Is adding an additional dome roof really the best way of reducing terminal emissions?

Aluminium domes under scrutiny

The technical evolution of aboveground storage for liquid hydrocarbons has led to some different concepts for cutting tank emissions:

- external floating roof tanks (EFRT)
- floating roof tanks covered by an aluminium dome (CFRT)
- fixed roof tanks with an internal floating roof (IFRT)
- fixed roof tanks connected to vapour balancing and vapour recovery (FRT+VRU).

In 2002 the German authorities issued extremely stringent rules of emission control with its TA-Luft.

Future hydrocarbon storage plants for liquids with vapour pressures above 13hPa at 20ºC have to use fixed roof tanks, connected to vapour balancing and vapour recovery.

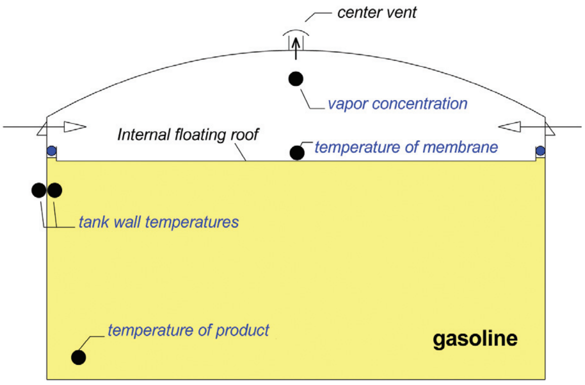
The authorities copied the idea of vapour balancing from the process imposed some years ago to the petrol supply chain between the refinery or depot to the fuel tank in cars. Here the petrol is passing through small horizontal tanks with no chance for the application of efficient floating covers or blankets.

With the introduction of the vapour balancing system, it was possible to avoid a reasonable portion of emissions within a short period of implementation.

At that time the authorities in Germany responsible for emission control simply put forward their political will instead of using well-balanced technical advice. The supply chain for petrol with its small and horizontal tanks needs completely different technologies for emission control compared to large capacity tank farms with flat bottom vertical tanks of diameters between 10m and 100m.

For a number of reasons vapour balancing is the wrong process for huge size tank farms like those in a refinery:

- It is not possible to balance hydrocarbon vapours to the pipeline, ship or refining apparatuses
- The unavoidable daily breathing of all fixed roof tanks at the same time asks for a number of gasholders and vapour recovery units for the different products of the refinery.



Driving forces for evaporation in tanks

In total, 1kg of hydrocarbons is held back, but a similar amount of CO_2, SO_2, NOx, dust, etc. is emitted with the electric power consumed, plus an enormous cost of investment, maintenance and labour.

This means the floating roof tank, with an external or internal floating roof will stay as the standard and best available technique for large-scale hydrocarbon storage.

Floating roof tanks with state-of-the-art sealing systems offer emission control efficiencies above 97% in comparison to fixed roof tanks without internal floating roofs.

Tanks equipped with threefold sealing systems and special guide pole seals can have efficiencies around 99%.

Today aluminium dome roofs installed over existing external floating roof tanks are a popular trend. But fire fighting specialists are still scared of aluminium dome roofs for hydrocarbon tanks.

What is the vapour concentration under such domes? Under which temperature will a weakening dome fall into the tank when there is a fire in the tank or close to the tank? How can a fire in a tank with aluminium dome be extinguished? The answers are vague.

The sales arguments for aluminium domes are:

- the elimination of rain and snow which cause corrosion
- no contamination of water sensitive storage products
- reduced hydrocarbon emissions by eliminating the suction forces of wind.

The question is do these advantages justify the high costs and the additional fire risks? These are questions every tank owner will consider.

An alternative way of reducing the impact of the wind is by adding further seals to the external floating roofs.

Special rainwater seals for external floating roofs have efficiencies of up to 99%.

In general, the collection of rainwater on external floating roofs is not a problem as long as the tank roofs are inspected from time to time. A certain quantity of rainwater on floating roofs can also be used positively as cooling media for the product in storage.

This means it is sometimes difficult to argue the necessity of an aluminium dome roof over an existing floating roof.

