Category		Title
NFR	1.B.2.a.v	Distribution of oil products
SNAP	0505	Gasoline distribution
	050501	Refinery dispatch station
	050502	Transport and depots (except 050503)
	050503	Service stations (including refuelling of cars)
	0504	Liquid fuel distribution (except gasoline distribution in 0505)
		Marine terminals (tankers, handling and storage)
	050401	Other handling and storage (including pipelines)
	050402	
ISIC		
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1 Overview

This chapter is about the distribution of oil products, in particular (but not limited to) gasoline distribution. This chapter discusses the emissions originating from:

- refinery dispatch stations, which includes filling of transport equipment (e.g. tank trucks) taking place within the refinery area;
- transport and depots, which includes emissions from transport equipment and from filling of transport equipment and storage tanks at terminals and depots supplied by a refinery;
- border terminal dispatch stations, since in most countries refined products are not only produced in the respective country but also imported by pipelines, ships, barges and road tankers (Schürmann 1994);
- service stations, at which the principle emissions are from gasoline tanks at the station (e.g. during filling, withdrawal) and emissions while refuelling gasoline cars.

For estimating emissions from non-gasoline liquid fuel production (SNAP code 0504), little information is available in this chapter. No Tier 2 emission factors are available for this activity.

Emissions from this source category have historically contributed significantly to the total anthropogenic non-methane volatile organic compounds (NMVOC) emissions. However, European Directive 94/63/EC (EU, 1994) has mandated vapour collection and recovery during the loading of gasoline transport equipment (i.e. tank trucks, rail tank cars and barges) and during the discharge of tank trucks into storage at service stations. It has also imposed emission controls on all gasoline storage tanks at terminals, dispatch stations and depots. The result of these controls has been a very significant reduction in NMVOC emissions from this sector in the EU.

2 Description of sources

2.1 Process description

Gasoline and other fuel distribution starts at the refinery dispatch station or at the border terminal dispatch station from where it is loaded into rail cars, barges, coastal tankers, pipelines for delivery to marketing terminals or depots or into road tankers (tank trucks) for delivery to service stations or small marketing depots. From marketing terminals or depots (or directly from border terminals) automotive fuels, e.g. gasoil and gasoline, are loaded into tank trucks for delivery to service stations where they are transferred into underground storage tanks and subsequently dispensed into automobile fuel tanks. This automotive fuels distribution chain, including the appropriate SNAP codes, is presented in Figure 2-1. Other fuels, e.g. aviation fuels, are distributed to the end-user, e.g. an airport, in a similar manner.

Figure 2-1 The automotive fuels distribution system, as included in this chapter. The figure includes the three subsystems with their appropriate SNAP codes for gasoline distribution

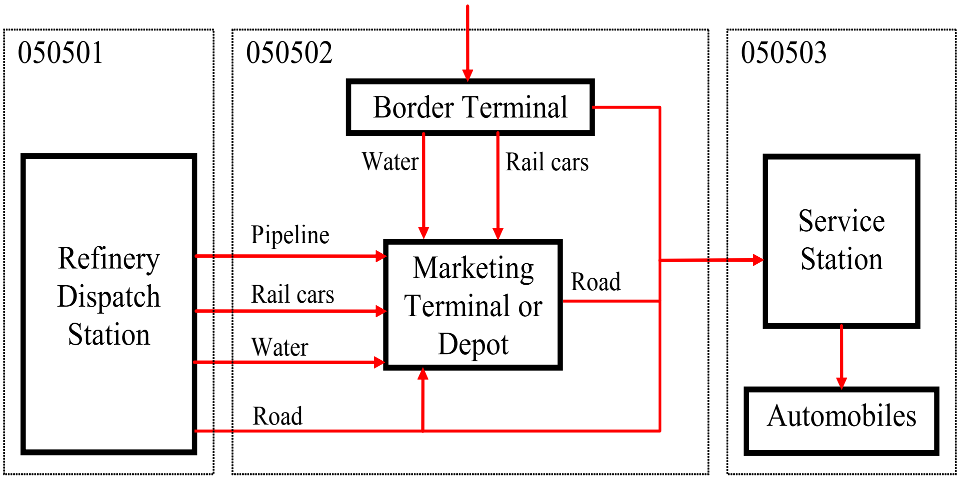
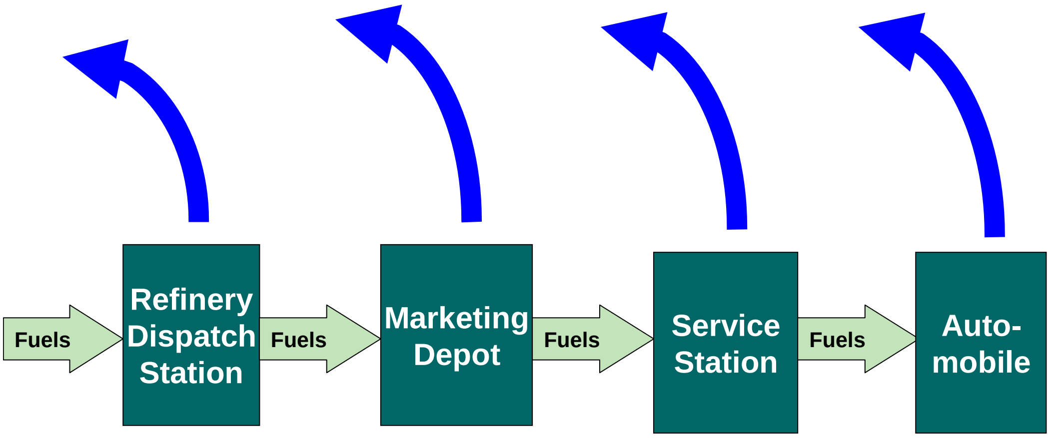


