TRIAL OF AN STS SILOXANE MONITOR ON A SEWAGE TREATMENT PLANT BIOGAS REGENERATIVE SILOXANE REMOVAL FILTER
February 4th - March 25th 2015

EXECUTIVE SUMMARY
The trial of the STS Siloxane Monitor has in two months demonstrated that the Regenerative filter cycle can be identified, quantified and predicted. The resultant data may be used for performance monitoring, to manage filter regeneration regimes or carbon filter cycles where appropriate, and or, prevent engine damage from siloxane laden gas.

INTRODUCTION
The site of the trial was in Southern England on an established Sewage Treatment works producing biogas from Anerobic Digestion of the sludge waste. The works processes household waste from the surrounding towns and some industrial effluents tankered into the site. The gas supply to the engines is cleaned by passing it through the regenerative filters which remove siloxane and other contaminants. Siloxanes are a class of organic chemicals containing silicon, which burn in the engines, producing silica, in effect sand, which is highly damaging to engines and results in major, frequent engine damage and hence overhauls. The filters are regenerated on a time basis currently set to once every 24 hours, there are two filters with one being the duty filter whilst the other is regenerated.

The STS Siloxane Monitor(SM) is designed to continuously measure the total siloxane load in the gas, thus allowing the filters to be changed at the optimum time.
This technique uses an optical system to measure individual gases in the presence of others. Many chemicals absorb IR light, and the wavelength at

which they do is characteristic of the chemical. D Series Siloxanes absorb IR at 12.45 microns, so the instrument has an optical filter which passes this light and rejects everything else. The instrument thus is specific for these chemicals.

Within the instrument, an IR source – a heated diamond surface – emits the IR, which passes through the filter, then down the gas cell which is 300mm long. At the far end, a solid state detector measures the IR signal. The sample flows through the gas cell and the system makes a continuous reading.
This system is very robust and sensitive – the standard detection limit for the SM is 1 mg/M cu.

INSTALLATION

A compressor cabinet situated at the outlet end of the Filter assembly was an appropriate site to install the Siloxane Monitor. Connections to the instrument are as follows. The biogas supply was made with ¼" OD PTFE tube which ran from the rear of the instrument to the sampling point on the outflow from the filter, a distance of 2 m. The pipework was lagged in an attempt to ensure that water and siloxanes in the gas did not condense out and thus produce variable readings. A preferred methodology would have been to implement a heated line in order to ensure that consistent environmental conditions in the piping were maintained.

The SM requires a nitrogen supply from a cylinder and this was sited next to the cabinet and connected to the instrument by ¼"nylon pipe, with a run length of 2.0M.
A third connection was made to the instrument – this was a vent line, taking the biogas from the instrument after analysis to waste. It consisted of a 6 M length of ¼" nylon tube secured to a vertical mast which terminated at the top with a down facing section. The waste exhaust is very small with a sample volume of only 600ml every hour.
The SM was plugged into a 240 v mains supply provided for the air compressor within the cubicle.
Installation of the SM was carried out on 4th February 2015 and was removed on 2nd April 2015.

