Three elements contribute to tanker VOC emissions reduction

Relatively inexpensive design and construction changes have led to Teekay Corporation receiving the *Clean Air Award*, given by Nor-Shipping and Det Norske Veritas at the exhibition held just outside Oslo in June, writes Brian Warshaw.

The citation reads '... in recognition of outstanding efforts to reduce the emission of greenhouse gases', and relates to the design of the *Amundsen Spirit* shuttle tanker currently being built by Samsung Heavy Industries shipyard at Geoje, South Korea. This vessel, and three other similar newbuild shuttle tankers due for delivery in 2010 and 2011, will operate in Norwegian waters.

Teekay is confident that, even with the most volatile North Sea oils, its new shuttle tankers will prevent more than 60% of VOC emissions during loading operations, compared to standard vessels, and will provide total elimination of vapour discharge throughout the voyage.

To achieve this, it is employing the experience gained in sea trials over a period of three years, namely by increasing the pressure at which it operates the vessel's tanks, the fitting of Knutsen OAS Shipping's patented KVOC increased diameter drop lines, and through the installation of a Compact VOC (CVOC) recovery system.

Three design elements will enable Teekay to meet the Norwegian emission regulations. First, as a high proportion of the VOC is generated when oil is loaded into the ship's tanks, Teekay has installed KVOC drop lines. These will reduce the siphonic or under-pressure effect that is experienced as oil enters the ships' tanks, and will reduce the creation of VOC vapour that would otherwise contribute to emissions during loading.

Second, it has strengthened the tanks to a design pressure of 0.7 barg, which will permit an operating pressure of 0.235 barg. This compares to the current industry norm of 2.5 barg, and 0.04 to 0.14 barg respectively, and will save an estimated discharge of 15% to 20% of the VOC emissions. When discharges have to be made, they will be tightly controlled by an improved design of pressure-vacuum valve, which is fast operating, opening and closing within a narrower pressure range than does the standard valve.

Finally, the CVOC recovery system manufactured by the Norwegian company GBA Marine recycles the inert gas and VOC vapour from the top of the cargo tank. As the

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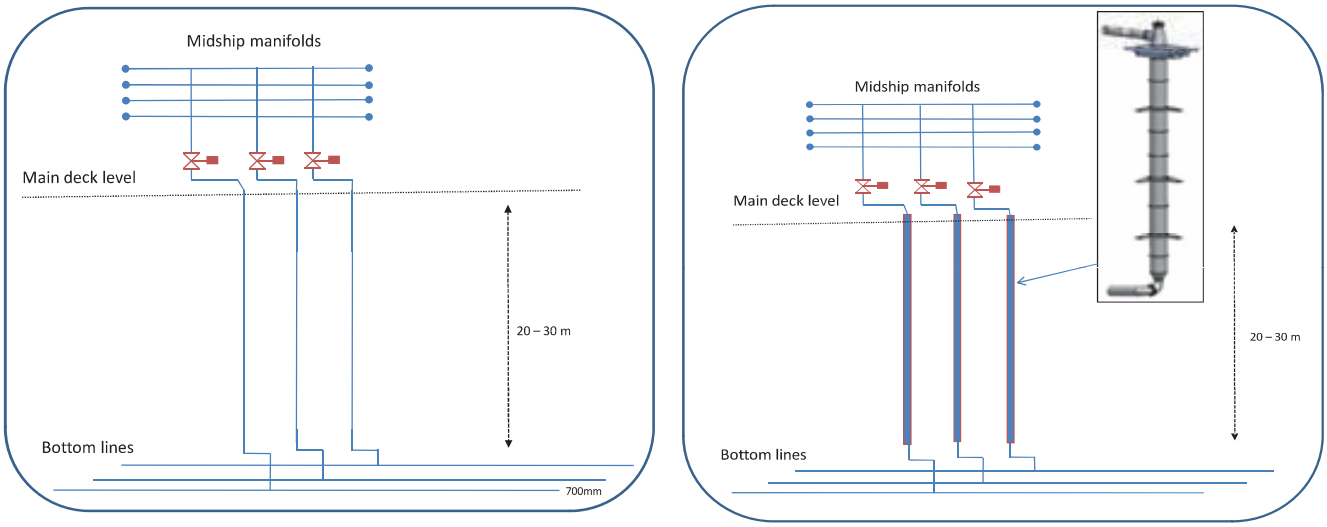

Schematic of KVOC's increased diameter drop lines.

