Capturing shuttle tanker vapours

The Norwegian government has set mandatory requirements for the capture of cargo vapours generated during offshore loading operations. Industry would like to add an economic incentive for installing vapour recovery equipment on their tankers

It has been estimated that annual cargo vapour emission losses work out at about 6.5 million tonnes (mt) of crude oil totalling $700 million for the global tanker industry. These losses comprise 3.3 mt of loading losses and 3.2 mt of in-transit losses.
The offshore loading of shuttle tankers in the Norwegian sector of the North Sea has been identified as a major source of oil cargo vapour emission losses and the largest single contributor to atmospheric pollution in the Scandinavian country.
As part of their commitment to the Kyoto Treaty, the Norwegian authorities have set an initial requirement that 40 per cent of offshore oil loading and storage operations must be carried out with volatile organic compound (VOC) emission control equipment in place by April 30, 2003. Over the longer term 70 per cent of offshore oil will have to be loaded and stored using emission control equipment by December 31, 2004 and 95 per cent by December 31, 2005.
Industry gave full backing to the initiative in June 2002 when the 23 energy companies which are licensees in the Norwegian oil fields signed a cooperative agreement to ensure that the targets set by the Norwegian Pollution Control Authority are met.
One of the specific requirements is that the equipment utilised must be able to recover 78 per cent of the non-methane VOCs during offshore loading and storage.
To meet the April 2003 deadline vapour recovery plants have been installed on eight shuttle tankers. In addition, Statoil has commissioned new plants for recovering crude oil VOC emissions on its Norne and Asgard A floating production storage and offloading (FPSO) vessels in the North Sea.

VOC condensation
A number of VOC emission control systems have been developed and are in the process of being evaluated on various shuttle tankers as part of the drive to determine what is the best available technology to meet the stringent pollution control requirements laid down by the Norwegian government.
Hamworthy KSE AS is the developer of one of the systems, and has continued to refine and upgrade its VOC condensation technology since the prototype system was installed on Navion Viking in 2000. "This project was financed by the Oil Industry Association in Norway, and the equipment has been operating according to design criteria since installation," comments Tore Lunde, a Hamworthy KSE director.
In 2002 Hamworthy KSE was awarded a contract for the first commercial VOC condensation plant by ExxonMobil for fitting onboard the shuttle tanker Stena Alexita which is serving the Balder and Jotun fields in the Norwegian North Sea. The installation was completed in March 2003, 12 months after the order was placed.

Steam power
The new, so-called first generation Hamworthy KSE plant is able to handle 16,000 m3/hour of VOCs generated during shuttle tanker loading. The system consists of a process module, VOC deck storage tank and a power supply to operate the equipment if spare power is not available onboard.
The process module on Stena Alexita is considerably smaller in size than that on Navion Viking and weighs 160 tonnes, compared to 230 tonnes for the prototype. The new unit also provides a better performance, recovering the minimum 78 per

cent of non-methane VOCs, as opposed to only 70 per cent for the Navion Viking prototype.
VOCs emitted from the crude oil during loading are condensed and stored in a tank mounted on deck. The lighter fractions, methane and ethane, can be burned to produce steam, which is, in turn, used in a boiler to drive the recovery plant. Thus, the process is not self-sufficient in energy but also ensures that no VOC emissions are given off to the atmosphere.

VOC recycling
Hamworthy KSE has recently further developed and simplified the VOC condensation principle together with Navion. The concept is called VOC Recycling and calls for a different approach to cargo tank venting. In normal circumstances, inert gas from the onboard generator is introduced into the cargo tanks as they are discharged, to maintain the necessary overpressure and to ensure the oxygen in the tank is kept below the explosive limit.
With VOC Recycling the VOCs are used as the blanket gas in the cargo tanks following discharge. During loading of the tanker, the VOC is condensed again and returned to the deck VOC tank. It has been found that having this hydrocarbon (HC) gas in the tank serves to reduce the levels of VOCs produced when a new cargo is loaded by as much as 40 per cent.
The source of the HC gas is the condensed VOCs in the deck storage tank. The ship operator has the choice of either using the contents of this tank as a blanket gas or boiler fuel, or discharging it with the rest of the cargo at the shore terminal.
Hamworthy KSE and Navion are currently introducing the VOC Recycling concept onto the market.
Hamworthy KSE also offers complete VOC plants for onshore terminals, based on the same proven technology as that used on the shuttle tankers.

Absorption route
A competing vapour recovery system is the process based on direct absorption of VOC emissions in a side stream of the loading oil which was developed by Kvaerner Process Systems (KPS). KPS was taken over by Hitec Marine last year, while more recently Hitec was the target of a successful takeover by the Advanced Production and Loading AS (APL) group. As such, the technology is firmly under new ownership.
With the APL approach, the equipment is assembled on a standard modular turnkey skid, which is supplied ready for hookup to the ship's system. The technology is based on the absorption of VOCs in a counter-current flow of crude oil in an absorber column. The vapour is fed into the bottom of the column, with the side stream of crude oil acting as the absorption medium.
The oil containing the absorbed VOC is then routed from the bottom of the column back to the loading line where it is mixed with the main oil loading stream. An oil pump and compressors are used to pressurise the oil and gas. Unabsorbed gases are relieved to the riser to increase the recovery efficiency.

