VOC MANAGEMENT FOR INTERNATIONAL SHIPPING

Proposed Volatile Organic Compounds (VOC) Control Measures Under MARPOL Annex VI

Environment and Climate Change Canada (ECCC)

Report No.: 2021-0245, Rev. 0
Document No.: 11IZDKCH-1
Date: 2021-03-24

Project name:	VOC management for international shipping	DNV Maritime
Report title:	Proposed Volatile Organic Compounds (VOC) Control Measures Under MARPOL Annex VI	Environment Advisory Veritasveien 1
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Date of issue:	2021-03-24	
Project No.:	10284686	
Organisation unit:	Environment Advisory	
Report No.:	2021-0245, Rev. 0	
Document No.:	11IZDKCH-1	

Applicable contract(s) governing the provision of this Report:

Objective: DNV has been commissioned by ECCC to review the technical merits and the feasibility of VOC management actions for international shipping, identify appropriate VOC control measures, and propose amendments to MARPOL Annex VI (Regulation 15) to manage VOC in the near-term to contribute to the IMO GHG Strategy. This report has been prepared for ECCC to assist the Government of Canada in understanding the VOC management issue from international shipping, and to inform the Government of Canada in developing positions in international negotiations.

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Keywords:
VOC control measures, VOC management, MARPOL Annex VI, IMO GHG strategy

Rev. No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
0	2021-03-24	Final report	L. Hammer/M. Leisner	Endre Lajord	Terje Sverud

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EXECUTIVE SUMMARY

Volatile Organic Compounds (VOCs) are on the list of candidate short term measures under the initial IMO GHG Strategy. This report has been prepared for ECCC to assist the Government of Canada in understanding the VOC management issue from international shipping, and to inform the Government of Canada in developing positions in international negotiations.

This study has four objectives:

- Prepare an overview of the impact, sources, and mechanisms for VOC emissions from tankers.
- Map existing VOC control measures available for shipping.
- Assess the feasibility of implementation of VOC control measures for international shipping.
- Propose amendment of MARPOL Annex VI (Regulation 15)

Impact, sources and mechanisms

VOC is a general term for organic chemical compounds that may cause harm to the environment or human health and with a composition that makes evaporation possible under normal atmospheric conditions of temperature and pressure. It is a pollutant to the air and act as a precursor to the formation of tropospheric ozone commonly termed smog. Tropospheric ozone is identified as a greenhouse gas (GHG) with a greater contribution per unit volume or tonnage to climate change than carbon dioxide. VOC can be a significant part of the GHG contribution from oil tankers and other tankers that carry volatile cargo but is a minor contribution to the total GHG emissions from shipping.

MARPOL does not define the term volatile organic compounds (VOCs). Since methane evaporates at a low temperature and pressure, the methane part of VOC is generally considered to be out of range for VOC management measures. In the following, the term VOC is used as a common term for non-methane volatile organic compounds (NMVOC).

VOC emissions are generated from cargo tanks of ships during loading and unloading, and to a lesser extent during transit and anchorage. Emission rates are a function of cargo composition and temperature, vessel motion and operational parameters such as loading time, cargo tank pressure and efficiency of vapour recovery (if present).

Although the focus of International Maritime Organisation (IMO) is the VOC emissions from ships, any regulatory developments should take into account the influence of external factors such as loading systems, terminal facilities and terminal practices.

It is generally accepted by the industry that VOC is generated by the following two main mechanisms (DNV, 2013):

1. VOC generated due to flashing when the product is exposed to a condition outside the stabilized equilibrium liquid condition; and
2. VOC generated due to surface evaporation from the liquid phase to the gas phase inside the cargo tanks.

Available VOC control measures

Maintaining the cargo tank pressure without unnecessary venting will reduce VOC emissions during laden transit. It is estimated that 20-30% of the VOC emissions are generated during laden transit and investigations from shuttle tankers in the North Sea indicates that maintaining the cargo tank pressure could reduce the emissions by 30-40% depending on tank design pressure.

Most of the VOC emissions is generated during loading (estimated to approximately 70% of total emission from ships). The ability to load cargo against a controlled back-pressure has been shown to reduce the quantity of VOC in the ullage space with a VOC emission reduction potential of approximately 10%.

A vapour return system used during terminal loading would send all cargo vapours to shore for processing with no VOC emissions to air. However, currently only few terminals are requiring loading with vapour emission control systems (VECS).

VOC recovery plants can reduce VOC emissions during loading and transit by up to 100% for shuttle tankers loading offshore where vapour return is not possible. Due to the high investment cost of the installation (~ 25-40 mill USD, or close to 30% of the newbuild cost for a VLCC) and also operational cost in combination with complexity of operation, it is difficult to see how advanced VOC recovery plants for mitigating VOC emissions will work as an effective measure on a global scale. Implementing such requirements is therefore not considered feasible for international shipping.

Procedural measures reducing VOC emissions exemplified by periodical testing of pressure/vacuum valves, avoidance of pressure release during transit and reduced frequency and extent of crude oil washing (COW) could reduce unnecessary releases of VOC.

Feasibility of VOC control measures and proposed amendments of MARPOL Annex VI (Regulation 15)

Measures to succeed in reducing the global VOC emissions from shipping need to consider safety aspects and a balance between the efficiency of the mitigating measure and the associated cost. The VOC control measures proposed are considered feasible within practical and economical boundaries for international shipping.

This includes the following technical measures:

- installation of pressure control systems in way of the mast riser for the purpose of automatic maintenance of tank pressure on voyage and during loading
- increased settings of P/V valves from current standard at 0.14 bar to 0.2 bar
- requirements to P/V valve type in terms of blow-down.

Proposed amendments of the regulatory text of MARPOL Annex VI, Regulation 15 accounting for the above is developed in Appendix A.

Further to the technical arrangements proposed included in regulation 15, it is proposed to amend the vague language in MEPC.185(59) “Guidelines for the development of a VOC management plan” and consider including specific requirements to operational procedures related to:

- periodical pressure testing/verification of set-pressure of P/V valves
- requiring that loading is started with low to moderate loading rate
- requiring the highest allowable ullage space pressure
- prohibiting manual pressure relief/blow-down of ullage space pressure
- requiring that in the event of inerting during voyage, the supply pressure is to be kept below opening pressure of the P/V valves
- require limitations to crude oil washing (COW)
- requirements specifying that all tank connections, e.g. for connection of instruments, that may be opened during normal operations are to be designed to prevent emissions of VOC.

1 INTRODUCTION

VOC emissions from international shipping can contribute to climate impacts both directly and indirectly through the formation of methane and ozone. Several VOCs, which are considered greenhouse gases, have higher global warming potentials than CO_2. VOC can be a significant part of the GHG contribution from oil tankers and other tankers that carry volatile cargo.

MARPOL does not define the term volatile organic compounds (VOCs). Since methane evaporates at a low temperature and pressure, the methane part of VOC is generally considered to be out of range for VOC management measures. In the following, the term VOC is used as a common term for non-methane volatile organic compounds (NMVOC).

VOC are on the list of candidate short term measures under the initial IMO GHG Strategy. According to the IMO's 4th GHG study, the estimated non-exhaust emissions of NMVOCs ranged from 2.28 to 2.51 million tonnes in 2012-2017. The result corresponds to 0.124% mass loss and results in VOC emissions of 2.4 million tonnes, which is very close to the value in 2006 (crude oil transport 1941 million tonnes, VOC emissions 2.4 million tonnes) reported the IMO GHG study 2009. In comparison IMO's 4th GHG study reported a total of 1,056 million tonnes of CO2 emissions from shipping.

Previous submissions to the IMO's Marine Environment Protection Committee (MEPC) have outlined concrete proposals for reducing VOC releases from shipping:

- In MEPC 65-4-20, Norway describes the two main processes that lead to VOC formation during loading, laden transit, unloading, and empty return; and specific operational practices which may reduce the formation of, or prevent the release of, fugitive VOC to atmosphere. Norway advises that fugitive VOC releases during loading and unloading are generally much higher than releases during laden transit or empty return.