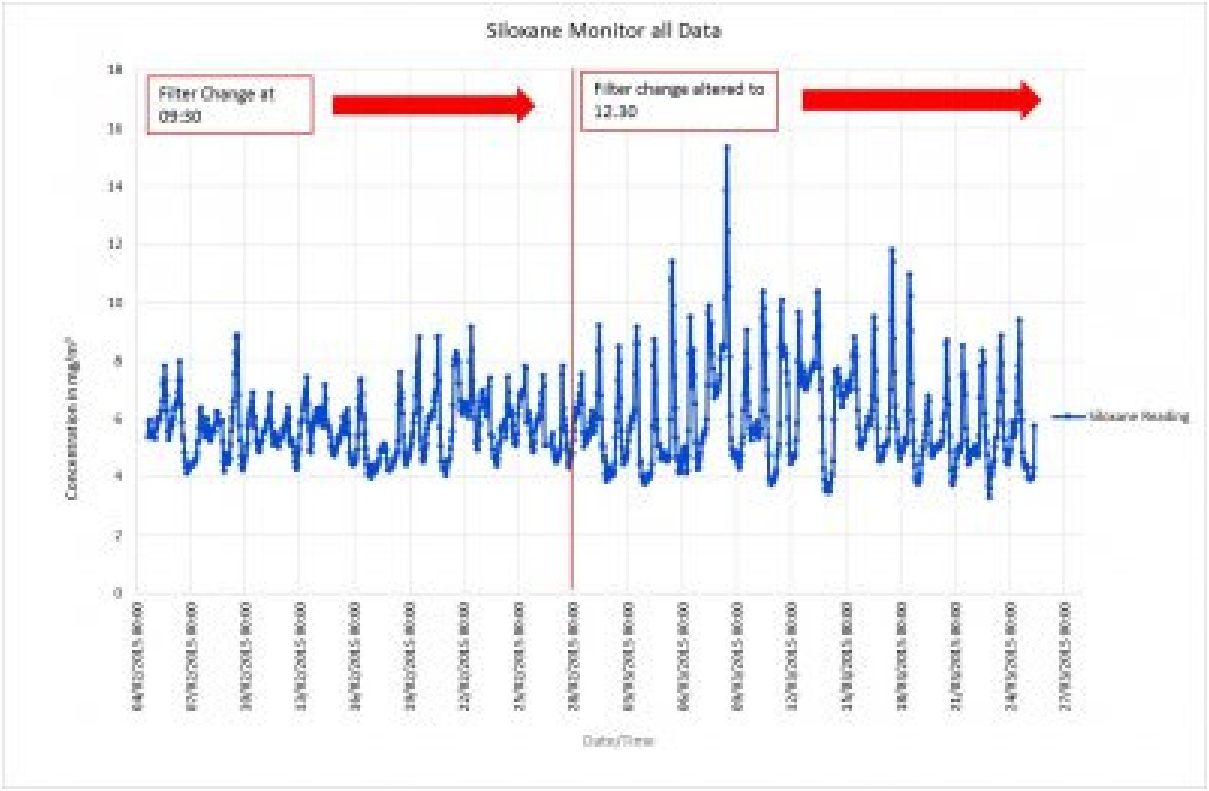
OPERATIONS

The SM is designed to operate continuously with minimal operator input. The monitor ran continuously during the trial and was only interrupted to down load data and also to run a series of blanks to establish correct function and provide baseline data.

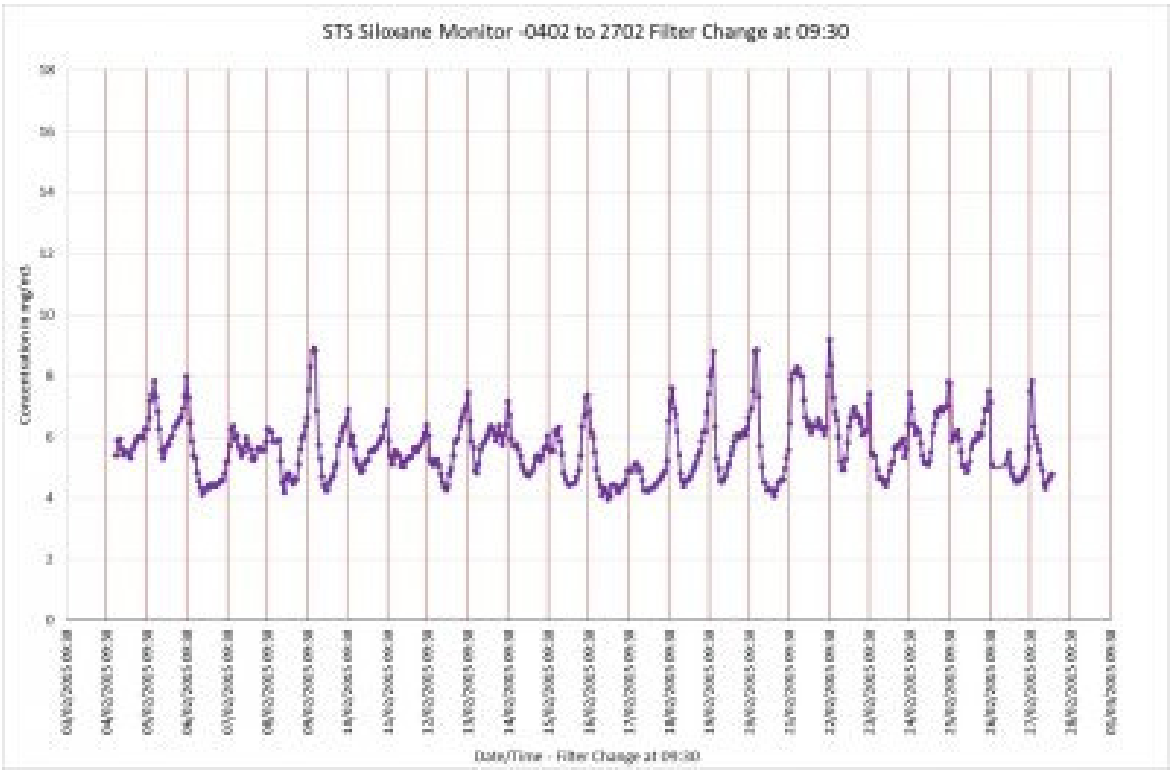
The instrument was operated, as necessary, by the site staff who were confident in its operation and understood the controls and data outputs.