Figure 2-2 Process scheme for the automotive fuels distribution system, as included in this chapter



2.2 Techniques

The refinery products (e.g. gasoline, gasoil, aviation and marine fuel) are stored in tanks of different construction, i.e. fixed roof tanks for products such as kerosene, gasoil or fuel oil or floating roof tanks for volatile products such as gasoline. Then the products are transferred to tank trucks, rail cars or marine vessels, using various techniques of loading, i.e. top, bottom, or submerged loading. Automotive fuels are delivered directly to service stations, where they are stored in underground tanks, or to marketing terminals or depots where they are stored in tanks similar to those used in refineries. In some countries the products are imported and stored at border terminals before distribution (see Figure 2-1).

Due to the volatility of gasoline, the majority of NMVOC emissions in the distribution of oil products occur during its storage and handling, and thus this chapter focuses on gasoline distribution.

2.2.1 Fixed roof tank

These tanks can be classified as follows (Schürmann, 1994):

- fixed roof tanks without internal floating roof (or 'deck') and without pressure/vacuum (PV) vent;
- fixed roof tanks with internal floating roof and without PV vent;
- fixed roof tanks without internal floating roof and with PV valve, whereby pressure range (e.g. +20 mbar/-5 mbar or +180 mbar/-50 mbar) has an influence on storage emissions.

The internal floating roofs are typically made of steel or aluminium sheets. The steel internal covers are longitudinally welded and in direct contact with the liquid surface. The aluminium covers generally have a closed surface of clamped sheets and either float several centimetres above the product surface on floats (Verein Deutscher Ingenieure (VDI), 1985) or are made of buoyant panels which float directly on the surface of the product.

Under the terms of Directive 94/63/EC (EU, 1994) fixed roof tanks storing gasoline must either be equipped with an internal floating roof, be vapour balanced or be connected to a vapour recovery unit.

2.2.2 External floating roof tank

A tank normally used in refinery dispatch operations as well as at principal marketing terminals. It consists of a cylindrical steel wall equipped with a floating roof. The roof (deck) floats on top of the product, and is equipped with seals to the sidewall to minimise vapour loss. Under the terms of Directive 94/63/EC (EU, 1994) external floating roof tanks storing gasoline must be equipped with secondary seals. External floating roof decks are of three general types: pontoons, pan, and double deck (Economic Commission for Europe (ECE), 1990, Canadian Council of Ministers of the Environment (CCME), 1991).

2.2.3 Bottom loading

A system for loading liquid petroleum products into a cargo tank truck or ship from the bottom, through a system of pipes, valves and dry-disconnect fittings (CCME, 1991). This type of loading is mandated for gasoline under the terms of Directive 94/63/EC (EU, 1994).

2.2.4 Splash loading

The loading arm is positioned with the outlet above the tank bottom so that the product falls to the liquid surface. As this leads to a high vapour evolution for volatile products (ECE, 1990), this type of loading mode is not permitted for gasoline loading under the terms of Directive 94/63/EC (EU, 1994).

2.2.5 Submerged top loading

Submerged top loading implies a system for loading products into any tank by means of a pipe to provide entry below the liquid surface, thereby minimising splash and vapour formation (CCME, 1991).

2.2.6 Underground storage tank

An underground storage tank is a tank that is completely buried by or covered with earth, backfill or concrete, or a partially buried tank. A partially buried tank means a storage tank that has 10 % or more of its volume below adjacent ground level. These tanks normally have fixed fill pipes which discharge at the bottom of the tank (CCME, 1991).

2.3 Emissions

Emissions of NMVOCs to atmosphere occur in nearly every element of the oil product distribution chain. The vast majority of emissions occur due to the storage and handling of gasoline due to their much higher volatility compared to other fuels such as gasoil, kerosene, etc. The emissions can be classified as follows (for details see ECE, 1990):

- emissions from bulk storage tanks (refinery dispatch station, border terminals, marketing depots);
- service station storage tank emissions;
- transport vehicle filling emissions;
- other emissions.

These will be discussed separately in this section.

2.3.1 Emissions from bulk storage tanks

There are basically two types of bulk storage tanks.

External floating roof tanks and fixed roof tanks with internal floating covers

There are three sources of emissions associated with the storage of volatile products.

1. Standing storage emissions

These are the major source of emissions. They are caused mainly by evaporation of liquid product through imperfections in the flexible peripheral seals. Included are any evaporative emissions through the deck structure and fittings such as manholes, gauge pipes and hatches, also roof support columns or legs. The emissions vary depending on design of surface covers (steel or aluminium); see subsections 2.2, Techniques and 2.4, Controls, of the present chapter. Additionally, for external floating roof tanks the wind has a significant influence on the magnitude of these emissions.

2. Withdrawal emissions

These emissions occur following the withdrawal of liquid product. They are due to evaporation of the film of product which adheres to the surface of the tank walls, and any tank roof support columns fitted. The magnitude of these emissions is mainly influenced by the product volatility and the tank shell inner surface condition, e.g. presence of rust or a tank lining.