- In MEPC 65-4-21, Norway describes consideration of the effects of the existing IMO framework on the control of VOC from tankers and indicates that the existing framework does not deliver sufficient emission reductions. Norway advises that MEPC should explore the various options for improvements of the VOC requirements set out in MARPOL Annex VI.

- In MEPC 67/4/20, Norway proposes improvements of the IMO framework on emissions of VOC, including proposals to amend Regulation 15 to require that in-line devices for automatically maintaining tank pressure shall be provided on tankers for which Regulation 15 applies, and to ensure that vapour emission control is implemented as a mandatory measure for all tankers and terminals.

- VOC are toxic substances that are harmful to human health and have potential effects on local air quality through the formation of tropospheric ozone, a component of smog. In MEPC 68-INF.2, Canada presented a case study of the potential impacts of fugitive VOC from petroleum tankers and barges on ozone in the region of Metro Vancouver. This study found that depending on the level of capture, marine sources of fugitive VOC could increase the peak ozone concentrations and geographic scale of incidences of ambient ozone concentrations exceeding 65 parts per billion (ppb).

The Government of Canada believes that the above proposals should be further assessed, discussed, and implemented as appropriate as part of the IMO's response to climate change.

DNV has been commissioned by ECCC to review the technical merits and the feasibility of VOC management actions for international shipping, identify appropriate VOC control measures, and propose amendments to MARPOL Annex VI (Regulation 15) to manage VOC in the near-term to contribute to the IMO GHG Strategy. This report has been prepared for ECCC to assist the Government of Canada in understanding the VOC management issue from international shipping, and to inform the Government of Canada in developing positions in international negotiations.

The report has the following structure:

- Chapter 2 – Method
- Chapter 3 – Current international regulations
- Chapter 4 – VOC emissions from tankers – impact, sources and mechanisms
- Chapter 5 – VOC control measures available for shipping and feasibility of implementation
- Chapter 6 – Proposed VOC control measures under MARPOL Annex VI - Regulation 15
- Chapter 7 – Proposed draft regulatory text for the IMO amendments to MARPOL Annex VI - Regulation 15

2 METHOD

This chapter briefly describes the methodology used in the work. Figure 2-1 illustrates the overall approach:

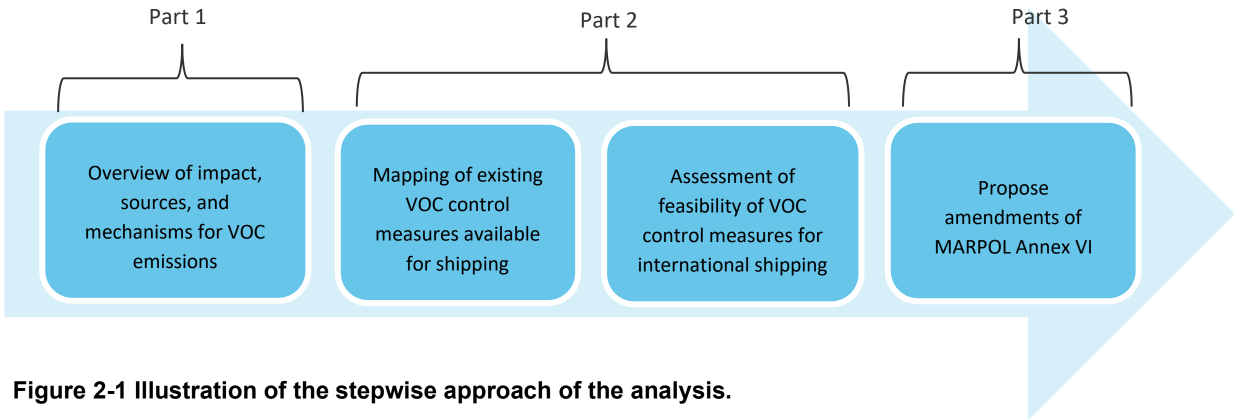

Figure 2-1 Illustration of the stepwise approach of the analysis.

The study is divided into three parts. In part 1, a brief overview of the environmental impact, the sources, and the mechanisms for VOC emissions is given as background for the assessment in part 2. Part 1 is primarily based on previous DNV studies (DNV 2000 and 2013) and in-house knowledge.

The mapping of existing VOC control measures performed in part 2 is based on review of available literature including but not limited to prior IMO submissions on the subject and the previous studies performed by DNV within this field. The overview cover oil and chemical tankers which are considered the main sources of VOC emissions and are the ship types regulated in MARPOL Annex VI (Regulation 15).

The assessment of feasibility of VOC control measures for international shipping in part 2 is based on but not limited to review of previous submissions to MEPC (MEPC 65-4-20, MEPC 65-4-21, MEPC 67/4/20, MEPC 68-INF.2) and previous studies performed by DNV within this field. Recent developments with respect to VOC emissions and control measures is also considered. The technical and economic feasibility of selected VOC control measures is analysed on a high level.

In part 3, DNV has developed proposed draft amendments to MARPOL Annex VI (Regulation 15) that could be used for submission to the IMO to contribute to the IMO GHG strategy. The proposed draft regulatory text cover oil and chemical tankers which are the ship types regulated in MARPOL Annex VI (Regulation 15).

3 CURRENT INTERNATIONAL REGULATIONS

VOC emissions from shipping are regulated by IMO through MARPOL 73/78, Annex VI, Regulation 15. The requirements are described in this chapter.

MARPOL ANNEX VI Regulation 15

MARPOL Annex VI acknowledges VOC as an air pollutant, but it does not regulate the emissions of VOC itself. Instead it requires that technical arrangements shall be provided onboard tankers in the event a Port Authority regulates the VOC emissions. MARPOL Annex VI requires that tankers carrying crude oil shall have on-board written procedures for minimizing VOC emissions. There are however no specific requirements to technical arrangements or procedures for how to achieve this, nor are there requirements to measure the effect of any such technical arrangements or procedures.

According to the definitions in MARPOL Annex VI, Regulation 15 applies to all oil and chemical tankers, and excludes gas carriers. With reference to regulation 15.7, IACS has interpreted that VOC management plans are not applicable to gas carriers.

Reg.15.1 – 15.5 - Vapour emission control systems (VECS)

Regulation 15.1 - 15.5 entered into force 01.07.2010. Under these regulations, IMO member states can require that ships loading at ports or terminals under their jurisdiction shall be provided with a vapour emission control system. The member states must prior to such requirements taking effect, inform IMO of which ports, sizes of tankers, specific cargoes that require VECS and effective date of enforcement.

VECS on board oil and chemical tankers consist of collection piping for the purpose of returning volatile organic compounds displaced by the cargo during loading at the terminal. The shore terminal shall be provided with facilities processing the received volatile organic compounds, as opposed to VOC being emitted to air from the tanker's cargo tank venting system.

Reg.15.6 – VOC Management Plan

Regulation 15.6 is applicable to oil tankers carrying crude oil. As opposed to requirements for vapour emission control systems, it does not apply to tankers carrying volatile oil products or chemicals.

The regulation requires that tankers carrying crude oil shall have on board an approved plan which contains procedures for minimizing VOC emissions in operation. While the requirements for vapour return systems are only applicable during loading, the VOC management plan shall include procedures for minimizing VOC emissions also during voyage and unloading and give consideration to the additional VOC generated by crude oil washing.

Regulation 15.6 refers to Guidelines for the development of a VOC management plan (MEPC.185(59)) for guidance.

4 VOC EMISSIONS FROM TANKERS – IMPACT, SOURCES AND MECHANISMS

4.1 Environmental impact of VOC emissions

Volatile Organic Compounds (VOCs) is a general term for organic chemical compounds that may cause harm to the environment or human health and with a composition that makes evaporation possible under normal atmospheric conditions of temperature and pressure.