RESULTS AND COMMENTS

The trial ran for 49 days, during which the SM made 1176 measurements.



The graph below shows the results obtained during the period 4th February to 28th February. During this period the plant was reported to be regenerating at 09:30 daily.

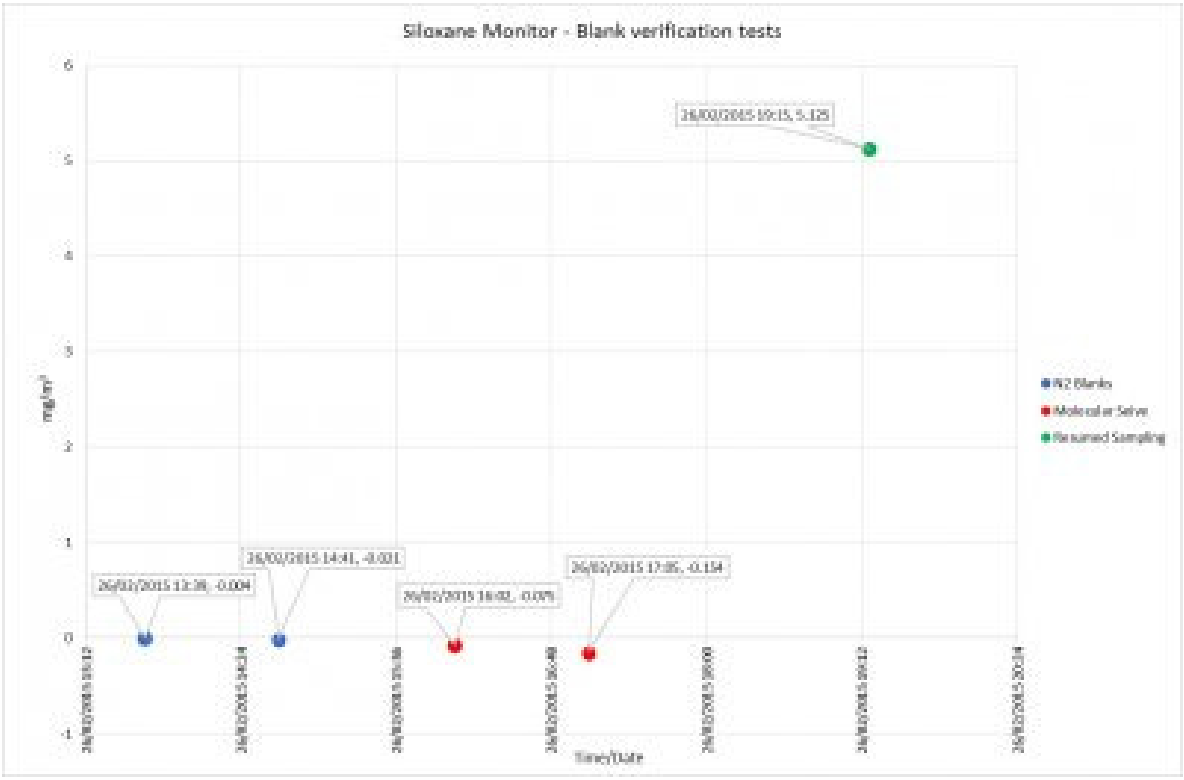


The regeneration process involves the new vessel being brought online by preconditioning the unit and then switching from the used to the new unit. There is a stage during this switch over where raw unfiltered gas will be released into the system and therefore the potential for the monitor to be affected should it be taking a sample at this point. We anticipated seeing a steadily increasing concentration of siloxanes before the change, then a rapid drop to very low levels afterwards. This effect was evident but the actual levels took slightly longer than anticipated to drop and did not reach a near zero figure as expected. Independent analysis of the supply post filter change still showed Siloxane levels of around 2+mg/m3 which explains part of this. A heated line would also have helped in ensuring there was no hang up which caused the levels to drop slower after regeneration.
On the 26th several background readings were taken by disconnecting the Biogas supply and feeding Nitrogen into the supply line, this would prove if the elevated background being displayed was an electronic error or was something being measured by the instrument. Likewise readings were also taken using a molecular sieve filter on the biogas supply which should remove all contaminants from the gas.