Good takeup
Absorption columns and knockout drums comprise the main components of the APL VOC modules. The environmental benefits of the recovery system technology were first tested on a pilot plant in 1997 and the first fullscale plant was successfully installed on the shuttle tanker Anna Knutsen a year later. Further refinement of the design has yielded continued size and weight savings, leading to the current third generation APL VOC recovery unit.
In 2001 contracts were signed for the supply of APL VOC systems for fitting aboard five shuttle tankers. Three were supplied - to Borga, Navion Anglia and Navion Oceania - under turnkey contracts, while for the other two - on Knock An and Juanita

- APL provided process support to its technology partner. These modules have now been fitted.
"Our technology is proven through the installation of operative units on six shuttle tankers operating in the North Sea," reports Lars Mellerud, vice president business development with APL. "No other supplier of VOC equipment can match our experience and the performance of our systems to date has been excellent.
"All our process units have the capacity to recover the VOCs generated during the loading of shuttle tankers at rates of up to 8,000 m3/hour. Furthermore, all the units were installed on time and as per budget."

Just reward?
Bearing in mind the traditional difficulties associated with making accurate measurements of the volume of oil loaded onboard and discharged from tankers, one of the challenges associated with the introduction of the new VOC recovery equipment is assessing precisely how effective it is in achieving the standards laid down by the Norwegian authorities.
Another controversial area is the extent to which those owners making an early commitment to the new VOC technology should be rewarded for their efforts.
"I think one of the most important issues we face today is the need to establish some type of compensation regime to reward those owners that have come forward and installed VOC equipment on their shuttle tankers," states Lars Mellerud. "There is still no financial incentive to implement this technology, since the final amount of oil recovered using the new VOC systems, compared to the volume of oil carried in the ship, is still very small.
"In fact, the volume of oil recovered is still within the range of cargo losses or gains that might be expected during the course of a voyage due to measuring uncertainties. Thus, for the moment, the only incentive to fit a VOC recovery or reduction system is the government requirement. There should also be an economic incentive."
APL is working on the problem by seeking to develop a different type of flow measurement equipment that will determine accurately the amount of oil recovered during loading operations through the use of its VOC equipment.
Tore Lunde of Hamworthy KSE echoes the sentiment. "Of course, further optimisation of our technology, by providing smaller and lower cost systems, is one challenge," he explains. "But if the VOC recovered can be given a value, the commitment to VOC systems then becomes not only an environmental investment for the industry, it can also be justified economically."

Prevention, not cure
Knutsen OAS, a leading operator of shuttle tankers on the Norwegian Shelf, has developed a system for tackling the VOC problem which takes a "prevention rather than cure" approach. The method seeks to reduce the generation of VOC emissions from tankers during loading operations, either offshore or at shore terminals. It is claimed to be a much simpler and less costly alternative than the VOC recovery systems, but one which achieves results which measure up to the Norwegian government's requirements.
"We investigated North Sea tanker loading procedures extensively and concluded that the way this operation is currently carried out is conducive to generating the maximum possible volume of VOCs," points out Per Lothe, project manager at Knutsen.
"We decided that the optimum approach was to reduce the generation of VOC vapours in the first place rather than attempt to control and remove all the VOCs that current loading operations give rise to. We have accomplished this with a system that requires no power. Thus, there are no operating costs and no production of harmful combustion emissions such as carbon dioxide and nitrogen oxides."

Knutsen dropline

Knutsen OAS has achieved this by designing a large-diameter drop pipe to control the introduction of the oil being loaded into the cargo tanks. Use of such an arrangement helps minimise pressure buildup, and hence VOC generation, in the cargo.

The shipowner installed the Knutsen Volatile Organic Compound (KVOC) system on the Ragnhild Knutsen in April 2002, since which time all loading operations have been carried out using the new technology. The specially designed, single, central drop pipe on the tanker is 2.5 metres in diameter. From the bottom of the pipe the oil is distributed along the bottom of the ship and introduced into each cargo tank.

"When high vapour pressure crude oils are loaded, KVOC enables a reduction in VOC emissions of 65-80 per cent compared to the volume generated during a normal loading operation," continues Per Lothe. "When low vapour pressure oils are loaded, the reduction is in the range 85-95 per cent. Also, if hydrogen sulphides are present in the oil, reductions of 80-90 per cent in emissions of this harmful product are possible using KVOC."

Knutsen OAS is currently marketing the KVOC system to the owners of shuttle tankers and their charterers. The ease of retrofit to existing ships is being touted as one of the strong selling points of the technology.

CSA pressure swing

Although Kvaerner Process Systems has sold it absorption technology to APL, it is still involved with vapour recovery engineering. The involvement is a result of the purchase of Cool Sorption AS (CSA) of Denmark by Aker of Norway. When Kvaerner and Aker merged their activities in 2002, CSA was made a full subsidiary of Kvaerner Process Systems.

CSA has delivered 140 shore-based vapour recovery plants over the past 20 years, most of which are for the control of gasoline vapours. In 1996 the company delivered a vapour recovery unit for the Sture crude oil loading terminal on Norway's west coast. Based on a two-stage cold liquid absorption process developed by CSA, this was the world's first such crude oil unit and remains the largest.

CSA is now applying the technology to ships, with a contract to fit the vapour recovery system onboard the shuttle tanker Navion Europa for use serving the Heidrun field, a comparatively small oil reservoir.

"We believe our pressure swing, carbon bed absorption system, combined with an upstream absorber, provides the most competitive solution," explains Tomm Lund, vice president business development at CSA. "It provides recovery rates in excess of 90 per cent, requires only 50 per cent of the energy needed to operate pressurised absorption, has low maintenance costs and a high degree of reliability, does not need a deckhouse and is easy to operate."