VOC is a pollutant to the air and act as a precursor to the formation of tropospheric ozone commonly termed smog. Tropospheric ozone is identified as a greenhouse gas (GHG) with a greater contribution per unit volume or tonnage to climate change than carbon dioxide. It has become more evident that it is of great importance to reduce climate gases such as methane if the global temperature increase is to be sufficiently controlled. Typical global warming potential (GWP) for VOC components are listed in Table 4-1.

Table 4-1 Global warming potential (GWP) examples, 100 year time horizon (DNV, 2013).

CO2	Methane[2)]	Ethane[1)]	Propane[1)]	Butane[1)]	Pentane
1	25	8.4	6.3	7.0	-

1) Indirect GWPs taken from Collins et al. (2002) and Table 2.8 in IPCC (2005) representing the impact of the VOC on the global distribution of methane and ozone.
2) GWP values and lifetimes from 2007 IPCC AR4 p212.

VOC are on the list of candidate short term measures under the initial IMO GHG Strategy. According to the IMO's 4th GHG study, the estimated non-exhaust emissions of NMVOCs ranged from 2.28 to 2.51 million tonnes in 2012-2017. The result corresponds to 0.124% mass loss and results in VOC emissions of 2.4 million tonnes, which is very close to the value in 2006 (crude oil transport 1941 million tonnes, VOC emissions 2.4 million tonnes) reported the IMO GHG study 2009. In comparison IMO's 4th GHG study reported a total of 1,056 million tonnes of CO2 emissions from shipping.

MARPOL does not define the term volatile organic compounds (VOCs). Since methane evaporates at a low temperature and pressure, the methane part of VOC is generally considered to be out of range for VOC management measures. In the following, the term VOC is used as a common term for non-methane volatile organic compounds (NMVOC).

Crude oil and refined products are mixtures of hydrocarbon compounds ranging from heavy liquids to light liquids with absorbed hydrocarbon gases not existing as liquids under normal ambient conditions.

VOC and other emissions from cargo tanks also present a hazard to the crew. Crude oil and refined products emit hazardous vapours, e.g. hydrogen sulphide (H_2S). H_2S is a very toxic, corrosive and flammable gas. It has a very low odour threshold and a distinctive odour of rotten eggs. Many crude oils come out of the well with high levels of H_2S, but a stabilisation process usually reduces this level before the crude oil is delivered to the tanker. H_2S can also be encountered in refined products such as naphtha, fuel oil, bunker fuels, bitumens and gas oils (ISGINTT, 2010).

Below we provide a brief description of the physical behaviour of a volatile liquid and the mechanisms influencing the formation of VOC.

4.2 Sources of VOC emissions

Figure 4-1 provides a schematic overview of the potential sources of VOC emissions associated with processing and shipping of liquid hydrocarbons. Emission rates are a function of cargo composition and temperature, vessel motion and operational parameters such as loading time, cargo tank pressure and efficiency of vapour recovery (if present).

The issue of VOC emissions should not be evaluated isolated from the processing facilities. The properties of the liquid along the value chain, as well as loading and unloading facilities, outside the influence of the vessel, may have a significant effect on the total VOC emission.

Related to shipping of liquid hydrocarbons, VOC may be released from the vessel during loading, transit, unloading and empty transit. Each of these stages of operation is relevant both for the transport of crude oil (red) and refined products (light blue), Figure 4-1, however, the VOC emissions may be different (DNV, 2013).

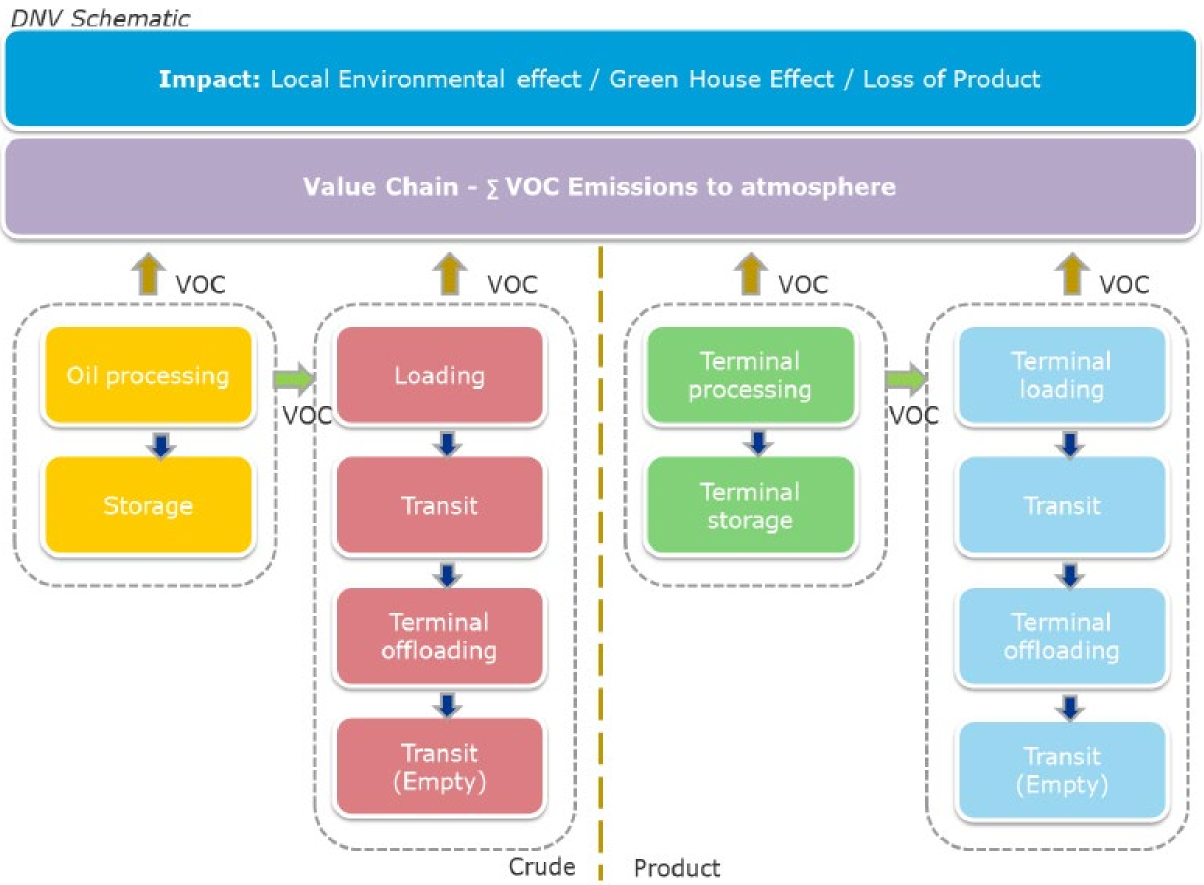

Figure 4-1 Potential sources of VOC emissions

Although the focus of IMO is the VOC emissions from ships, any regulatory developments should take into account the influence of external factors such as loading systems, terminal facilities and required terminal practices.

4.3 Generating mechanisms for VOC

It is generally accepted by the industry that VOC is generated by the following two main mechanisms, see Figure 4-2:

1. VOC generated due to flashing when the product is exposed to a condition outside the stabilized equilibrium liquid condition; and
2. VOC generated due to surface evaporation from the liquid phase to the gas phase inside the cargo tanks.

It should be noted that the two mechanisms are mutually dependent. Vapour formed in the loading line may give a less volatile liquid but also affect the stirring and diffusion in the liquid phase inside the tank, i.e. suppressing one mechanism may promote the other.

