## *7.21 Petrol distribution (from the mineral oil refinery dispatch station (petrol) to service stations including transport and depots (petrol))*

### 7.21.1 Coverage

Activities covered relate to the transport and distribution of petrol from mineral oil refinery dispatch stations or terminals, to service-stations often via intermediate storages. The terminal is any facility which is used for the storage and loading of petrol onto road tankers, rail tankers, or vessels, including all storage installations on the site of the facility. A refinery may have its own terminal fed by pipeline in close proximity but external to the refinery site or a dispatch station which is located on the refinery. The service-station is an installation where petrol is dispensed to motor vehicle fuel tanks from stationary underground storage tanks [1].

### 7.21.2 Emission sources

At terminals, petrol is stored in External Floating Roof Tank (EFRT) or in Internal Floating Roof Tanks (IFRT).

Petrol transport is carried out by a combination of road, rail and water transport and by pipeline; this last means releases no significant emissions.

At terminals, different means are used for loading of mobile containers (road tankers, rail tankers, barges and marine tankers). Bottom loading and top loading of containers are used. VOC emissions depend on the type of container being loaded, the degree of saturation of the vapour in the cargo tank [2] and also how loading is carried out.

Petrol is delivered to service-stations where it is transferred into underground storage tanks and subsequently dispensed into automobile fuel tanks. At service-stations, filling of underground tanks is carried out via a fixed vertical pipe installed within the tank to which the road tanker is connected using a hose. VOC emissions occur from the storage tank loading and breathing although the latter is minimal as the tank is underground and hence not subject to diurnal changes in solar heating.

At service-stations, in addition to the emissions arising from fuel deliveries, there are emissions released from the refuelling of vehicles.

Vehicle-refuelling operations are considered to be a major source of VOC emissions. These emissions are attributable to vapour displaced from the automobile tank by dispensed petrol. The major factors affecting the quantity of emissions are the volume of petrol dispensed, petrol temperature, vehicle tank temperature, petrol vapour pressure, and dispensing rates. Especially, the vehicle tank temperature is nowadays of major importance for refuelling emissions of modern gasoline injection cars. These VOC emissions can be controlled by vapour balancing systems, so-called Stage II controls which have been legislated for on a national basis in a large number of EU countries or by an enlarged carbon canister system which is mandated in the USA.

### 7.21.3 BAT, Associated Emission Levels (AEL)

Emission control options from mobile tank filling and service-station storage tank filling are generally named stage I controls. In the EU, these activities are regulated under the European Parliament and Council Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound emissions resulting from the storage of petrol and its distribution from terminals to service stations [1].

Emission control options concerning car refuelling are generally termed stage II controls.

In the scope of air thematic strategy programme, the EU has issued a proposal of directive related to stage II of petrol vapour recovery during refuelling of passenger cars [11]. BAT, associated emission levels.

#### 7.21.3.1 Petrol storage

BAT are described in chapter 7.5.

#### 7.21.3.2 Stage I controls

Stage I controls mainly consist of vapour balance lines and vapour recovery units (VRU) to recover petrol. Modified loading, e.g. bottom loading of road tankers, results in a smaller vapour loss than top loading. Bottom loading enables reduced VOC emissions compared to top loading and importantly permits more efficient vapour collection than with modified top loading arms.

Vapours collected at service stations from the discharge of petrol from road tankers can be returned via the road tankers and recovered in the terminal VRU. The VRU unit is based on adsorption on activated carbon, absorption, membrane separation or hybrid systems combining cooling/absorption and compression/absorption/membrane separation [9]. The overall efficiency of VRU ranges from 95 to more than 99 % [9]. Stage I controls also mean modifications to road and rail tankers and to ships and barges. In the latter cases, extra care must be taken to maintain safety standards particularly to prevent propagation of ignition and over- or under-pressurisation of cargo tanks.

#### 7.21.3.3 Stage II controls

VOC emissions from car refuelling can be controlled by vapour balancing systems, so-called stage II controls, or by an enlargement of the on-board canister already installed on automobiles to capture fuel system hot soak losses. Stage II controls are technically capable of achieving a 85-92% recovery (depending on the capture efficiency). The costs of stage II are rather site-specific and vary widely.

To reduce VOC emissions from vehicle tank filling at service stations, active vapour recovery systems can be used. They are based on the following principle: the petrol air vapour mixture escaping from the tank during filling is sucked off at the vapour spout of the nozzle and vapours are returned back to the storage tank. The air/vapour mixture has to be returned proportionally to the flow rate of petrol delivered. Components of an open active petrol vapour recovery system include:

- A vapour recovery nozzle,
- A hose through which vapours are collected and a pipe through which the vapours are returned to the underground tank
- A vacuum pump and a system to control the ratio of the volume of vapour recovered to the volume of petrol dispensed in the vehicle tank.