3. Filling of the tank

After repairs or complete emptying when the floating roof stands on its supports causes additional emissions.

Fixed roof tanks without internal floating covers

1. Displacement emissions

These occur due to displacement of the mixture of air and hydrocarbon vapour by the incoming product. The vapour emitted originates mainly by evaporation from the previous tank contents during storage.

2. Withdrawal emissions
These occur following intake of air via the pressure/vacuum relief valves. Dilution of the hydrocarbon vapour/air mixture previously contained in the vapour space will lead to further evaporation to restore the equilibrium.

3. Working emissions
These are defined as the sum of displacement and withdrawal emissions caused by gasoline movements.

4. Breathing emissions
These are caused by temperature variations and changes in the barometric pressure, which in turn cause expansion and contraction of both liquid and vapour within the tank.

2.3.2 Service station storage tank emissions

The main contribution comes from displacement when an incoming bulk delivery of gasoline is received into tanks. There are also withdrawal and breathing emissions, the latter being of minor significance since tanks are normally double-walled underground tanks and are not subject to 'above-ground' diurnal temperature changes but the variation in atmospheric pressure influences the breathing emissions.

2.3.3 Transport vehicle filling emissions

These occur when gasoline is transferred from storage tanks into transport vehicles, i.e. road tankers, rail cars, barges, ships and when dispensed into cars. The emissions are a combination of vapour from the previous tank contents and the vapour evolved as a result of splashing and turbulence during filling. The transit or breathing losses are minor (see 'Spilling and leakage' under subsection 2.3.4 of the present chapter). Four categories of loss from spillage during refuelling were identified (see below). Most of these losses can be avoided by correct maintenance and handling of the dispensing equipment:

- pre-fill drip from the nozzle while being handled between the pump and the vehicle;
- spit-back of gasoline from the fuel tank filler pipe, resulting from the pressure build -up in the vapour space;
- overflow from the filler pipe;
- post-fill drip from the nozzle while being handled between the vehicle and the pump.

2.3.4 Other emissions

Emissions described here are of minor magnitude as compared to those described above and include the following:

1. Fugitive emissions
Fugitive emissions may occur following seepage of gasoline liquid through parts of handling equipment such as pipeline gaskets; also pump and valve stem seals. Pipelines are closed systems and essentially emission free. They are, however, subject to some fugitive losses at pumping stations.

2. Ship and barge ballasting emissions

Hydrocarbon vapours are displaced into the atmosphere when a compartment, which has previously contained crude oil, gasoline or other highly volatile products, is loaded with ballast water.

3. Transport vehicle emissions whilst travelling

These are often negligible because the vapour and pressure retention capability of the tank or compartment will be above the level at which breathing will be induced by the temperature variations that may occur.

4. Spillage and leakage

Any activity involving the transfer of gasoline from one form of container to another is a potential point of spillage. Also, leakage from storage and handling equipment such as loading arms, swivels and storage tanks, in addition to flanges and valves, can contribute to vapour emissions. Such emissions will only make a minimum contribution to the total which occurs in the gasoline distribution sector, providing facilities are well designed and operated efficiently.

2.4 Controls

Considerable reduction of hydrocarbon emissions from gasoline distribution network is achieved by modifying truck, barge or rail car tanks loading practices, installing vapour recovery units (VRU), vapour balancing displacement vapours back into the delivery tanker at service stations and providing fixed roof storage tanks with internal floating covers. These emission controls have been mandated under the terms of Directive 94/63/EC (EU, 1994). For more details on control options described in this section, see Richards et al, 1990; ECE, 1990, CCME, 1991, VDI, 1985.

2.4.1 Storage tanks

There are several ways to control emissions from storage tanks. Vapour emissions from tankage storing gasoline can be controlled by the use of external floating roof tanks or fixed roof tanks with internal floating roofs. These can reduce vapour emissions from fixed roof tankage by over 90 % (VDI, 1985, European Commission, 2006). A very simple but effective measure for fixed roof tanks is to paint the shell of the tank white. A white coating reflects 70 % of the energy of the irradiating sunlight (see VDI, 1985 for more details on effects of different colour and type of coatings). Another option is to install Stage IA devices, described in the next subsection of this chapter.

2.4.2 Stage I controls

Stage I controls refer to a variety of techniques reducing NMVOC emissions at marketing terminals (Stage IA) and when gasoline is delivered to service stations (Stage IB).

Stage IA

Stage IA systems basically include two parts.

Vapour balance lines between tanks and loading gantries

When a group of fixed-roof gasoline tanks is subject to simultaneous receipts and deliveries, interconnecting the tank vapour spaces can reduce emissions to the atmosphere by allowing displaced vapours from a receiving tank to flow into the vapour space of a delivering tank. Under the terms of Directive 94/63/EC, vapour-balanced tanks at terminals with gasoline throughputs in excess of 25 000 t/year must be connected to a vapour recovery unit.

Vapour recovery units (VRU)

These units usually remove hydrocarbons emitted from tanks or vehicle loading operations by either cooling/condensation, liquid-loading absorption, membrane separation, carbon adsorption or a combination of these processes (for details of the processes see ECE, 1990, European Commission, 2006). The recovered hydrocarbons are usually returned to tankage in liquid form. VRUs are either single-stage, with recovery efficiencies better than 98 % from membrane separation and carbon-adsorption type VRUs, or double-stage, with additional processing of the first-stage tail gas, with design efficiencies in excess of 99 %. The additional cost of the second stage and the small incremental reduction in emissions has been shown to make single- stage VRUs more cost-effective than double-stage units (Richards et. al, 1990). Directive 94/63/EC mandates single-stage units with an emission limit of 35 g/Nm^3 for any one hour.

