

Hydrogen Sulphide Comparison Testing

Below shows extracts from our H₂S comparison testing between our VE Technology system and a conventional system; the benefit of the VE Technology philosophy is clear:

1.1 Testing Summary Overview

Testing the Chromatograph & the Pipeline Simulator

The delay that these items can cause and the way in which those delays will be evaluated are:

The Chromatograph

For a chromatograph to measure the true value of an analyte it has to be calibrated with/against a calibration gas. Because a chromatograph essentially counts the number of atoms in a fixed volume the pressure and temperature of that fixed volume has to be controlled (be the same) during the measurement and the calibration process. The chromatograph itself controls the temperature; the pressure is controlled by a combination of atmospheric pressure and the inlet pressure of the gas to the chromatograph. The valves, tubing and fittings used to control the inlet pressure to the chromatograph may cause some sorption/circulation effects/delays and so need to be tested as part of the chromatograph response time.

The Pipeline Simulator

The pipeline simulator contains a significant mass of gas, in sampling terms, when being used at 70 Bar. It also has a significant surface area where sorption can take place and temporally reduce the concentration of the span gas, however the simulator will be Sulfinert coated to diminish this effect. Additionally there could be some flow circulation issues while being purged out even though the simulator has been designed to minimise flow circulation effects.

The problem in testing the pipeline simulator at pressure is that it will require additional items to control the pressure into the analyser (something like a sample conditioning system). To minimise this problem a special pressure reducing arrangement has been devised with all wetted surfaces, in the flowing stream, being Sulfinert coated.

An initial test will be performed with analytical pressure in the pipeline simulator to obtain comparative information (i.e. the simulator will be run at low pressure, so the outlet can be connected directly into the analyser therefore excluding any additional equipment).

The Pipeline Simulator

The pipeline simulator is not intended to look anything like a pipeline.

The purpose of the pipeline simulator is to be able to surround different types of sampling probe tips with gas of known composition, in sealed conditions, at pressures typically found in natural gas pipelines.

The pipeline simulator has to be designed so that, ideally, a step/instantaneous changes to the gas composition surrounding the probe can be made.

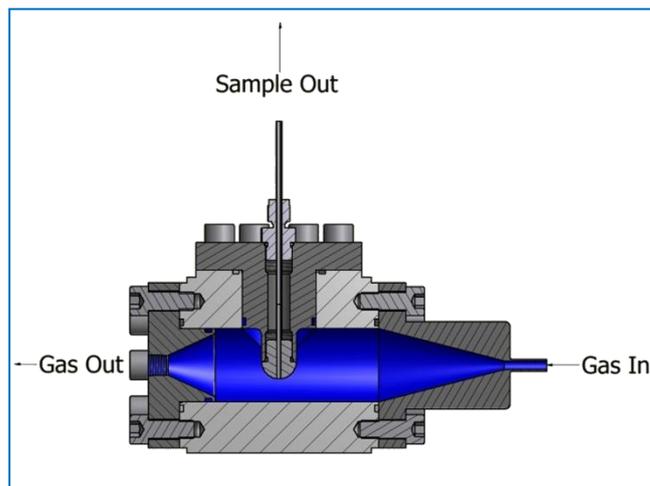


Figure 1 - Pipeline Simulator (Blue highlighting the internal volume/swept area)

As it is not possible to make an absolute instantaneous change to the composition of a gas in a sealed system, (purging, diffusion and sorption effects will always cause some delay), the pipeline simulator has been designed to minimise all these effects by:

1. Having the wetted surfaces of the simulator machined to a fine surface finish, 0.4-0.8 μ Ra, followed by electropolishing and finally coating with SilcoNert surface treatment.
2. Minimising any entrapment areas.
3. Using specially FEP coated seals.
4. Being dynamically designed to enable flow through purging
5. Sighting the probe tip away from surfaces in an area where flow through purging is almost ideal.

See following images/models and sections etc.