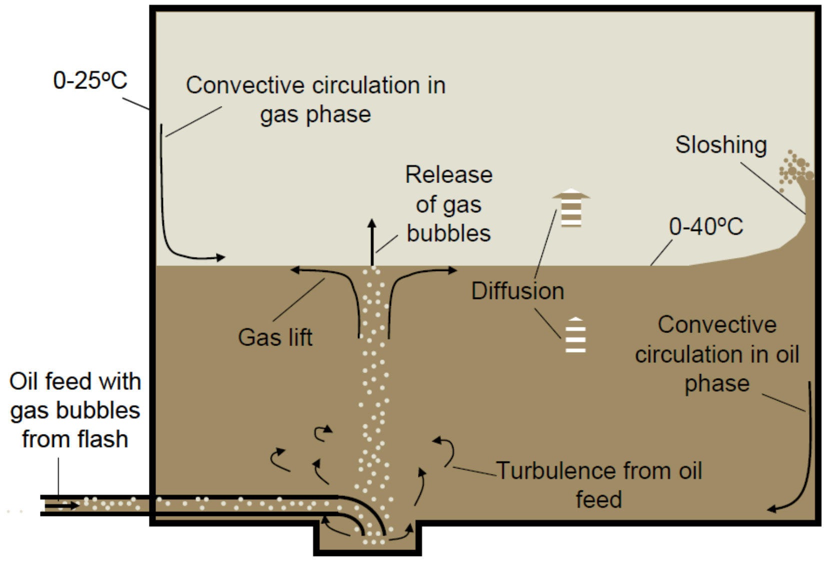

Figure 4-2 Mechanisms for VOC formation (DNV, 2013)

As a measure for the volatility of an oil, the Reid's Vapour Pressure (RVP) is commonly used. This is the vapour pressure of an oil measured in accordance with a specific procedure at a temperature of 37.8°C (100°F) in a container with a gas volume 4 times the volume of the liquid. This vapour pressure (RVP) gives a good indication of the degassing properties of an oil.

The True (saturated) Vapour Pressure (TVP) is also a measure of the pressure above a liquid at a specified temperature. Compared to RVP the TVP represent the partial vapour pressure measured in a container with a negligible vapour space, i.e. resembling a vapour pressure in a cargo tank with a 2% ullage.

For a crude oil which contains absorbed gases, the RVP will be lower than the TVP at 37.8 ºC. The reason is that when the absorbed gases migrates into a vapour space 4 times the volume of the liquid sample, the measured saturated vapour pressure represents a 'de-gassed' liquid.

In a closed and fully loaded cargo tank with a vapour space about 2% of the tank volume, the actual partial hydrocarbon vapour pressure will be the true vapour pressure, TVP.

For a homogenous cargo not containing absorbed gases, the RVP and the TVP measured at 37.8 ºC will be approximately equal.

For a homogenous cargo (refined product) the vapour pressure in the ullage space of a cargo tank is not affected by the size of the ullage volume, but only determined by the temperature. This is not so with cargoes consisting of a mixture of components. Crude oil is a typical example of such a cargo. Crude oil contains hydrocarbon components ranging from the very volatile ones such as methane to bituminous hydrocarbons.

The vapour pressure in a closed ullage space above a crude oil cargo is the sum of the partial pressure of each individual hydrocarbon component present in the cargo. For each component there is a given relation between the concentration of the component in the liquid and its partial vapour pressure in the vapour space. For a volatile component (e.g. methane) a small concentration in the liquid gives a high partial vapour pressure.

If the vapour space volume is large compared to the liquid volume, as is the case with the Reid's testing apparatus, the migration of the volatile components from the liquid into the vapour space will lower the concentration in the liquid, and hence give a lower partial pressure than that corresponding to the initial concentration in the crude.

In a loaded cargo tank where the vapour space volume is very small compared to the volume of the liquid, the migration of the most volatile components from the liquid phase into the vapour space will not change the concentration in the liquid to any significant degree, and hence the vapour pressure will give a true measure of the volatility properties of that crude oil.

The TVP also indicates whether the liquid boils or not. It boils if its TVP at the temperature considered is above or equal to the pressure in the tank containing the liquid. It will continue boiling until its TVP equals the vapour space pressure (until most volatile components have escaped).

If one assumes a cargo tank being closed during a voyage, the pressure will vary with the temperature. In a gas filled tank (empty inerted tank) a temperature change of 20°C will only cause pressure change of approximately 0.07 bar. If the tank is loaded with crude oil, the same temperature change will cause the pressure to rise/fall by a magnitude of 0.2 to 0.4 bar, depending on the volatility of the cargo.

4.3.1 VOC emissions during loading

During loading the net release of VOC from the cargo tank is determined by the initial concentration of VOC in the cargo tank prior to start of loading and net VOC formed from loaded product. Unless emission control measures are implemented, the VOC formed and displaced from cargo tank during loading will be discharged to the atmosphere.

During loading of cargo, vapours will be given off to the ullage space (“vapour growth”) in order to establish the concentration balance that exists for the given cargo composition at prevailing temperatures.

The lightest hydrocarbon (HC) components of the oil will flash into vapour and form VOC gas when the pressure is reduced below the TVP. The flashing process can be compared to boiling which occurs when the oil is heated above the boiling point. Even though the oil is stabilized before it is loaded to the oil tanker, only a moderate variation in pressure and temperature is sufficient to cause flashing or boiling. This may for example be caused by the geometry of the external loading arrangement where the pressure may fall below the TVP at certain points.

If the mixing in the ullage space was kept minimal, the vapours given off would form a stratified layer above the liquid surface, and the gas expelled through the cargo tank venting system would mainly be inert gas not containing significant amount of cargo vapours.

However, unwanted agitation of ullage atmosphere is usually caused by inert gas inflow causing turbulent mixing in the upper part of the ullage space. Agitation of the liquid cargo will be caused by cargo inlet turbulence, and in the case of offshore loading, by wave induced ship movements.

It is worthwhile to note that if loading is commenced against a hydrocarbon rich atmosphere, i.e. retained from last cargo unloading, vapour losses from the cargo loaded may be greatly reduced since the concentration balance will exist from the beginning.

4.3.2 VOC emissions during laden transit

The VOC emissions during laden transit is generally experienced to be significantly less than during loading; however, it cannot be concluded that this contribution can be neglected.

The VOC release during laden transit is governed by the following factors:

- composition of liquid product after loading (residual light components);
- composition in the vapour space of the cargo tank;
- cargo tank pressure;
- cargo temperature; and
- weather condition during transit.

After completion of cargo loading, vapours will be given off from the crude oil until a partial pressure corresponding to the TVP at the prevailing temperature is reached. Total ullage pressure will be the sum of the partial pressure of cargo vapour pressure and inert gas pressure.

If the ullage space pressure at the end of loading was close to the opening pressure of the pressure/vacuum valves (P/V valves), the establishing of an equilibrium cargo vapour pressure will cause opening of P/V valves and release of pressure. However, the amount of gas released will be small provided the TVP of the cargo at actual temperature is lower than the setting of the P/V valves. If, on the other hand, the TVP is higher than the set pressure of the P/V valves, vapour will continue to be released until the concentration in the cargo is reduced to a level corresponding to a TVP equal to the set pressure.

Knowing that RVP is the standard vapour pressure information given for crude oils, this may well happen. Moreover, the SOLAS Convention uses RVP as a criterion for permitting high vapour pressure cargoes to be carried in standard type oil tankers, i.e. carriage is permitted if RVP is below atmospheric pressure (SOLAS II-2/Reg. 1.6).

Recalling that TVP is higher than RVP and that RVP is the actual vapour pressure at 37.8°C after the crude sample oil has been degassed into a vapour space volume 4 times the oil volume, a "worst case" scenario may be envisioned as follows:

A crude oil cargo with RVP close to the atmospheric pressure is loaded at temperatures close to 37.8°C. Depending on the set pressure of the P/V valves, between 3 and 4 cargo tank volumes of vapours will theoretically have to be released before ullage pressure stabilizes at a pressure below set pressure of the P/V valves.

In practice not all the vapours will be lost; how much depends on the length of the voyage and the degree of agitation of the cargo due to movements of the ship (“sloshing”). However, the scenario described above will result in significant VOC emissions.