Leakage can occur in the vapour collection system, particularly with top-loading systems modified for vapour collection. This was recognised in Directive 94/63/EC which mandated bottom loading of road tankers and regular testing of road tankers for vapour tightness.

Stage IB

Stage IB applies to vapour balancing systems between service station tanks and road tankers supplying gasoline to them. Saturated vapours, displaced from the tank vent pipes when receiving gasoline, are returned to the truck compartment from which the gasoline is supplied, via a piping system and/or hoses. There are several piping configurations possible; for details see Richards et al., 1990 or ECE, 1990. It has been reported that with well designed systems vapour collection efficiencies are high (Schürmann, 1994, uses in his report a reduction efficiency of 100 % for stations equipped with Stage IB controls). Directive 94/63/EC mandates Stage IB emission controls for all service stations with gasoline throughputs in excess of 100 m^3/year.

2.4.3 Tank trucks

To reduce emissions, loading techniques can be modified as below:

- submerged top loading (reduces VOC emissions by 40 to 60 %);
- submerged top loading with in-line vapour return;
- submerged top loading with external vapour return;
- bottom loading;
- bottom loading with vapour return;
- Directive 94/63/EC (EU, 1994) mandates that road tankers used for gasoline must be bottom loaded, and the vapours displaced during loading returned to a VRU for recovery.

2.4.4 Rail cars

Rail cars are generally top loaded in Europe. Directive 94/63/EC (EU, 1994) mandates that the vapours displaced during loading of rail cars with gasoline must be returned to a VRU for recovery. The vapour collection efficiency could be improved if bottom loading would be introduced on a wider scale. Its introduction would additionally require automatic overfill protection systems on all rail cars.

2.4.5 Barges/ships

Modified loading techniques reduce loading losses by 60 to 80 %. This involves low initial loading to reduce turbulence when filling the bottom, fast bulk (bottom) loading and slow final loading to reduce turbulence in the vicinity of the ullage as the liquid approaches the top (ECE, 1990). Directive 94/63/EC (EU, 1994) mandates that the vapours displaced during loading of inland waterway barges with gasoline must be returned to a VRU for recovery.

A study undertaken for the European Commission (AEAT, 2001) in 2001 on emission controls for sea-going vessels concluded that, at that time, the costs to retrofit marine tankers with vapour collection systems and install shore-side vapour recovery units was not cost-effective. However, issues with local air quality have resulted in a ship-loading vapour-emission control system being installed, e.g. at Gothenburg oil harbour.

2.4.6 Car refuelling

Stage II controls

Stage II applies to vapour balancing systems between automobile fuel tanks during refuelling and the service station tank supplying the gasoline. Saturated vapours are displaced from the automobile fuel tank and returned to the service station tank via special fittings in the dispensing nozzle. Essential to this system is the existence of Stage IB controls in place; otherwise Stage II devices may only delay the venting of vapour to the atmosphere.

There are two basic types of Stage II petrol vapour recovery systems: passive and active systems.

Passive systems (‘balance’ systems) utilise the pressure generated by the flow of fuel into the vehicle tank to force the vapours back through a return line into the service station underground storage tanks. For this to work effectively, a good seal around the filler nozzle and the filler neck is required. This is usually achieved by a rubber bellow or boot fitted to the nozzle.

Active systems (‘assist’ systems) use a vacuum pump to draw the petrol vapours through a return line to the underground storage tank. This is the most widely used system in Europe; passive systems are reported to be awkward to operate due to the shape and extra weight of the nozzle.

The key elements of active Stage II systems include:

- a vapour flow control system which regulates the amount of vapour drawn into the storage tank in proportion to the amount of fuel dispensed (either through a proportional valve or by controlling the vapour pump directly from the fuel pump). The volumetric return rate of vapour will generally be within +/- 5 % of the volume of fuel dispensed;
- a vapour pump that sucks back vapour from the nozzle to the underground storage tank, with a coaxial hose;
- the nozzle, which generally looks similar to a normal pump nozzle and which typically has a vapour sleeve positioned away from the spout. Where there is more than one nozzle on each side of a dispenser, each nozzle is typically fitted with a valve which ensures that only the nozzle in use will suck back vapours.

Many of the EC Member States have legislated for the installation of Stage II, although there are national variations in the site throughput threshold above which systems must be fitted.

On-board canisters

These are a viable alternative to Stage II controls and have been mandated in the USA. Gasoline automobiles are already fitted with a ‘small’ canister to capture diurnal, hot soak emissions. An enlarged version of this canister can also capture refuelling emissions. According to the experience in the USA and Concawe (McArragher et al, 1987), enlarged carbon canisters can reduce refuelling emissions by more than 95 %. Canisters are filled with activated carbon to which all external fuel system vents are connected. Any diurnal, hot soak as well as refuelling hydrocarbon emissions are adsorbed by the carbon and retained in the canister. The carbon is purged of hydrocarbons during normal driving by drawing the air back through the canister and into the engine where it is burnt.