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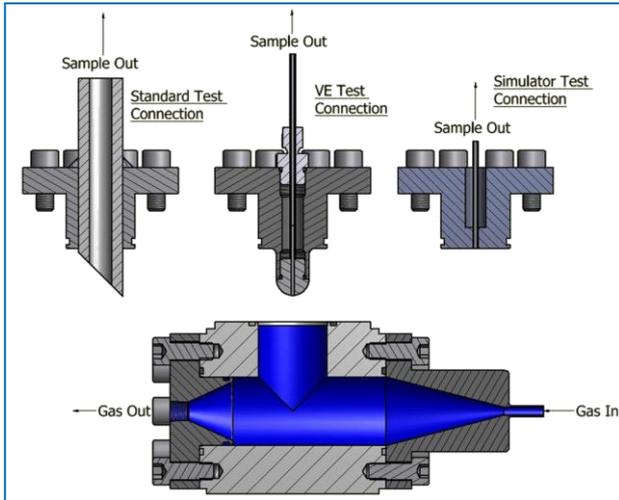


Figure 2 - Probe Entry into Pipeline Simulator (Showing Standard Probe, VE Technology Probe and Simulator Test options)

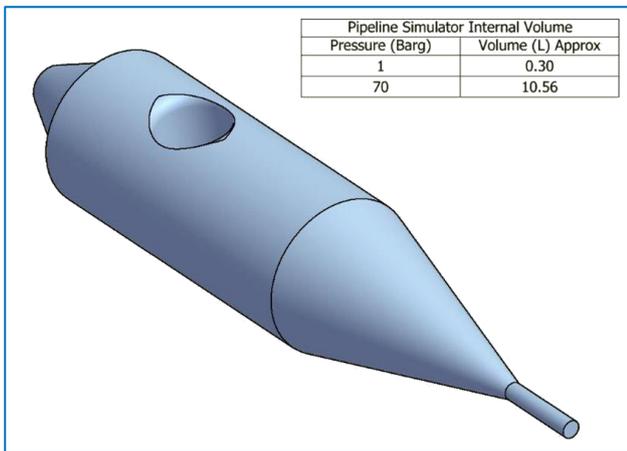


Figure 3 - Pipeline Simulator Internal Volume (excluding volume taken up by the VE Technology test connection)

Testing the Sampling systems.

Such that a true comparison can be made, each set of sampling equipment will be set up to replicate how it would actually be used in a real life situation on site. This therefore includes sample transport lines (heated/temperature controlled) of an approximate average length of some current 60 systems installed on the UK national grid system.

Common Test Setup

Each performance test will require the span and zero-gases to be alternatively switched. In order to eliminate any cross contamination in such an arrangement a double block and bleed system will be used with gas continuously flowing through the bleed port on the blocked side. In this way the sorption affects in the gas control arrangements prior to the switching arrangement will be eliminated. The valves and very short lengths of interconnect piping between them will all be Sulfinert coated. The valves to be used will be of an angled drilled ball design in a 3 ported body to eliminate any dead spaces associated with tee's etc. The response from the analyser from just the pipeline simulator compared to a step change in the input gas, on a 15 minute cycle basis, is compared in figure 4.

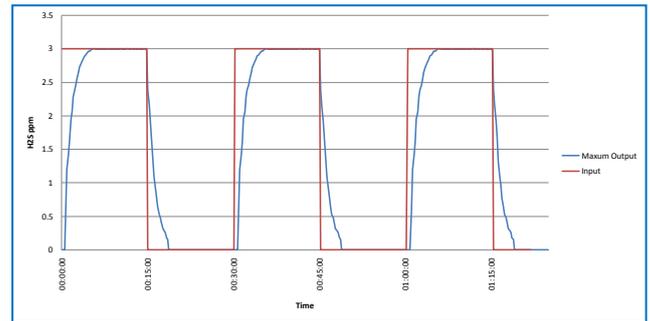


Figure 4 - Cyclic response of test rig

The response from a conditioned standard VE Technology system compared to the “step” change response, on a 15 minute cycle basis, from the pipeline simulator is shown in figure 5.