For crude oil cargoes loaded having a TVP below opening set-point of the P/V valves, VOC emissions will mainly occur due to:

- temperature variations
- leakages from the vapour space
- inert gas topping-up.

During transit the ullage pressure will vary with the temperature. If the ullage space is kept completely sealed, no cargo vapours will be lost. The variations in the cargo vapour partial pressure with temperature are caused by hydrocarbons being released from the liquid phase at increasing temperature and absorbed at decreasing temperatures.

If the ullage pressure raises above the set point of the P/V valve due to temperature variations, the valve will open, and cargo vapour is lost. Because the ullage volume is very small compared to the cargo tank (commonly 2 percent), the accumulated loss of cargo due to opening of P/V valves during voyage is not significant.

However, if the P/V valves are leaking, cargo vapours are continuously lost. This may cause sizeable VOC emissions. With total leakage areas of 1 cm^2, cargo losses are estimated to be in the region of 30-40 tonnes for a voyage of 30 days length, assuming a partial pressure of cargo vapours constituting half of the total ullage space pressure.

VOC emissions during transit may increase due to unfortunate inert gas topping up procedures. If ullage pressure decreases below a given limit, topping up with inert gas must be done. Fairly small amounts of inert gas are needed for topping up, but due to the large size of the inert gas blowers very often excessive amounts of inert gas is supplied. For vessels having full capacity P/V valves fitted to each tank, the excess gas will pass through the ullage space and effectively purge the space whereby cargo vapours will be lost. For vessels having relief valves fitted to the inert gas main, such purging will not occur and only minimal quantities of cargo vapours are lost.

4.3.3 VOC emissions during unloading

Emission of VOC during unloading to onshore terminals is not necessarily negligible. It should be noted that the amount of cargo vapours in the tank at the end of unloading will be discharged to atmosphere at the next loading cycle.

When cargo is discharged the increasing ullage volume will be refilled by inert gas. This will reduce the content of cargo vapours. The reduction is counteracted by vapours released from the liquid cargo in an attempt to restore the balance between vapour concentration in the liquid and the inert filled ullage space. Together with an increased vapour concentration in the ullage atmosphere above the cargo, the point of temporary balancing is approached, and the degassing rate is slowed down.

If the agitation of the liquid and the vapour space is small or moderate the resulting atmosphere in the tank at the end of discharge will be a layer of saturated vapour/inert gas mixture and a progressively leaner mixture towards the top of the tank. This means that less cargo vapours will be displaced at next loading.

The design of the inert gas supply will affect the degree of agitation, i.e., a vertical inlet causes turbulent mixing while a horizontal inlet in the tank hatch trunk causes minimal mixing.

If mixing in the liquid cargo and in the ullage atmosphere is large, the concentration of cargo vapours upon completion of discharge will be equal to the saturation concentration for the given cargo at the prevailing temperature.

Crude oil washing carried out during discharge would be effectively mixing both the liquid cargo and the ullage atmosphere and will cause the vapour concentration to be at the saturation point. This means that more cargo vapours will be displaced at next loading.

If excess inert gas is supplied during crude oil washing/cargo unloading and the tank venting arrangements are such that this causes purging of the ullage space, further vapour losses will occur.

4.3.4 VOC emissions during empty transit

Large VOC emissions during empty transit is normally limited to the intentional reduction of VOC concentration in the tank atmosphere (purging) prior to gas freeing with air for the purpose of tank inspections and dry-dockings.

It is difficult to see how such emissions can be avoided or restricted, as it would require that all gas freeing must take place at a terminal with vapour emission control facilities.

Smaller VOC emissions are possible from cargo tanks which have not been crude oil washed during or after unloading. Such tanks contain residues which have the capacity to release absorbed vapours.

The vapour concentration in the upper parts of the tank depends on the degree of agitation of the tank atmosphere during unloading.

After unloading, diffusion and convective mixing, will over time create a homogeneous atmosphere throughout the tank causing further vapour release from the cargo residues with consequent atmosphere pressure increase and release through the venting system.

Sea and air temperature increase during the voyage will cause release of absorbed vapours causing increase in tank pressure and possible release of VOC through venting system.

If inert gas topping-up of tank pressure causes P/V valves to open due to inferior pressure control system of the inert gas supply this will increase loss of vapour.

4.3.5 Summary of VOC emissions in different operational modes

The factors affecting VOC emissions in different operational modes are summarized in Table 4-2 below.

In reading the table, it could be noted that a DNV study estimating VOC lost from crude oil transport in 1996 (Endresen et al., 2003) indicated that 70 % was lost during loading, 27 % at voyage, and 3% during unloading.

Table 4-2 Summary of factors affecting VOC emissions in different operational modes.

Operational mode	Factors affecting VOC emissions

VOC emissions during loading	Main contribution to VOC emissions.
	Depending on:
	• initial concentration of VOC in the cargo tank prior to start of loading
	• net VOC formed from loaded product
	  - cargo composition
	  - degree of agitation depending on cargo inlet design, inert gas inflow.

VOC emissions during laden transit	Experienced to be significantly less than during loading. Depending on: • composition of liquid product after loading (residual light components); • composition in the vapour space of the cargo tank; • cargo tank pressure; • cargo temperature; and • weather condition during transit. May increase due to: • leakages from the vapour space • inert gas topping-up.
VOC emissions during unloading	Not necessarily negligible. Depending on: • degree of agitation due to inert gas supply design and COW • excess inert gas supply.
VOC emissions during empty transit	Generally limited to purging prior to gas freeing (tank inspections/dry docking). In normal operation minor contributions could occur from: • residues (lack of COW during unloading) • inert gas topping-up causing opening of P/V valves.

5 VOC CONTROL MEASURES AVAILABLE FOR SHIPPING AND FEASIBILITY OF IMPLEMENTATION

In this chapter, an overview of the VOC control measures available for shipping is presented, and the feasibility of implementing such measures within practical and economical boundaries for international shipping is considered.

VOC emission volumes from tankers are currently not measured or regulated. Previous submissions to IMO have suggested to initiate studies to establish a more robust framework for VOC emissions from ships, namely:

- a study of VOC emissions from crude oil tankers relative to crude volatility during terminal loadings and associated laden voyage. An important part of the study would be to assess the residual VOC in cargo tanks after discharge and crude oil washing (COW);
- a study to evaluate possible simplified methods for measuring and estimating the VOC emissions from oil tankers during terminal loading and on laden voyage; and
- a study to evaluate the effect of operational procedures and technical measures with respect to reduction of VOC emissions.

Regardless of such further studies, based on present information, implementation of certain short-term measures will have a beneficial effect even though it is difficult to quantify given the above.

5.1 Ship design features affecting VOC emissions

5.1.1 Maintaining cargo tank pressure

As discussed in chapter 4.3, maintaining the cargo tank pressure without unnecessary venting will reduce VOC emissions during laden transit. The ability to load cargo against a controlled back-pressure has been shown to reduce the quantity of VOC in the ullage space.

P/V valves

Experiences from ship owners operating in the North Sea (Hansen, H R. et al., 2010) confirm the benefit of maintaining a high tank pressure during laden transit. The current standard for P/V valve set pressure is at 0.14 bar. From a strength point of view, it is possible to increase the set point to 0.2 bar without need for reinforcement of cargo tank structures. A 0.2 bar set-point is standard for product- and chemical tankers.

The studies indicate that maintaining the tank pressure at a pressure equivalent to standard P/V valve settings (0.14 bar) could reduce VOC emissions on laden transit by approximately 30%. Increasing the P/V valve setting from 0.14 to 0.2 bar could provide a further 10% reduction on voyage.

Recently constructed shuttle tankers operating in the North Sea have implemented an increased setting of P/V valves to 0.6 bar. It has been estimated that closed loading against back-pressure of 0.6 bar and avoiding manual release on voyage resulted in 40% reduction during loading and 80% in laden transit.