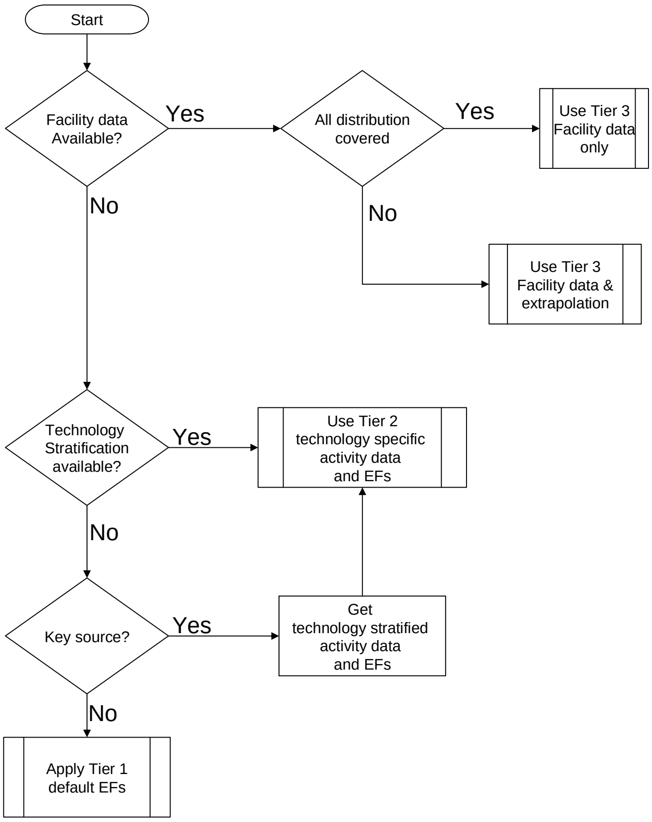
3 Methods

3.1 Choice of method

Figure 3-1 presents the procedure to select the methods for estimating emissions from the distribution of oil products. The basic idea is:

- if detailed information is available, use it;
- if the source category is a key category, a Tier 2 or better method must be applied and detailed input data must be collected. The decision tree directs the user in such cases to the Tier 2 method, since it is expected that it is more easy to obtain the necessary input data for this approach than to collect facility level data needed for a Tier 3 estimate;
- the alternative of applying a Tier 3 method, using detailed process modelling, is not explicitly included in this decision tree. However, detailed modelling will always be done at facility level and results of such modelling could be seen as 'facility data' in the decision tree.

Figure 3-1 Decision tree for source category 1.B.2.a.v Distribution of oil products



3.2 Tier 1 default approach

3.2.1 Algorithm

The Tier 1 approach for oil product distribution uses the general equation:

$$E_{pollutant} = AR_{production} \times EF_{pollutant} \tag{1}$$

where:

$E_{pollutant}$ = the emission of a certain pollutant,

$AR_{production}$ = the total amount of gasoline sold,

$EF_{pollutant}$ = the emission factor for the selected pollutant.

As gasoline generates the majority of NMVOC emissions, this equation is applied at the national level, using the total amount of gasoline sold as production statistics.

The Tier 1 emission factors assume an averaged or typical technology and abatement implementation in the country and integrate all sub-processes within the distribution process.

In cases where specific abatement options are to be taken into account a Tier 1 method is not applicable and a Tier 2 or Tier 3 approach must be used.

3.2.2 Default emission factors

The Tier 1 emission factor is derived from a study of Concawe (Richards et al., 1990). In that study the potential average reduction in the uncontrolled NMVOC emissions from gasoline distribution was calculated. The assumed liquid gasoline density is 730 kg/m^3 and the assumed condensed vapour density is 600 kg/m^3. As the implementation of Directive 94/63/EC (EU, 1994) has resulted in the installation of Stage I vapour recovery in the EU, an NMVOC emission factor for controlled techniques is given in

Table 3-1. Note, however, that this study did not consider the impact of emission controls for automotive refuelling (Stage II). The Tier 1 emission factor, therefore, is for a gasoline distribution network with emission controls fitted to storage tanks, mobile container loading and tank truck discharge at service stations, but with no emission controls for automotive refuelling. The latter has been installed in some countries, so the Tier 1 default factor will result in too high an estimate of emissions in these countries. The use of Tier 2 factors would be required to establish more accurate estimates on a national basis.

Table 3-1 Tier 1 emission factor for source category 1.B.2.a.v Distribution of oil products

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
Not applicable	NOx, CO, NH3, PM2.5, PM10, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	2	kg/Mg gasoline handled	0.2	20	Richards et al. (1990)

3.2.3 Activity data

To apply the Tier 1 default emission factor for NMVOC emissions from gasoline distribution, it is good practice to use the total annual amount of gasoline sold in the country/region as activity statistics.

3.3 Tier 2 technology-specific approach

3.3.1 Algorithm

The Tier 2 approach is similar to the Tier 1 approach. To apply the Tier 2 approach, both the activity data and the emission factors need to be stratified according to the different techniques in the distribution of oil products that may occur in the country.

The approach followed to apply a Tier 2 approach is as follows.

Stratify the oil product distribution in the country to model the different product and process types occurring in the national industry into the inventory by:

- defining the production using each of the separate product and/or process types (together called 'technologies' in the formulae below) separately, and
- applying technology specific emission factors for each process type:

$$E_{pollutant} = \sum_{technologies} AR_{production,technology} \times EF_{technology,pollutant} \quad (2)$$

where:

$AR_{production,technology}$ = the production rate within the source category, for the specific technology,

$EF_{technology,pollutant}$ = the emission factor for this technology and this pollutant.