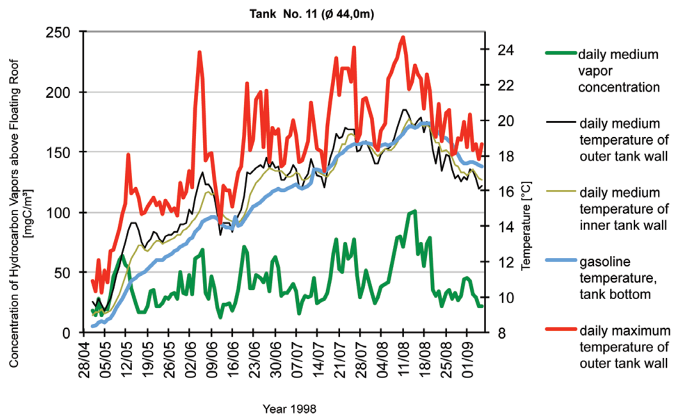
Test results

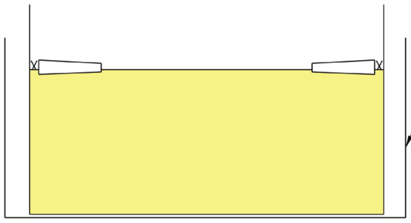
One investigation looked at the emission from 20 fixed roof tanks at a farm in Switzerland mainly storing petrol products. The tanks are 44m diameter, free vented by roof vents and equipped with pan type internal floating roofs. Emission tests with different type of seals had been carried out, year after year, within 1991 and 1998. The test in 1998, during April to September, was focused on the influence of temperature of tank walls and storage product.

The following tank temperatures were recorded, in parallel to the hydrocarbon concentration above the inner floating roof:

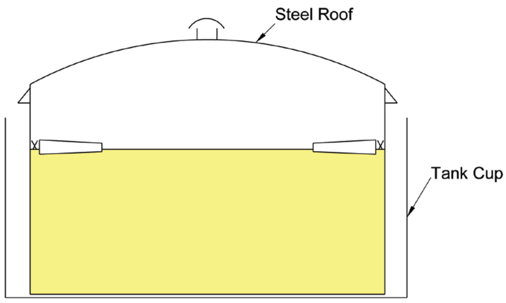
- petrol temperature, 1.5 m

Tank temperatures each month





External floating roof tank with tank cup



Internal floating roof tank with tank cup

from tank bottom, 1.5 m inside the tank
- daily medium temperature of inner tank wall, 1m below liquid level, in south direction
- daily medium temperature of outer tank wall, 1m below liquid level, in south direction
- daily maximum temperature of outer tank wall
- temperature of steel membrane of floating roof, centre of tank.

The temperature of the petrol stored started at the end of April with 9ºC. In the middle of August a maximum temperature of the storage product was received at 20ºC. In the middle of September the temperature of the product was down to 17ºC.

From theories of hydrocarbon evaporation and emission, everybody expected the emission data (here the hydrocarbon concentration above the floating roof) to follow the change of temperature of the storage product.

But during the whole test period the concentrations of hydrocarbons leaving the tank oscillated between 20 and 90 mgC/m³. Concentrations of 60 mgC/m³ were measured in May at petrol temperatures of only 10ºC and concentrations of only 30 mgC/m³ were seen in August, at petrol temperatures of 19ºC.

The reason for this is that the rate of evaporation and emissions was going up and down with the maximum temperatures of the tank wall, irrespective of the temperature of the liquid stored.

This means the emission of a storage tank depends on the warmest areas in the liquid. In summer time these are the areas of tank walls, close below the liquid level, heated up by direct sun radiation. In wintertime we expect the warmest points not at the tank wall but at the liquid level inside the tank.

After eight years of emission testing the following guidelines have been established:

- The efficiency of floating roof seals can always be upgraded. Each further stage of the sealing system will bring down the quantity of emission to approximately 50% of the stage before – as long as the temperature of the storage product stays below a certain limit temperature, equivalent to a vapour pressure of the storage product of approximately 500mbar. Above such, vapour pressures upgrading of sealing systems will show little effect
- The maximum temperatures of the tank walls during summer time governs the yearly emission of the whole storage tank. This means the whitest possible tank walls are a great help.
- In case of storage products with vapour pressures above 500mbar at storage temperature, the possibilities of partial tank wall shadowing or tank wall cooling is advisable
- An additional tank roof has no positive effect to the driving forces of evaporation. In contrary to this, the additional roof or dome will slightly increase the temperatures of the storage product and the vapour pressure
- All hydrocarbons bypassing the floating roof and the sealing system are emissions, irrespective of an additional tank roof.

After examining these findings it may be beneficial to look at the best way of increasing environmental control and tank safety.

For some, money would be better spent on an additional tank cup, rather than another tank roof.

Such a cup would reduce tank wall temperatures and therefore the temperatures of the storage products. At the same time a tank cup will dramatically increase the safety aspects of the storage tank.

For more information:
www.imhof-tanktechnik.de