The ratio Vapour/Petrol (V/P) has to range from 95 % to 105/110 % vol. Greater V/P ratio cannot be used to avoid excessive pressure built up and consequent VOC release through the pressure relief valves of the storage tank.

The control of the ratio can be achieved by a proportional valve controlled either hydraulically or electronically. Electronic regulation systems are the most widely used. However two systems can be distinguished: the Electronic Controlled Vapour Recovery (ECVR) – open loop – without regulation and the Electronic Controlled Vapour Recovery – Self Calibrating Gas – with regulation.

With active systems ECVR without regulation, VOC recovery efficiency cannot be maintained effectively during the entire life time of the system. If maintenance and checks are not operated carefully and periodically, efficiency decreases as the V/P ratio rapidly deviates from the optimal values. A leak on the vapour line will reduce the volume of vapour returned and hence the recovery efficiency.

With active systems ECVR with regulation, the control of vapour recovery is adjusted after each filling operation. Each deviation from the optimum value is compensated electronically. The efficiency is consequently stable during the life time of the system.

In both cases, theoretical VOC emission recovery efficiency is about 85 to 92 % wt. However in real life, the efficiency of the ECVR with regulation is constant and consequently larger than the efficiency of the ECVR without regulation. Faults can be detected and alarms can be installed to prevent operations outside optimal values. If a fault is detected, the petrol delivery can be de-activated until the fault is rectified [3]. This type of demand is presently implemented in some countries such as Germany, Switzerland and UK.

Although experience with the first generation of Stage II systems was poor, the combination of routine dry-tests (which electronically simulate the liquid flow and measure the air sucked in), regular visual inspection by the service station personnel and the installation of a 'fault code' system (which check that the equipment is working properly e.g. that the vapour pump is functional and that the vapour control valves are operating within defined limits) can achieve consistently high recovery efficiencies at approximately one tenth of the cost of the automatic monitoring system.

To achieve an overall VOC recovery efficiency of about 95 % wt, the V/P ratio has to be increased by a factor 1.3 to 1.5 [4]. However, vapour recovery systems with V/P ratio larger than 100-110 % can only be used if additional types of systems able to prevent any excessive pressure and consequent VOC release through the pressure relief valves of the storage tank, are used. These systems are based on membranes or compression and condensation [4], [6]. As example, the membrane unit is installed in parallel to the vent stack of the petrol underground tank. The vapour sucked during car refuelling is always returned to the storage by an active system. However the V/P ratio used is higher. Consequently the surplus of vapours generates an over pressure in the storage tank. The pressure gauge of the vacuum pump of the membrane unit controls the pressure. At a certain pressure, the vacuum pump is activated and the tank pressure relieves over the membrane module to the atmosphere. A global efficiency of 95% is obtained according to reference 4.

Other vapour recovery systems can be used, in which petrol vapours are recovered at the dispenser and returned directly for sale. The equipment includes an active system to suck vapours with the vacuum pump, a heat exchanger and a compressor which condenses the petrol vapours and a tank in which water is separated from recovered petrol. The petrol recovered is conducted to the dispenser for refilling a vehicle.

**Table 1: Associated emission levels with BAT to reduce VOC emissions in refinery petrol dispatch station**

| Emission source | BAT and reduction efficiency | BAT associated emission levels* kg VOC/m$^3$/kPa [2], [9] |
|---|---|---|
| Road tanker filling, bottom or top loading and vapour balancing during previous off loading and VRU | VRU with 95 to 99 % efficiency [9] | 0.0228 x 0.05 to 0.0228 x 0.01 |
| Rail tanker, top loading and VRU | | 0.0108 x 0.05 to 0.0108 x 0.01 |
| Marine tanker, typical cargo tank condition | | 0.004 x 0.05 to 0.004 x 0.01 |
| Barge – typical cargo tank conditions | | 0.007x 0.05 to 0.007 x 0.01 |

*Not available in reference [9] but calculated with reference [2].

**Table 2: Associated emission levels with BAT to reduce VOC emissions in intermediate petrol storages**

| Intermediate depot | | |
|---|---|---|
| **Emission source** | **BAT and reduction efficiency** | **BAT associated emission level kg VOC /m$^3$/kPa* [2], [9]** |
| Petrol storage | Internal floating roof<br>External floating roof<br>Other tank designs and appropriate colours<br>97 to 99.5 % compared to a fixed roof tank without measure [12] | Refer to the efficiency provided |
| Road tanker filling, bottom or top loading and vapour balancing during previous off loading and VRU | VRU with 95 to 99 % efficiency [9] | 0.0228 x 0.01 to<br>0.0228 x 0.05 |

*Not available in reference [9] but calculated with reference [2].