A country where only one technology is implemented will result in a penetration factor of 100 % and the algorithm in equation (2) reduces to:

$$E_{pollutant} = AR_{production} \times EF_{technology,pollutant} \quad (3)$$

where:

$E_{pollutant}$ = the emission of the specified pollutant,

$AR_{production}$ = the activity rate within this source category,

$EF_{pollutant}$ = the emission factor for this pollutant.

The emission factors in this approach still will include all sub-processes with the distribution of oil products.

3.3.2 Technology-specific emission factors

In the tables below, NMVOC emission factors are presented for the various ‘technologies’ within this source category. The majority of the factors are taken from Concawe (2015) and, if not specified otherwise, based on uncontrolled processes. The technologies for loading products into mobile containers are the same at refinery dispatch stations, border terminal dispatch stations, terminals and depots. These will be given a generic term in this section of ‘oil product loading facility’.

3.3.2.1 Refinery dispatch stations and terminals: oil product loading facility

The tables below provide the Tier 2 emission factors for NMVOC emissions from oil product loading facilities. These are provided for gasoline throughput only. Emission factors for the distribution of non-gasoline oil products (SNAP code 0504) are not available.

Table 3-2 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Loading facilities, Road tanker

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050501	Refinery dispatch station			
Technologies/Practices	Road tanker, bottom loading No vapour balancing during previous off-loading				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, PM2.5, PM10, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	9	g/m3 throughput/kPa TVP	5	12	CONCAWE (2015)

Table 3-3 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Loading facilities, Road tanker

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050501	Refinery dispatch station			
Technologies/Practices	Road tanker, top loading No vapour balancing during previous off-loading				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, PM2.5, PM10, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	9	g/m3 throughput/kPa TVP	6	13	CONCAWE (2015)

Table 3-4 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Loading facilities, Road tanker

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050501	Refinery dispatch station			
Technologies/Practices	Road tanker, bottom or top loading. Vapour balancing (Stage IB) during previous off-loading				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, PM2.5, PM10, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	23	g/m3 throughput/kPa TVP	14	32	CONCAWE (2015)

Table 3-5 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Loading facilities, Rail tanker

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050501	Refinery dispatch station			
Technologies/Practices	Rail tanker				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, PM2.5, PM10, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	11	g/m3 throughput/kPa TVP	6	22	CONCAWE (2015)

Table 3-6 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Loading facilities, Marine tanker

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050501	Refinery dispatch station			
Technologies/Practices	Marine tanker Typical cargo tank condition				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, PM2.5, PM10, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	4	g/m3 throughput/kPa TVP	2	8	CONCAWE (2015)

Table 3-7 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Loading facilities, Barge

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050501	Refinery dispatch station			
Technologies/Practices	Barge Typical cargo tank condition				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, PM2.5, PM10, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	7	g/m3 throughput/kPa TVP	4	10	CONCAWE (2015)

3.3.2.2 Service stations

In the tables below, the technology-specific emission factors for service stations are provided. As the majority of the emissions at service stations are from gasoline storage and refuelling (compared to emissions from gasoil), emission factors are only provided for gasoline.

Table 3-8 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Service stations, Storage tank filling

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050503	Service stations (including refuelling of cars)			
Technologies/Practices	Storage tank Filling without Stage 1B				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, PM2.5, PM10, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	24	g/m3 throughput/kPa TVP	14	34	CONCAWE (2015)

Table 3-9 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Service stations, Storage tank breathing

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050503	Service stations (including refuelling of cars)			
Technologies/Practices	Storage tank Breathing				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, TSP, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	3	g/m3 throughput/kPa TVP	2	4	CONCAWE (2015)

Table 3-10 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Service stations, Automobile refuelling

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050503	Service stations (including refuelling of cars)			
Technologies/Practices	Automobile refuelling with no emission controls in operation				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, TSP, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	37	g/m3 throughput/kPa TVP	22	52	CONCAWE (2015)

Table 3-11 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Service stations, Automobile refuelling: drips and spills

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050503	Service stations (including refuelling of cars)			
Technologies/Practices	Automobile refuelling Drips and minor spillage				
Region or regional conditions					
Abatement technologies	uncontrolled				
Not applicable	NOx, CO, NH3, TSP, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	2	g/m3 throughput/kPa TVP	1	3	CONCAWE (2015)

The emission factors in the tables above depend on the true vapour pressure (TVP). This pressure is the vapour pressure at loading, and depends on the loading temperature. The definition of the TVP is as follows:

$$TVP = RVP \times 10^{AT+B}, \quad (4)$$

where

$$A = 0.000007047 \times RVP + 0.0132,$$

$$B = 0.0002311 \times RVP - 0.5236,$$

T is the temperature (in °C),

RVP is the Reid Vapour Pressure (in kPa).

The annual average loading temperature at terminals can be assumed to equal the average annual ambient temperature.

More information regarding TVP and RVP is available in US EPA AP42 - Chapter 7 and Section 1 (US EPA, 2006).

3.3.2.3 Transport and depots: storage

Emissions from transport were identified in subsection 2.3.4 of this chapter as negligible. The emission factors for filling mobile containers at depots are the same as those for refinery dispatch stations provided in subsection 3.3.2.1.