GBA Marine's Swirl Absorber seen fitted on board *Navion Hispania*.

oil flows from the bottom of the tank and through the patented *Swirl Absorber,* it creates a large area of contact into which the VOC is absorbed. By absorbing the vapour back into the oil phase, the pressure in the tank decreases, eliminating the need to discharge VOC to atmosphere during the voyage between the offshore loading facility, and the import terminal.

This is the first time that all three concepts have been assembled on a single tanker, and the development is being undertaken with the support of the VOC Industry Co-operation committee that represents the oil companies operating on the Norwegian continental shelf.

In a statement, Teekay said that based on crude oil priced at $70 per barrel, the retained oil will enable the capital cost to be recovered in about five years. In addition to the environmental benefits, the working conditions for the crew on deck will be improved, and there will not be any VOC vapour to enter the accommodation area through the ventilation system.

KVOC technology

The secret of how the Knutsen OAS Shipping's KVOC technology eliminates volatile organic compound (VOC) vapour formation during crude oil loading has been revealed in a private report undertaken by Det Norske Veritas (DNV).

Essentially it is a large diameter drop line without moving parts or instrumentation, consequently requiring no energy to function, or maintenance throughout the life of the vessel.

DNV found that VOC was generated by flashing throughout the piping system transporting oil from the storage tank to the cargo tank; and evaporation from the oil surface inside the tank. In particular it reported that; 'A significant amount of VOC gas is generated by flashing at the top of a conventional drop line; the vertical pipe with a height of 20-30 m connecting the pipes at deck level and the bottom lines feeding the cargo tanks."

Diameter increased

After looking at, and discarding the idea of a smaller diameter drop line, Per Lothe, project director, settled on the idea of increasing the diameter of the drop pipe. "If one keeps the inlet flow velocity at a rate that doesn't fill the pipe, the pressure will be the same all the time," he explained. "The reduced flow of

KVOC® drop pipe installed on *Sallie Knutsen*

crude oil into the bottom cargo tank feed line does not try to take the gas bubbles with it. There is a gas column in the middle of the down pipe, and liquid around the side. This means there will be a constant static pressure in the drop line balanced by the backpressure from the tanks."

Based on validation studies of the HYSYS simulation computer program developed by Christensen Processing to estimate the volume of VOC that would be generated during the loading of a tanker with conventional drop pipes, DNV concluded that the KVOC system prevented most of the VOC formation being generated in the conventional drop line it replaces. Total VOC formation is not entirely eliminated during the loading process due to flashing at locations outside the ship, and evaporation inside cargo tanks; however, it does have some effect on reducing these emissions.

After running a series of simulation loadings for a typical Suezmax tanker with drop lines at a height of 22 m, and the cargo tanks filled to 98%, DNV said that a saving of between 85 to 130 tonnes when loading a typical one million barrel tanker (160,000 cu m) with Basrah crude oil depending on the Reid Vapour Pressure could be achieved. With crude oil priced at a nominal $50 per barrel, the investment in the KVOC drop pipes would be repaid in 12 to 18 months.

Lothe commented that the technology is suitable for product and LNG loading as well as crude oil. He is particularly pleased at the interest coming from the US for its use on lightering vessels. "The only place that VOC is generated during lightering is the drop line in the ship. The oil is only going up, over the side horizontally, into the ship, and then down again. So the KVOC system will eliminate almost all the VOC generation," he said. "They lose a lot of oil through emissions during this process.'

During the seven years that Knutsen has been developing and testing the KVOC technology, it has installed and operated nine systems on its own vessels, and plans six more by 2011. Three will be on newbuilds, and three are to be retrofitted. Teekay Shipping has ordered four systems for newbuildings being constructed by Samsung Heavy Industries in South Korea. TO