with regard to the data submissions for both European Pollutant Emission Register (EPER) mandated by European Directive 96/61/EC on integrated pollution prevention and control (IPPC) and UNECE Kiev Protocol on Pollutant Release and Transfer Registers (PRTR),

In particular CONCAWE initiated a review of the published emission factors for those air pollutants which may be emitted in excess of the EPER threshold values from sources found at the majority of European refineries. CONCAWE, therefore, has drawn up a compendium of emission factors, with associated references, for the uncontrolled release of air pollutants (Concawe, 2006). The compendium can not be fully comprehensive as emission factors are not available in the public domain for all sources and/or pollutants. CONCAWE, however, considers this to be the most appropriate set of emissions factors for the refining sector.

The CONCAWE report provides the air pollutant emission estimation algorithms, incorporating those factors, which CONCAWE recommends for EPER and PRTR reporting purposes. The emission factors provided are for uncontrolled releases. Reported emissions must take account of any abatement equipment installed e.g. wet gas scrubbers, electrostatic precipitators, etc. Where emission factors are available, algorithms are provided for sources found in the majority of European refineries.

Concawe report suggests the use of the latest edition of API documents for Floating Roof Tanks (API,2003), and Vertical Fixed Roof Tanks (API, 2002). For Aboveground Horizontal Tanks, Concawe report suggests to use the latest edition of U.S. EPA methodology (U.S.EPA, 1995). Note that this reference normally contains the latest version of previously quoted API methodologies. An emission calculation software is available from the US EPA via their website, <http://www.epa.gov>, or on a CD-ROM (U.S.EPA, 2005). This CD also contains the EPA publication (U.S.EPA, 1995) and API documents (API 2002; 2003).

**9 SPECIES PROFILES**

Refinery products and intermediates vary considerably in the make up of emissions and only a very general speciated profile may be given. Where possible, speciated profiles should be

obtained for each refinery. The U.S. EPA methodology provides a method for calculating tank-specific speciation factors.

## 10 UNCERTAINTY ESTIMATES

Uncertainties in throughput statistics are considered to be less than 5%.

Field measurements by the UK suggest that emission estimates based on API calculations underestimates emissions by factors of 2-4. Mass balance calculations carried out by the UK Institute of Petroleum suggest a similar scale of underestimate.

The emission factors relating crude oil throughput (feedstock) to emission vary by more than a factor of ten in some cases.

## 11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

### Simpler Methodology

This approach uses single emission factors to estimate emissions from an entire refinery. Little account is taken of the variation between refineries and changes in the quantity and type of volatile products manufactured. For example, NMVOC emissions from a refinery, which reduces production of kerosene and increases production of motor spirit, could be expected to change, even if the crude oil throughput remains the same.

As an illustration of how product output may vary, the table below shows the increase in the production of volatile products between 1980 and 1990, in the U.K.:

**Table 11.1: UK Volatile Products Production**

Year	Total Crude Processed (10 <sup>3</sup> Mg)	Total Volatile Products (10 <sup>3</sup> Mg)
1980	86393	28979
1990	88692	40455

In this example, using crude oil throughput as the activity statistic would result in a similar NMVOC emissions between 1980 and 1990. If emission factors could be derived for each of the volatile product outputs, then a significant change in emission estimates is likely.

### Detailed Methodology

The U.S. EPA and API methodologies require detailed information from each oil refinery. However, emission estimates based on this method have been shown to differ significantly from measurements taken at refineries in the U.K. A detailed review of this discrepancy and the calculation of these emissions should be considered. If the U.S. EPA model appears promising for emission estimation, the addition of default climate parameters, for other regions of the world, to the TANKS model should be considered. This would ensure that different regions using the detailed method are calculating emissions in a consistent fashion. If a country did not have the resources to do a detailed emissions estimate, then the TANK

model could be used to derive representative emission factors for a typical refinery for use in the simple methodology.

## 12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Each refinery should be considered a point source.

## 13 TEMPORAL DISAGGREGATION CRITERIA

No temporal disaggregation is possible if the simpler methodology is used.

If the detailed methodology is used, the refineries should report a typical diurnal variation (average hourly over 24 hours) and seasonal (average monthly over one year).

## 14 ADDITIONAL COMMENTS

## 15 SUPPLEMENTARY DOCUMENTS

## 16 VERIFICATION PROCEDURES

Compare estimates with mass balance calculations, i.e. the difference between crude throughput and products produced.

## 17 REFERENCES

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## 18 BIBLIOGRAPHY

### 19 RELEASE VERSION, DATE AND SOURCE

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