The other source of emissions at depots is gasoline storage. Table 3-12 provides the Tier 2 emission factor for gasoline storage at terminals and depots. This emission factor is derived from a study of Concawe (Richards et al. 1990). In this study the potential average reduction in the uncontrolled NMVOC emissions from gasoline distribution was calculated. The assumed liquid gasoline density is 730 kg/m^3 and the assumed condensed vapour density is 600 kg/m^3. The implementation of Directive 94/63/EC (EU, 1994) has resulted in the installation of gasoline storage tank controls, primarily internal floating roofs in fixed roof tanks. The NMVOC emission factor given in

Table 3-12 is for gasoline depot tanks fitted with floating roofs.

Table 3-12 Tier 2 emission factors for source category 1.B.2.a.v Distribution of oil products, Terminals and depots, Storage

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050502	Transport and depots (except 05.05.03)			
Technologies/Practices	Gasoline storage tanks				
Region or regional conditions					
Abatement technologies	Tanks fitted with floating roofs				
Not applicable	NOx, CO, NH3, TSP, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	0.06	kg/Mg gasoline handled	0.01	0.6	Richards et al. (1990)

It should be noted that the emissions from individual floating roof tanks have very little correlation to their throughput. This is because the vast majority of emissions occur from vapour leaks past seals and roof fittings. Emissions vary on a tank to tank basis depending, for example, on the true vapour pressure of the stored gasoline and type and number of fittings. The emission factor provided should not be used to estimate emissions on a site-by-site basis. For this application, or to obtain a more accurate national emission estimate, it is good practice to use the algorithms provided by the US EPA (2006), see subsection 3.4.1 of the present chapter.

3.3.3 Abatement

A number of add on technologies exist that are aimed at reducing the emissions of specific pollutants. The resulting emission can be calculated by replacing the technology specific emission factor with an abated emission factor as given in the formula:

$$EF_{technology,abated} = (1 - \eta_{abatement}) \times EF_{technology,unabated} \qquad (5)$$

This section presents default abatement efficiencies for a number of abatement options, applicable in this sector.

Table 3-13 Abatement efficiencies (ηabatement) for source category 1.B.2.a.v Distribution of oil products, Loading facilities, Mobile container filling

Tier 2 abatement efficiency					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050501	Refinery dispatch station			
Technologies/Practices	Loading facilities, mobile container filling Membrane or carbon adsorption type single-stage VRU				
Region or regional conditions					
Abatement technologies	Vapour recovery				
Not applicable	NOx, CO, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	0.98		0.97	0.99	EMEP/EEA (2006)

Table 3-14 Abatement efficiencies ($\eta_{abatement}$) for source category 1.B.2.a.v Distribution of oil products, Service stations, Storage tank filling

Tier 2 abatement efficiency					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050503	Service stations			
Technologies/Practices	Storage tank filling Stage 1B – Vapour balancing during bulk gasoline tank filling				
Region or regional conditions					
Abatement technologies	Vapour recovery				
Not applicable	NOx, CO, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	0.95		0.93	0.97	EMEP/EEA (2006)

Table 3-15 Abatement efficiencies ($\eta_{abatement}$) for source category 1.B.2.a.v Distribution of oil products, Service stations, Refuelling

Tier 2 abatement efficiency					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050503	Service stations			
Technologies/Practices	Refuelling Stage II automotive refuelling controls				
Region or regional conditions					
Abatement technologies	Vapour recovery				
Not applicable	NOx, CO, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	0.85		0.60	0.96	EG TEI (2009)

Table 3-16 Abatement efficiencies ($\eta_{abatement}$) for source category 1.B.2.a.v Distribution of oil products, Service stations, Refuelling

Tier 2 abatement efficiency					
	Code	Name			
NFR Source Category	1.B.2.a.v	Distribution of oil products			
Fuel	NA				
SNAP (if applicable)	050503	Service stations			
Technologies/Practices	Refuelling – Enlarged automotive carbon canister to control refuelling emissions				
Region or regional conditions					
Abatement technologies	Vapour recovery				
Not applicable	NOx, CO, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	0.95		0.93	0.97	EMEP/EEA (2006)

3.3.4 Activity data

More detailed country-specific data are needed as far as the technical parameters of equipment as well as operation practices are concerned. This includes:

- *loading facilities at refinery dispatch stations, terminals and depots* — volume of volatile products loaded into different transport modes (e.g. rail truck, pipeline, tank truck); loading practices for specific modes of transport (e.g. top-submerged, bottom); type and extent of emission control measures in place (e.g. Stage I);

- *storage at terminals and depots* — volume of gasoline throughput in these tanks;
- *service stations* — volume of gasoline sold; type and extent of emission control measures in place (e.g. Stage IB, Stage II);
- average ambient temperature;
- *Reid vapour pressure (RVP) of distributed volatile products, mainly gasoline* — from the annual average RVP value and average temperature data the true vapour pressure can be calculated (required for Tier 2 emission factors).

3.4 Tier 3 emission modelling and use of facility data

3.4.1 Algorithm

A Tier 3 emission estimate for this source category would involve process modelling. Using process details separate estimates will be made for each process taking account of abatement systems installed. For example for storage tanks, details of tank size fittings, etc. can be used to estimate emissions on a tank by tank basis.