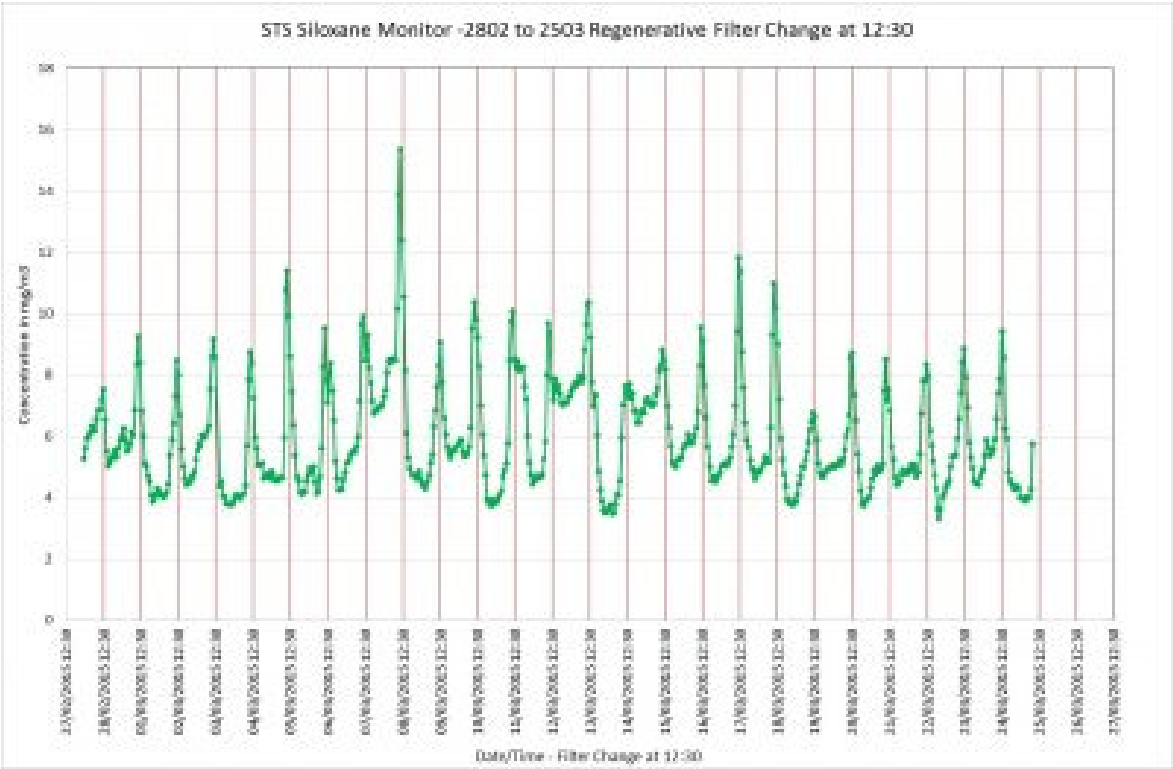
Both of these showed a Zero reading indicating that the instrument was working correctly but that the background being seen was indeed a contaminant within the gas.

SAMPLE SampleID Concentration(mg/m3)

