About VOC Emission from Crude Oil Carriers

During loading, storage and transportation of crude oil on ships, Volatile Organic Compounds (VOC) is emitted to the atmosphere. Evidently, the emission represents a loss of considerable monetary value. But the harmful consequences to the environment are supposed to be of greater importance.

Why/What

Large VOC emission usually comes from offshore loading of shuttle tankers and Floating Production, Storage and Offloading units (FPSOs and FSOs). Loadings at onshore terminals are also responsible for VOC emission. In this context VOC is mostly hydrocarbon gases ranging from methane to heptane. MARINTEK has measured variations in emissions from 0.1 kg VOCs per tonne of cargo (terminal loading) to 2.8 kg VOCs per tonne (offshore loading in bad weather). For a typical shuttle tanker load of 100000 tonnes, the latter represents around 2200 barrels of oil. With 100 US$/ barrel this represents a monetary value of 220000 US$.

Methane is a greenhouse gas with a global warming potential (GWP) of 21 (CO_2 has a GWP of 1). The remainder of the VOCs, known as NMVOCs, forms together with NOx and sunlight ground-level ozone that is detrimental to vegetation and human health. Norwegian authorities have committed themselves to a 37 % reduction in NMVOC emissions compared to the 1990 level (Gothenburg Protocol, 1999). Since the storage and loading of crude oil on ships are responsible for more than 50% of Norway's NMVOC emissions, the Norwegian authorities have implemented stringent emission reduction regulations in this area.

The Gulf of Mexico Air Quality Study reported by the US Minerals Management Service revealed that ozone concentration in the onshore areas of Texas and Louisiana frequently exceeded the National Ambient Air Quality Standard. In 1993 emissions from oil and gas exploration, development and production in the Outer Continental Shelf (OCS) regions of the Gulf of Mexico contributed a small but significant fraction of this ozone concentration. In 2001 the US Minerals Management Service decided that the operation of Floating Production Storage and Offloading units (FPSOs) and shuttle tankers was an acceptable means for producing and transporting crude oil in OCS. Unless they are appropriately dealt with, VOC emissions from such activities will increase ozone concentrations in onshore areas in the future.

Main parameters

The VOC emission is a function of many parameters including:

- The composition and temperature of the loaded cargo
- The vessel motion
- Operational parameters such as loading time for each cargo tank, cargo tank pressure and amount of crude oil washing.

Determination of magnitude

Several methods have been used to determine VOC emissions. These include:

- Measuring the flow, pressure, temperature and composition of the gas emitted. This provides the most accurate determination of VOC emissions.
- Simulating with the aid of a dedicated simulation tool. For this method, the input data must be representative.
- Determining the difference between the loaded and discharged mass of cargo. Results may be hampered by measurement errors at both ends, which may be larger than this difference. As the approach is also subject to systematic errors, e.g. change in the molecular weight of the cargo due to the release of light ends, the uncertainty becomes very large.
- Sampling of the loaded and discharged cargos with determination of their composition, which is used to calculate the VOC emission. It is difficult to ensure that the samples are representative for the cargos, that light ends are not lost before the samples are analysed and that the determination of the content of light ends is accurate enough. Once again, the uncertainty becomes large.

VOC emission reduction methods

Reducing the release of VOCs from the cargo will obviously reduce VOC emissions. This can be achieved, for example by:

- Reducing the content of light ends in the cargo before loading.
- Reducing the temperature of the cargo.
- Filling cargo tanks sequentially instead of in parallel.
- Increasing the cargo tank pressure.
- Reducing the amount of crude oil washing
- Reducing the roll and pitch of the vessel.

If the above measures cannot be employed, or they do not provide a sufficient reduction in VOC emissions, other measures must be adopted, such as:

- The emitted gas is returned ashore or to the supplying unit, e.g. a floating storage unit, where it can be appropriately treated.
- A hydrocarbon gas is used as blanket gas during discharge instead of inert gas. This is particularly suitable for a floating production, storage and offloading unit where the blanket gas is taken from the process, and returned to the process again during tank filling.
- Recovery plants that separate VOCs from the inert gas and store the separated VOCs. Such plants have been and still are installed on many shuttle tankers that carry cargos from Norwegian offshore fields.

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