**Table 3: Emission levels of available techniques to reduce VOC emissions from service-stations**

| | **Service-stations** | | |
|---|---|---|---|
| **VOC source** | **Available techniques** | **Reduction efficiency** | **Emission level kg VOC /m$^3$/kPa [2] and [6]** |
| Underground storage tank filling | Vapour return to the mobile container (breathing losses not covered) | Vapour return efficiency > 95 % | 0.0011 |
| Car refuelling | Well controlled and maintained active systems with common vapour/petrol ratio of 95 to 105 % v/v | Vapour recovery efficiency > 85% w/w | 0.0367 x 0.15 |

kPa is the true vapour pressure of the product delivered, m$^3$ of petrol

## 7.21.4 Cost data for emission reduction techniques

Costs of stage I and stage II options are available for service-stations. Costs for service-stations depend on the size of the station. Costs can be estimated as presented in the following table. Investment costs for stage I come from the EGTEI data [5]. Investment costs for conventional ECVR without regulation at the dispenser come from manufacturer data [7] and costs of works from reference [8]. These costs have been determined for an ADEME study not yet published, made in 2007 by CITEPA [6].

**Table 4: Costs for stage I and stage II in service-stations of different sizes**

| | | Emissions kg VOC/y | Avoided emissions kg VOC/y | Invest-ment € | Operatio-nal cost €/an | Total annual cost (10 years and 4 % interest rate)€/an | Cost per ton of VOC abated €/t VOC avoided |
|---|---|---|---|---|---|---|---|
| RI01 < 100 $m^3$ / an | No reduction | 90 | | | | | |
| | Stage I | 59 | 32 | 6 400 | | 789 | 24 955 |
| | Stage I and II | 16 | 74 | 14 300 | 100 | 1 863 | 25 194 |
| RI02 100 to 500 $m^3$ / an | No reduction | 588 | | | | | |
| | Stage I | 382 | 206 | 9 800 | | 1 208 | 5 879 |
| | Stage I and II | 107 | 481 | 22 600 | 200 | 2 986 | 6 213 |
| RI03 500 to 1000 $m^3$ / an | No reduction | 1 582 | 0 | | | | |
| | Stage I | 1 028 | 553 | 12 600 | | 1 553 | 2 807 |
| | Stage I and II | 288 | 1 294 | 30 200 | 400 | 4 123 | 3 186 |
| RI04 1000 to 2000 $m^3$ / an | No reduction | 4 067 | | | | | |
| | Stage I | 2 645 | 1 423 | 15 200 | | 1 874 | 1 317 |
| | Stage I and II | 740 | 3 328 | 37 900 | 600 | 5 273 | 1 584 |
| RI05 2000 to 3000 $m^3$/an | No reduction | 5 197 | | | | | |
| | Stage I | 3 379 | 1 818 | 17 500 | | 2 158 | 1 187 |
| | Stage I and II | 945 | 4 252 | 45 000 | 800 | 6 348 | 1 493 |
| RI06 3000 to 4500 $m^3$ / an | No reduction | 7 909 | | | | | |
| | Stage I | 5 142 | 2 767 | 19 800 | | 2 441 | 882 |
| | Stage I and II | 1 438 | 6 471 | 52 100 | 1 000 | 7 423 | 1 147 |
| RI07 > 4500 $m^3$ / an | No reduction | 19 208 | | | | | |
| | Stage I | 12 488 | 6 719 | 27 000 | | 3 329 | 495 |
| | Stage I and II | 3 493 | 15 714 | 79 000 | 2 000 | 11 740 | 747 |

For active systems, the cost efficiency ratio depends on the size of stations and decreases with the decrease of the size. Costs range from 900 to 1 350 € / t VOC abated for stations larger than 3 000 $m^3$ per year, 1 700 – 1 800 € / t VOC abated for stations from 1 000 to 3 000 $m^3$ per year and become larger for smaller stations : 3 500 € / t VOC abated for stations from 500 to 1000 $m^3$ per year, 6 500 € / t VOC abated for stations from 100 to 500 $m^3$ per year and 25 400 € / t VOC abated for stations delivering less than 100 $m^3$ per year.

### 7.21.5 References used for chapter 7.21

[1] European Parliament and Council Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (NMVOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations

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[9] European Commission - Reference document on best available techniques for mineral oil and gas refineries - BREF – February 2003 – European commission – Available at: http://eipccb.jrc.es

[10] EPA - Emission factor documentation for AP42 section 7.1 - Organic liquid storage tanks

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[11] Proposal for a European Parliament and Council Directive on Stage II petrol vapour recovery during refueling of passenger cars at service stations, {SEC(2008) 2937}, {SEC(2008) 2938} 4.12.2008, COM(2008) 812 final

[12] European Commission - reference document on BAT on emissions from storage – February 2003 – Available at: http://eipccb.jrc.es