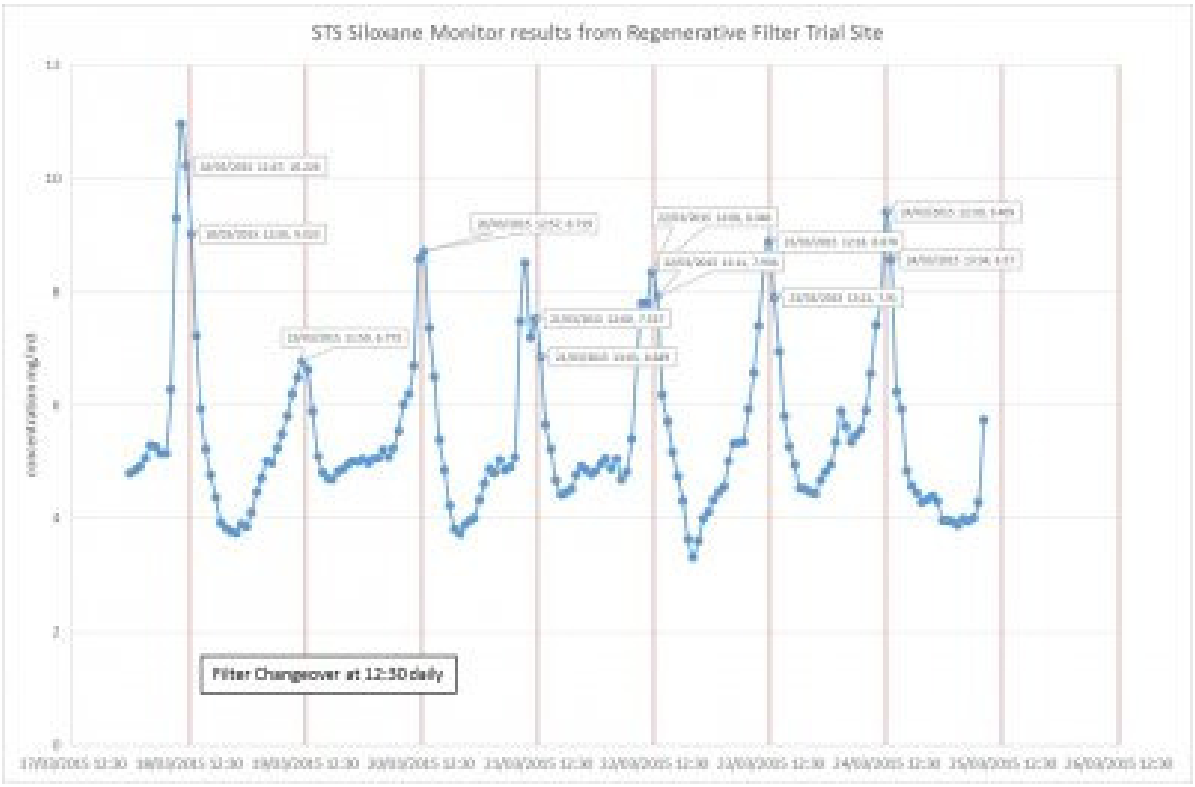
N2 Blank 5.1 -0.004
N2 Blank 5.2 -0.021
Drier Filter on post filter gas 6.1 -0.075
Drier Filter on post filter gas 6.2 -0.154