Increasing the tank pressure up to 0.2 bar by adjusting the set pressure on the P/V valves is not considered to imply a significant added cost. Depending on whether the P/V valves are spring loaded, weight based or magnet type, they might need to be changed entirely. An increase of P/V valve setting from 0.14 to 0.2 bar would also possibly require a modification of the P/V breaker.

A further increase in tank pressure (up to 0.6 bar) would require approximately 550 tonnes additional steel (for a shuttle tanker), and increased height of deck water seal and P/V-breaker (~ 1 mill USD).

The design of P/V valves in terms of blow-down also affects VOC emissions. Some P/V valve designs are such that they close at a very low pressure and effectively result in depressurization of the cargo tank. From a VOC emission perspective, P/V valves having a closing pressure as high as possible is beneficial.

Pressure Control System

A pressure control system is consisting of a pressure regulating device fitted in the line connecting the top of the cargo tanks to the vent mast. This could be a pressure relief valve providing a desired back pressure upstream of the valve or a regulating valve controlled by the tank pressure. Such valves are installed on a number of oil tankers in operation today.

The arrangement will enable automatic maintenance of tank pressure on voyage and allow for loading with a controlled back-pressure in the ullage space of the cargo tanks. It would additionally eliminate the need for manual pressure relief, which is standard procedure today, and also eliminate possible hazards to crew related to opening of multiple P/V valves in the cargo deck area.

Experiences from ship owners performing offshore loading on the Norwegian Continental Shelf are showing reduced VOC emissions (compared to open vent riser) of 7% when loading against 0.14 bar back pressure (standard opening pressure of P/V valves) and a 10% reduction against 0.2 bar.

If an automatic pressure control valve (PCV) is not already incorporated in the design stage, the additional cost would be low (~15 000 USD).

5.1.2 Vapour emission control systems

Vapour emission control systems (VECS) on board oil and chemical tankers consist of collection piping for the purpose of returning VOC displaced by the cargo during loading to the terminal. The shore terminal shall be provided with facilities processing the received VOC, as opposed to it being emitted to air from the tanker's cargo tank venting system.

The US Coast Guard (USCG) implemented requirements to vapour emission control systems for ships already in 1990 through USCG 46 CFR Part 39. As these requirements are mandatory for any ship loading specific cargoes at US terminals, it has become a standard for all oil and chemical tankers on international voyage.

IMO developed similar standards in MSC/Circ.585 "Standards for vapour emission control systems" in 1992.

The regulations require vapour return piping with standard flanges in the manifold area, level gauging (e.g. tank radars) and level alarms for the purpose of prevention of overfilling, as well as a minimum capacity of pressure/vacuum relief devices (e.g. P/V valves). Maximum loading rate shall be determined based on pressure drop calculations. The purpose is to confirm that the pressure drop in the VECS piping does not exceed the set-pressure of the ship P/V valves and thus result in unintentional VOC release.

A vapour return system used during terminal loading would, provided vapour is adequately processed at the terminal facility, significantly reduce the total VOC emissions from ships.

Since MARPOL Annex VI entered into force, the only IMO Member States that have designated ports at which VOC emissions are regulated and hence require that the ship is fitted with a VECS, are in the Netherlands and the Republic of Korea. This indicates that it is not attractive to the IMO Member States to implement these VOC emission regulations and make VECS mandatory.

One challenge appears to be that not all terminals worldwide have the facilities to process the vapour. Furthermore, it appears that not all terminals with such capability are using it. One reason could be that the vapour, for example, from crude oil tankers, contains inert gas which is considered an unwanted and incombustible contaminant in the terminal process system, and therefore requires special equipment and processing facilities, as well as possibly the supply of process gas to support the combustion process.

Another reason may be that there are no local VOC regulations or that these are inadequate (e.g. that actual emissions are not validated). Thus, one of the challenges for achieving significant reduction of VOC emissions from ships is the terminal operators' motivation or willingness to invest in or utilize existing reception facilities for VOC.

The costs and effectiveness of measures to reduce VOC emissions from the loading and unloading of ships' tanks in the EU are identified and assessed in a study for the European Commission (AEAT, 2001).

5.1.3 Cargo loading system design

The amount of VOC generation during loading is affected by the design of the cargo loading system. A loading system designed to keep the agitation of the liquid in the tank to a minimum by having a low inlet velocity would be favourable. Keeping the inlet flow away from internal structures to prevent turbulences and keeping the distance between end of a drop line and tank bottom as small as possible to avoid excessive splashing during initial phase of cargo loading will also reduce the generation of VOC. Terminating the drop line at a sloping angle towards the bulkhead at the lowest possible point is a preferred solution. These design measures at newbuilding stage will have marginal cost.

Passive VOC control systems for loading, i.e. specially designed cargo loading systems designed to limit flashing during loading, exists with a moderate cost (~700 000 USD).

5.1.4 VOC recovery plants

The Norwegian Authorities imposed restrictions on VOC emissions in 2003. Since more than 50 % of Norway's VOC emissions occur during storage and loading of crude oil, stringent emission reduction regulations have been implemented which apply to all shuttle tankers receiving crude oil from offshore processing platforms on the Norwegian continental shelf. VOCs evaporating from the cargo tanks during loading must be captured by a VOC recovery plant.

There are a number of VOC reducing technologies available. VOC recovery technologies applied for shuttle tankers in the North Sea are based on different working principles such as condensation, absorption and or adsorption.

New shuttle tankers operating in the North Sea has taken this a step further by using the recovered VOC as fuel. They are operating on LNG as a primary fuel and use recovered VOC as a secondary fuel to travel from the oil fields on their own waste gas rather than releasing it into the atmosphere. This reduces both emissions and consumption of bunkered fuel considerably. In the new generation of VOC recovery plants (Figure 5-1) the heavier hydrocarbons are converted into liquid VOCs (LVOC) using several compression and cooling phases and stored in a tank on deck. The lighter hydrocarbons, referred to as surplus VOCs (SVOC), are not liquefied. The main component of SVOC is methane gas that will be burnt in a gas turbine for electricity generation, delivering twice the efficiency of a traditional boiler and steam generator arrangement.[1]

[1] Eco-friendly shuttle tankers for Norway: https://www.dnv.com/expert-story/maritime-impact/Eco-friendly-shuttle-tankers-for-Norway.html

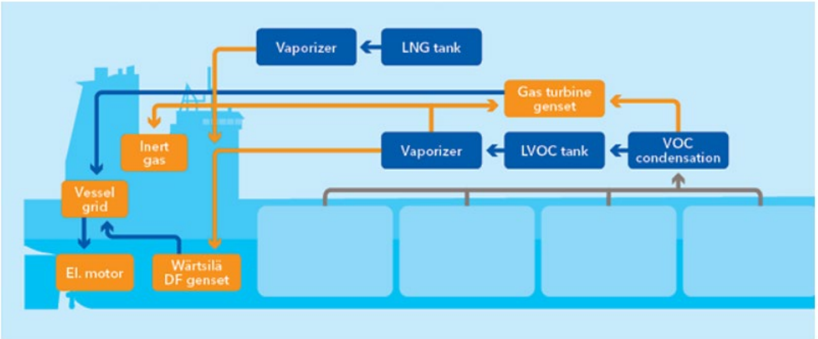

Figure 5-1 Principle sketch of new generation of "state-of-the-art" VOC recovery plant where a mix of LNG and VOC is used as secondary fuel.

VOC recovery plants can reduce VOC emissions during loading and transit by up to 100% for shuttle tankers loading offshore where vapour return is not possible. Due to the high investment cost of the installation (~ 25-40 mill USD, or close to 30% of the newbuild cost for a VLCC) and also operational cost in combination with complexity of operation, it is difficult to see how advanced VOC recovery plants for mitigating VOC emissions will work as an effective measure on a global scale. Implementing such requirements is therefore not considered feasible for international shipping.

