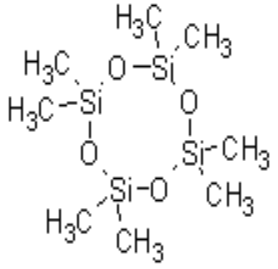
Siloxane contamination and solutions

What are the sources of Siloxanes in gas?

Volatile methyl siloxanes (VMS) are a class of chemicals with an increasing range of applications. In the last 5 years the use has increased five fold and set to increase in the next 5 years by the same amount. (source: Imperial College, London)

They are widely used in personal care products such as deodorants, tooth-pastes, skin care preparations, hair conditioners and as carriers in anti-perspirants. They are also used as effective industrial cleaning agents.



Recently legislation has encouraged the dry cleaning industry to change from using chrlorofluorosolvents to more environmentally friendly products, such as siloxanes.

The waste from these industries is frequently disposed of in landfill sites. As organic matter decomposes it produces methane and carbon dioxide. The siloxanes blend with this and contaminate the gas which is used to fuel engines that produce electricity.

Sewage treatment works acquire siloxanes via industrial and domestic discharges. This is often supplemented by road tankers adding waste directly into the treatment process. The contamination is similar to that experienced on landfill sites, with the resultant gas used to fuel engines.

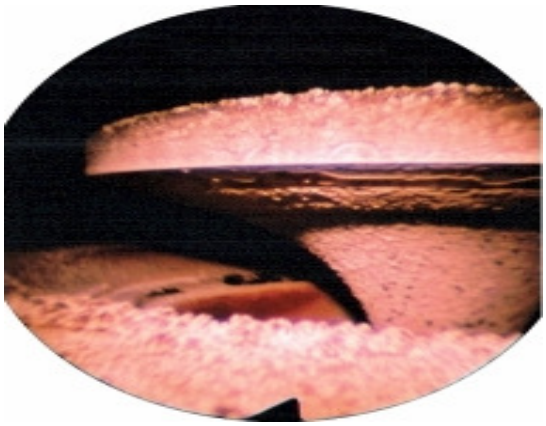
The gas produced by these sites is frequently contaminated by siloxanes particularly the cyclic D3, D4, D5 and the linear L2 all of which will form into silicon dioxide during the combustion process.

What are the effects of siloxanes in LFG & Sewage gas?

Siloxanes in the landfill and sewage gas convert into silicon dioxide as combustion takes place in the engine. The silicon dioxide combines with other elements in the gas, and with the lubrication oil to form a hard matrix that accumulates on the combustion surfaces.

As the deposits accumulate, the engines efficiency falls causing detonation in the combustion chambers. The resultant unburned fuel contaminates the exhaust gas increasing emissions. At this point the engine may need to be "de-rated" (Output reduced) to prevent significant engine damage and to reduce emissions.

If run unchecked, severe damage can occur to valves, pistons, piston rings, liners, cylinder heads, spark plugs and turbochargers (see photos over), necessitating premature servicing and costly repairs.



Silicon matrix deposits on a head & valves causing a collision between valves and piston crown

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A piston coated in deposits

What can be done to overcome the effects of siloxane contamination?

Various methods have been employed in an attempt reduce the effect of the silicon dioxide deposits in engines used by the landfill and sewage industries. Fluid injection systems do allow the silicon matrix to soften making removal easier, however in the long term it is preferable to remove the siloxanes from the gas before they reach the engine preventing the formation of deposits.

Active carbon filtration systems are available which filter the contaminants for a finite period, these can be large installations (sometimes requiring planning permission) and need manual removal of spent activated carbon and disposal of the contaminated medium.
Recently derivatives of the active carbon principal have been developed which offer a cartridge / silo replacement and removal service of the spent carbon. Although this avoids some of the disposal and safety issues, it is costly and requires constant maintenance. Normally these installations have a large footprint and require site planning before commissioning and a costly chiller to remove the water from the gas.

The Pptek *BioGas AutoKleen (BGAK)* is a small (~1.5mx2.2mx4.0m) self-contained unit that automatically regenerates the filter medium and requires a minimum of ongoing maintenance. The filter units, under normal conditions, will absorb siloxanes for up to 5 years before the medium requires replacement. The Pptek system is automatically regenerated at regular intervals; the resulting condensate is composed mostly of high boiling siloxanes that are believed to be non-ozone depleting in the stratosphere and have negligible global warming potential due to their short atmospheric lifetimes (e.g. Swanson et al.,1996). The US EPA has granted VMS compounds exemption from regulation as VOC ozone precursors. Siloxanes have been shown to degrade rapidly in the presence of soil (Carpenter et al 1995) with more than 50% converted to a water soluble fraction after 4-6 weeks.
The Pptek BioGas AutoKleen system is cost effective to operate, removes the problem causing siloxanes, is environmentally friendly and enables engines to be run for their full potential between service intervals and overhauls.