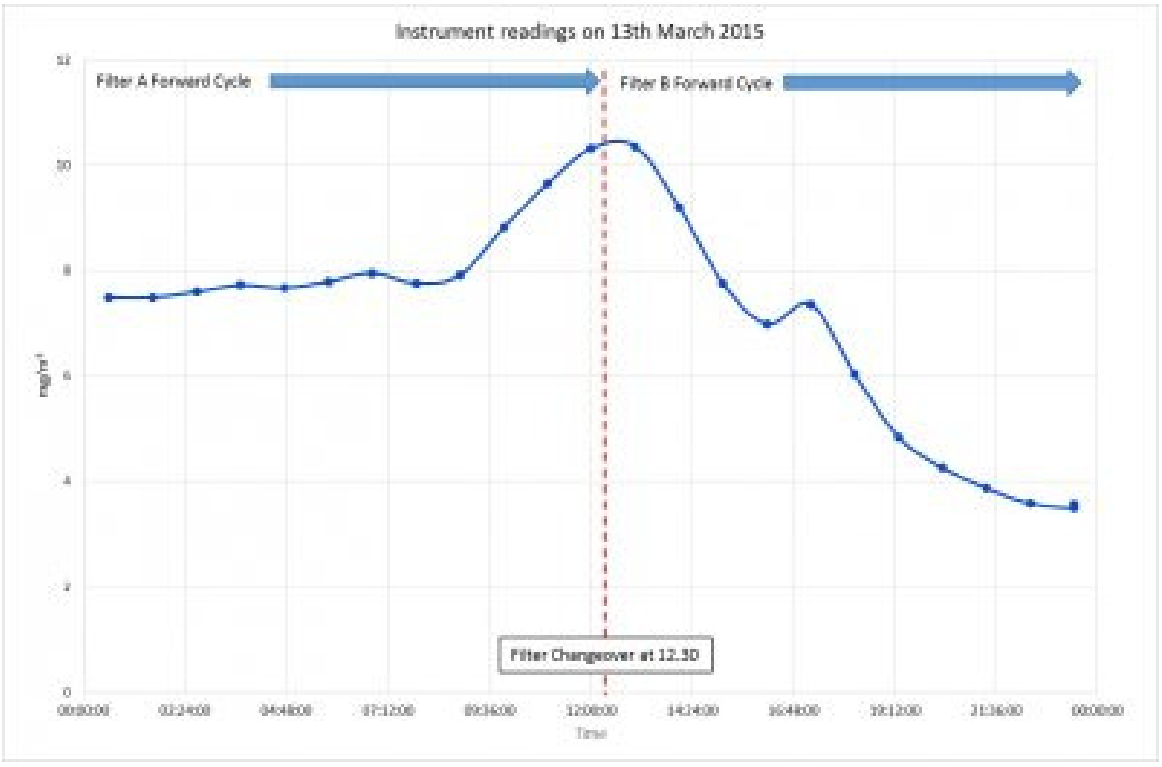


The following graph shows the period from 1st March to 25th March. During this phase the regeneration was adjusted to start at 12:30 daily. Again the siloxane monitor tracks the regeneration very closely demonstrating that the peaks seen are definitively the end of the forward cycle for the filter.



The graph shows the final week of the trial from the 18/03 to 25/03. This provides a more detailed view of the daily filter change cycle showing the trend of the siloxanes gradually building before a rapid breakthrough occurs. It also shows a slower than anticipated return to lower levels after the filter has changed over. This is due in part to a period mid changeover where raw gas is bypassed and may be being sampled and secondly due to condensing of the solixanes in the unheated line. A heated line should resolve this issue although this does not affect the validity of the results or the ability to use the data for process optimisation.





FUTURE INSTALLATIONS

The kiosk provided would not be sufficiently weather proof for a long term installation, a suitable kiosk can be recommended which would house the instrument and also the Nitrogen Cylinder. The performance of the SM can only be as good as the sample it receives – if siloxane losses are suffered in pipelines, there is nothing that the SM can do to recover this loss.
We would therefore recommend that lines should be as short as possible, must be lagged and ideally heated, so that we can have confidence in year round operation.

DATA & NETWORKING

The SM is currently designed to operate with an SD data card but also supply users with an SD to USB converter should they not have an available SD slot.
Data is currently generated as a a CSV file which can be easily interpreted. . Pre-written excel data sheets and graphs are being considered for future software releases to which all users have 3 years of free updates.

STS can offer a data communication package for remote access to instrument data. There are a number of options available including GSM and radio repeaters for poor signal areas, email alerts may be set for notification of instrument alarm conditions and threshold breaches for siloxane concentration. Interface into existing systems may also be possible dependent on site systems. A quote can be provided following the conclusion of discussions on site specific requirements.

COST BENEFITS OF REGENERATIVE FILTER MONITORING

Regenerative Filters provide a highly effective and relatively low maintenance solution to Siloxane removal. The SM provides constant data on the Siloxane level in the post filter gas which is currently not monitored on a regular basis. The data may therefore be used in the consideration of optimisation of the plant to potentially reduce costly energy use in regeneration where actually the filter is not saturated and is still cleaning the gas to an acceptable standard. Increasing time between regenerations would reduce the number of cycles and consequently reduce energy consumption.

Conversely should the monitor show that the filters are beginning to pass higher than acceptable levels of siloxane the regeneration could be triggered

earlier and thus prevent damaging siloxane laden gas from entering the engine.

If the filter is changed too late, then engine damage results. This will appear as shortened life of oil, shortened intervals between top end overhauls, increased cost of replacement components, especially sparking plugs and most importantly, downtime resulting in loss of electricity sales and ROC payments. This is rather difficult to calculate, but with suggested costs of top end overhauls in the £25,000-50,000 range, oil at £0.6/litre and sparking plugs at £10000 a set, a very few days of siloxane damage will equate to the cost of the SM, especially bearing in mind that these repair costs apply to all of the engines receiving the filtered gas.

CONCLUSION

This trial has successfully demonstrated the ability of the STS Siloxane Monitor to provide accurate information on the status of the filters, sufficient to enable decisions to be taken in their operation and optimisation. The trial covered 49 days, the instrument reported 1176 measurements without technical problems and with Site staff operating the instrument as necessary. The regeneration cycle was accurately defined, giving confidence that the instrument can be relied on to indicate the filter status.