5.2 Operational procedures affecting VOC emissions

5.2.1 Periodical testing of P/V valves

As indicated in 4.3.2, leakages from P/V valves and other tank openings can result in not insignificant VOC releases. Preventive maintenance of P/V valves verifying tightness and correct opening/closing pressure together with proper maintenance of tank hatches and other tank openings will reduce unnecessary releases of VOC.

5.2.2 Avoidance of manual pressure relief during transit

As described in 4.3.2 there will be more or less avoidable discharges of VOC from the cargo tanks during laden transit. In addition to these discharges it is also common practice to perform manual pressure relief of cargo tanks en route. Manual blow down of cargo tanks releases VOC to air and results in subsequent generation of more VOC in the ullage space due to reduced vapour pressure.

IMO MEPC.185(89) "Guidelines for the Development of a VOC Management Plan" is specifying that:

"*the ship should define a target operating pressure for the cargo tanks. This pressure should be as high as safely possible and the ship should aim to maintain tanks at this level during the loading and carriage of relevant cargo;"*

Target operating pressures much lower than the set pressure of P/V valves (as low as 0.05 bar) have been seen specified in VOC management plans.

When evaluating the necessity of the recommended procedure above, it should be noted that the tanks are designed to withstand a vapour pressure of 0.25 bar, SOLAS specifies P/V valves as a measure for automatic tank pressure control and that the tanks are required to be fitted with redundant pressure relief systems. For vessels arranged with a pressure control system as described in 5.1.1, the need for a specific target operating pressure and manual pressure release during normal operation is no longer deemed necessary.

It has been indicated that terminal and/or ship practice require that ships must conduct pressure relief prior to arrival at terminal. The reason for this is uncertain considering that tank openings are to remain closed during discharging (sampling and level gauging is carried out through closed "vapour-locks"). If such practices exist, then much of the VOC reduction measures during loading and on voyage would be effectively futile. To what extent such practices are applied and the reason why, should be investigated and possible measures to prevent them should be established.

5.2.3 Reduced frequency and extent of crude oil washing (COW)

When a cargo tank is discharged inert gas is supplied to fill the increasing vapour space. As discussed in 4.3.3 it is an advantage from a VOC emission perspective to keep the agitation of the liquid and the vapour space as small as possible. With low agitation the resulting atmosphere in the tank at the end of discharge will be a layer of saturated vapour/inert gas mixture and a progressively leaner mixture towards the top of the tank. This means that less cargo vapours will be displaced at next loading. However, if the tank is crude oil washed during cargo discharge this causes severe agitation of the tank atmosphere and release of cargo vapours from the crude washing liquid as well as from the cargo residues in the tank. Consequently, one could consider the following for crude oil washing of cargo tanks:

- Reduce frequency of crude oil washing to that required by MARPOL unless special circumstances (e.g. crude quality) make it necessary.
- Reduce extent of crude oil washing to the minimum required for sediment control purposes unless special circumstances (e.g. crude quality) makes it necessary. A full cycle (top-bottom-top for single nozzle machines) will normally not be necessary. Washing covering lower stringers and tank bottom will in most cases be sufficient.
- Closed cycle COW may be considered (i.e. re-circulate crude oil used for washing to/from slop tanks). This reduces vapour release from the crude oil compared to using ’fresh’ oil bleed from discharge lines.
- If vessel’s trim/bending moment permit, tanks intended to be washed should be discharged first. Vapour released when these tanks are washed may then be used to fill the other tanks being discharged.

The procedural measures discussed above could be implemented by improvement of the VOC management plan (with no additional cost).

5.3 Summary of feasibility of implementation of VOC control measures for international shipping

The assessment of feasibility of VOC Control measures based on the practical and economical boundaries for international shipping considered in 5.1 and 5.2 is summarized in Table 5-1.

In this context low cost means in the range 0-50 000 USD, moderate cost means in the range 0.5-1 mill USD and high cost means in the range 25-40 mill USD. Several VOC control measures could be implemented to no or low added cost. The implementation of measures to moderate or high cost are considered less feasible for international shipping. The VOC reduction potentials are indicative figures based on limited available information.

Table 5-1 Summary of assessment of feasibility of VOC control measures for international shipping

VOC control measure	Cost	VOC emission reduction potential	Recommended for international shipping
Maintaining cargo tank pressure			
P/V-valves at 0.14 bar set pressure (voyage)	No added cost	Up to 30%	Feasible
P/V-valves at 0.20 bar set pressure (voyage)	No/low cost	Up to 40%	Feasible
P/V-valves at 0.6 bar set pressure (voyage)	Moderate cost	Up to 80%	Not feasible
Pressure control system 0.14 bar (loading)	No/low cost	Up to 7%	Feasible
Pressure control system 0.2 bar (loading)	Low cost	Up to 10%	Feasible
Pressure control system 0.6 bar (loading)	Moderate cost	Up to 40%	Not feasible
Vapour emission control systems	No added cost (assumed standard design)	Up to 100% Depending on terminal	Feasible
Design of inert gas supply to tank	No added cost	-	Feasible
Cargo loading system design			
Design of cargo loading system	No added cost	-	Feasible
Passive VOC control systems for loading	Moderate cost	-	Not feasible
VOC recovery plants	High cost	Up to 100%	Not feasible
Operational procedures	No added cost	Refer to above reduction potentials related to maintaining cargo tank pressure	Feasible

In the summary above, newbuilds are considered, but many of the VOC control measures could be implemented also for the existing fleet at low cost.

6 PROPOSED VOC CONTROL MEASURES UNDER MARPOL ANNEX VI - REGULATION 15

Measures to succeed in reducing the global VOC emissions need to consider safety aspects and a balance between the efficiency of the mitigating measure and the associated cost as discussed in chapter 5. The VOC Control measures proposed in this chapter are considered feasible within practical and economical boundaries for international shipping.

Regulatory text for amendment of MARPOL Annex VI, Regulation 15 reflecting these proposals is provided in Appendix A.

Further to the technical arrangements proposed included in regulation 15, it is proposed to amend the vague language in MEPC.185(59) "Guidelines for the development of a VOC management plan" and include specific requirements to operational procedures in line with 6.2.

6.1 Ship Design Features - Technical measures

Maintaining cargo tank pressure

The requirements suggested below are possible measures to improve the pressure control and hence reduce the formation of VOC:

a) Requirement to installation of pressure control systems in way of the mast riser for the purpose of automatic maintenance of tank pressure on voyage and during loading. This would eliminate the need for manual pressure relief which is standard procedure today and eliminate possible hazards to crew related to opening of multiple P/V valves in the cargo deck area.

b) Requirements to increased settings of P/V valves from current standard at 0.14 bar to 0.2 bar. This would generally not require reinforcements of tanks structures.

c) Requirements to P/V valve type in terms of blow-down. It is understood that some P/V valve designs are such that they close at a very low pressure and effectively result in de-pressurization. From a VOC perspective, the closing pressure should be as high as possible.

Vapour emission control systems

A vapour emission control system is a fixed piping systems and associated monitoring systems for the purpose of safely returning VOC generated in cargo tanks back to a shore reception facility during loading.

Such systems are mandatory for oil and chemical tankers intending to load a range of specified cargoes in the United States. Therefore, most, if not all, oil and chemical tankers are provided with such systems. However, as per MARPOL Annex VI, regulation 15.2, the measure is only applicable and thus implemented in those terminals where a Party to the Convention has notified the Organization. The result is that the measure is currently implemented and effective only for tankers loading certain cargoes at certain terminals in the Republic of Korea and the Netherlands (MEPC.1/Circ.774).

d) It is proposed that regulation 15 should be amended to ensure that vapour emission control systems are implemented as a mandatory measure for all tankers, reflecting the current industry standard.

It is noted that a vapour emission control system on a tanker alone will not be an effective measure unless the loading terminals are provided with and operate adequate facilities for receiving and processing the VOC generated.