3.4.2 Tier 3 emission modelling and use of facility data

3.4.2.1 Storage emission estimation methodologies

For the types of storage tanks used to store volatile liquids at terminals and depots, emission estimation methodologies are provided by the US EPA (2006). These methodologies require information on the tank contents, size, shell colour, floating roof fitting types and number, etc. on a tank-by-tank basis. Emission calculation software utilizing the algorithms in the US EPA publication is available on the EPA website www.epa.gov, or on a CD-ROM (US EPA, 2005) although this software is now outdated and is not reliably functional on computers using modern operating systems.

3.4.2.2 Vapour recovery unit efficiency

Directive 94/63/EC requires emission limit compliance testing of VRUs. The data from these tests can be used to determine a more accurate value of the VRU abatement efficiency than the default provided in Table 3-13.

3.4.3 Activity data

Depending on the type of method using, different activity statistics are required. This is information on a case-by-case basis, e.g. for each storage tank individually, taking into account the specifications of each tank.

4 Data quality

4.1 Completeness

No specific issues.

4.2 Avoiding double counting with other sectors

In this chapter, the methodology to calculate the emissions from gasoline distribution system as well as from storage of gasoline in the refinery dispatch station is described. However, chapter 1.B.2.a.iv

Refining/storage on refineries in this Guidebook covers the latter source. Therefore, there is a danger of double counting especially in the case when the simplified methodology is used and consequently aggregated emission factors are used. In the proposed methodology emissions from refinery, storage tanks are reported in 1.B.2.a.iv and emission from loading of mobile container in refinery are reported in this chapter.

4.3 Verification

The emission factors presented in this chapter are not necessarily representative for a particular region/country due to substantial differences in handling practices, product properties as well as meteorological conditions. The verification can be based on local measurements or measurements performed for similar conditions.

4.3.1 Best Available Technique emission factors

The BREF document on Best Available Techniques for emissions from storage (European Commission, 2006) describes the techniques to be used to achieve the lowest available emission levels for the storage, handling and transport of any liquid, gaseous or solid substance.

No specific emission levels are provided applicable for this source category, therefore this section does not provide a table with BAT-associated emission factors.

4.4 Developing a consistent time series and recalculation

No specific issues

4.5 Uncertainty assessment

4.5.1 Emission factor uncertainties

No specific issues.

4.5.2 Activity data uncertainties

No specific issues.

4.6 Inventory quality assurance/quality control QA/QC

No specific issues

4.7 Gridding

Where no detailed information is available on location and throughputs of considered elements of the gasoline distribution network, it is good practice to distribute the emissions from service stations (050503) evenly across regions (e.g., administrative units) or grids or based on population data. The same applies to emissions from sub-sector (050502) if the appropriate data are not available although the location and throughput of principal marketing depots as well as border terminals should be known. The location of refineries is usually known (in many countries there are few, if not only one). Therefore, emissions from refinery dispatch stations (050501) can be attributed to a particular region or grid.

4.8 Reporting and documentation

No specific issues

5 Glossary

Fixed roof tank	A fixed roof tank consists of a cylindrical steel shell topped by a coned roof and could be equipped with internal floating cover in aluminium or steel as well as with a pressure/vacuum vent (PV vent).
Floating roof tank	A tank normally used in terminal operations which is equipped with a roof floating on top of the gasoline.
Marketing depot	One or more storage tanks where gasoline is received by pipeline, road truck, barge or rail car, and is stored in bulk for subsequent transportation or distribution by road truck — see *Terminal*.
Onboard canister	A container filled with an adsorbent (e.g., activated carbon) which collects gasoline vapours in a motor vehicle.
Reid vapour pressure (RVP)	The vapour pressure of a product (e.g. gasoline) is determined by a standard laboratory method called RVP, which measures its inherent tendency to evaporate at 38 °C with vapour/liquid ratio of 4/1. RVP is reported in kPa. For details of the equipment and procedures refer to the following standard methods: IP 69/78 (Vapour pressure Reid method), ASTM D323 (Vapour pressure of petroleum products Reid method), ISO 3000-1974 (Petroleum products — Determination of vapour pressure — Reid method).
Service station	Any premises at which gasoline is dispensed into the fuel tanks of motor vehicles, including marinas (gasoline fuelling point which services water craft) with land-based storage.
Stage I controls	The equipment used to recover gasoline vapours at refinery dispatch stations, marketing depots, terminals and from service stations.
Stage II controls	The equipment used to recover gasoline vapours emitted during motor vehicle refuelling at service stations.
Terminal	The term generally applied to a large throughput depot. These tend to have more storage tanks than a marketing depot.
True vapour pressure (TVP)	If any liquid is introduced into an evacuated container, molecules will escape from the liquid surface by virtue of their kinetic energy to form vapour. Thereafter, some vapour will condense and eventually a state of equilibrium is reached, which is sustained if the temperature remains constant. The observed pressure in absolute units in the vapour space is defined as the true vapour pressure (TVP) of the liquid at the constant temperature applicable. See the end of subsection 3.3.2.1 for the definition, as the formula to calculate the TVP is given there.

Vapour balancing	Vapours displaced from tanks receiving gasoline are returned to tanks delivering the gasoline.
Vapour recovery unit (VRU)	An installation, normally located at a terminal, which receives gasoline vapours from cargo tanks and recovers them for subsequent use, e.g. condensation.

6 References

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7 Point of enquiry

Enquiries concerning this chapter should be directed to the relevant leader(s) of the Task Force on Emission Inventories and Projection's expert panel on combustion and industry. Please refer to the TFEIP website (www.tfeip-secretariat.org/) for the contact details of the current expert panel leaders.