6.2 Operational Procedures - Improvement of the VOC management plan

Regulation 15.6 requires that procedures for minimizing VOC emissions shall be developed for crude oil tankers. It does not include a maximum limit on VOC emissions, specific requirements to technical arrangements to be provided, or specific operational methods to be used. The consequence is that VOC management plans mainly reflect current operational practices with recommendations on methods that can be followed. Without specific requirements to technical arrangements or specific operational procedures and enforcement of the implementation of these, it is unlikely that the VOC management plan will contribute to significant VOC emission reductions. Therefore, the conclusion is that unless specific requirements to technical arrangements or specific operational methods are implemented, the VOC management plan according to 15.6 is not considered to result in significant reduction of VOC from crude oil tankers.

Proposed improvements to VOC Management Plan – Regulation 15.6

The following presents specific procedures that can contribute to improving the VOC management regime:

- Consider requirements to periodical pressure testing/verification of set-pressure of P/V valves (to avoid leaks and reduced opening pressure).
- Consider requiring that loading is started with low to moderate loading rate until loading outlets in tanks are well submerged (e.g. filling to 1m) to avoid agitation of the layer of saturated vapour at the bottom of the tank.
- Consider requiring the highest allowable ullage space pressure as this reduces vapour release from the cargo during loading. A procedure where the initial slow loading takes place with the mast riser valve open (to release mainly inert gas) followed by closing the riser valve and let the P/V valves on the tanks or in-line pressure regulating valves in way of the mast riser take care of the release of excess vapour/inert gas during the subsequent loading.
- Consider prohibiting manual pressure relief/blow-down of ullage (vapour space) pressure. Because inert gas pressure is required to be continuously recorded, enforcement of such a requirement is possible. Instead, pressure relief should be handled automatically by P/V valves, by in-line P/V-breather valves or by in-line pressure control systems. Most VOC manuals specify that manual pressure relief is to be conducted at the mast riser, despite the fact that all ships have P/V valves that can do this automatically. Furthermore, a number of ships are equipped with in-line P/V-breather valves (in way of mast riser) for the specific purpose of automatic pressure relief. It has been indicated that the reason for this is to concentrate release to mast riser and avoid multiple VOC releases from P/V valves in the cargo deck area as a measure of crew safety during maintenance. It has also been indicated that some consider the P/V valves to be an emergency device only, although this is not the case as per SOLAS. Also note that on board e.g. chemical tankers as well as some older oil tankers automatic pressure relief through P/V valves is the only means of tank venting. In many cases, the manual pressure relief at the mast riser is specified to be carried out at a pressure significantly below the P/V valve opening pressure.
- Consider requiring that in the event of inerting during voyage, the supply pressure is to be kept below opening pressure of the P/V valves.
- Consider to require that in connection with crude oil washing (COW), the ship shall not wash more tanks than what is required by the Convention (1/4 of the tanks), unless special circumstances make it necessary (dependent on crude quality). Currently it is understood that some Oil Majors specify that tankers are to do a complete COW of all cargo tanks after discharge.
- Consider requiring that during COW, a full cycle (top-bottom-top for single nozzle machines) is to be avoided (dependent on crude quality). Washing that covers lower stringers and tank bottom will in most cases be enough for sediment control.

- Consider requiring closed cycle COW (i.e. re-circulate crude oil used for washing to/from slop tanks). This reduces vapour release from the crude oil compared to using ’fresh’ oil bleed from discharge lines. Note that the solvent effect of the crude may be jeopardized when “spent” crude is used for COW.
- Consider requiring that if vessel’s trim/bending moment permits, tanks intended to be crude oil washed should be discharged first. Vapour released when these tanks are washed may then be used to fill the other tanks being discharged.
- Consider requirements specifying that all tank connections that may be opened during normal operations are to be designed to prevent emissions of VOC. Typically all tankers today have so called “vapour-locks” which are pipes at top of tanks provided with ball valves with threads for connection of instruments for e.g. manual sounding, temperature measurements and cargo sampling.
- Consider improving vague language in current text of MEPC.185(59) “Guidelines for the development of a VOC management plan”.

7 REFERENCES

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A. APPENDIX A - PROPOSED DRAFT REGULATORY TEXT FOR THE IMO AMENDMENTS TO MARPOL ANNEX VI - REGULATION 15

The proposed amendments to MARPOL Annex VI, Regulation 15 are provided below (modifications are shown with deleted text in **~~bold strikethrough~~**, and new text **bold underlined**:

"MARPOL Annex VI - Regulations for the Prevention of Air Pollution from Ships

Ch.3 - Requirements for control of emissions from ships

Regulation 15 Volatile Organic Compounds (VOCs)

~~1 If the emissions of VOCs from a tanker are to be regulated in a port or ports or a terminal or terminals under the jurisdiction of a Party, they shall be regulated in accordance with the provisions of this regulation.~~

~~2 A Party regulating tankers for VOC emissions shall submit a notification to the Organization.~~ [*] **~~This notification shall include information on the size of tankers to be controlled, the cargoes requiring vapour emission control systems, and the effective date of such control. The notification shall be submitted at least six months before the effective date.~~**

~~* Refer to *Notification to the Organization on ports or terminals where volatile organic compounds (VOCs) emissions are to be regulated (MEPC.1/Circ.509).*~~

~~3 A Party which designates ports or terminals at which VOCs emissions from tankers are to be regulated shall ensure that vapour emission control systems, approved by that Party taking into account the safety standards for such systems developed by the Organization,~~ [†] **~~are provided in any designated port and terminal and are operated safely and in a manner so as to avoid undue delay to a ship.~~**

† Refer to *Standards for vapour emission control systems (MSC/Circ.585).*

~~4 The Organization shall circulate a list of the ports and terminals designated by Parties to other Parties and Member States of the Organization for their information.~~

~~5~~ **1** A**ll** tanker**s** to which **~~paragraph 1 of~~** this regulation applies shall be provided with a vapour emission collection system approved by the Administration taking into account the safety standards for such systems developed by the Organization [‡][*] **~~, and shall use this system during the loading of relevant cargoes. A port or terminal which has installed vapour emission control systems in accordance with this regulation may accept tankers which are not fitted with vapour collection systems for a period of three years after the effective date identified in paragraph 2 of this regulation.~~**

~~* Refer to *Notification to the Organization on ports or terminals where volatile organic compounds (VOCs) emissions are to be regulated (MEPC.1/Circ.509)* .~~

2 A tanker carrying crude oil shall be provided with pressure control system in way of the mast riser for the purpose of automatic maintenance of tank pressure on voyage and during loading.

3 All tankers to which this regulation applies shall have a pressure relief valve setting of minimum 0.2 bar. The closing pressure should be xx (as high as possible) bar.

~~6~~ <u>**4**</u> A tanker carrying crude oil shall have on board and implement a VOC Management Plan approved by the Administration *. Such a plan shall be prepared taking into account the guidelines developed by the Organization. The plan shall be specific to each ship and shall at least:

* Refer to *Guidelines for the development of a VOC management plan (MEPC.185(59)) . Refer also to Technical information on systems and operation to assist development of VOC management plans (MEPC.1/Circ.680), and Technical information on a vapour pressure control system in order to facilitate the Development of a (VOC) Management Plan (MEPC.1/Circ.719).*

.1 provide written procedures for minimizing VOC emissions during the loading, sea passage and discharge of cargo;
.2 give consideration to the additional VOC generated by crude oil washing;
.3 identify a person responsible for implementing the plan; and
.4 for ships on international voyages, be written in the working language of the master and officers and, if the working language of the master and officers is not English, French, or Spanish, include a translation into one of these languages.

~~7~~ <u>**5**</u> This regulation shall also apply to gas carriers only if the type of loading and containment systems allow safe retention of non-methane VOCs on board or their safe return ashore. *

* *Refer to* International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk *(resolution MSC.370(93))."*