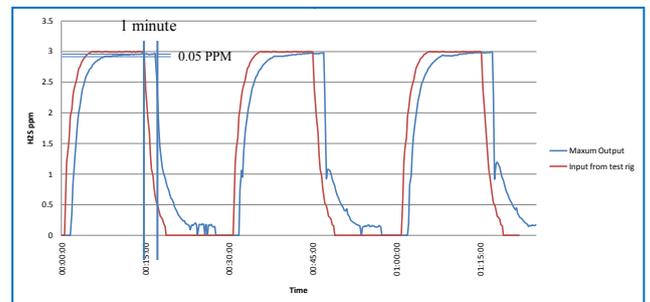


Figure 5 - Cyclic response of conditioned VE Technology® system

It can be seen that the conditioned VE Technology system follows the pipeline simulator response with a 2 – 3 minute delay depending on the concentration up to in excess of the T90 value.

The response from a conditioned conventional system compared to the “step” change response, on a 15 minute cycle basis, from the pipeline simulator is shown in figure 6.

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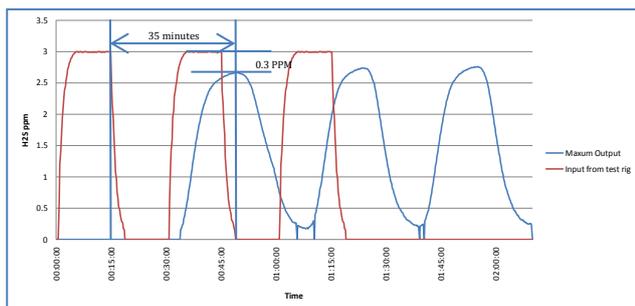


Figure 6 - Cyclic response of conventional system

This figure shows just how far a conventional sampling system can cause the analytical results to both lag and be out of sync with what's happening in the pipeline.

1.2 Possible effect of sampling system on Analytical response to cyclic conditions at Network Entry H2S Levels

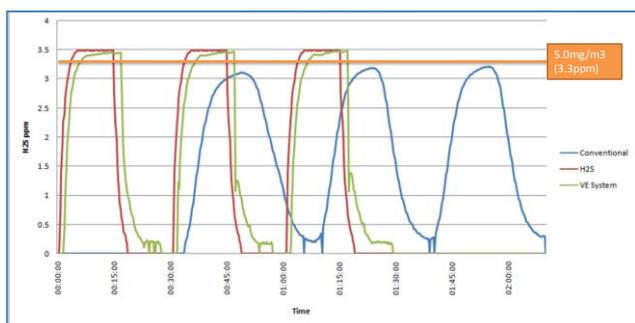


Figure 7 - Possible effects of sampling system (Network entry limits)

Although figure 7 does not show true results, the results are expanded/ extrapolated so as to represent a test gas in excess of the entry limits. 3.3ppm is the legal limit and if readings are found to be above this, then National Grid will shut the pipe line down immediately. Figure 7 shows that the conventional probe never actually reaches the limit, therefore, this gas would be very dangerous and nobody would even know.

This enables a clear demonstration of how the sampling system can effect/mask the analysis results. When changes in concentration of contaminants occur around entry condition levels the results are never actually seen by the analyser. For more information on H2S please see <http://www.hse.gov.uk/aboutus/meetings/committees/ships/180902/45f.pdf>

Conclusion

Like links in a chain, every component between the source stream and the analyser is required to deliver the sample intact and in time, in order to achieve an accurate and representative measurement. Any one component can break this chain and distort readings if not appropriately designed or selected, and if multiple components contribute sampling error then there can be no link between readings and reality.

The level of error and uncertainty generated by the sample system alone can far outweigh the uncertainty of measurement of the analytical device. In this report, a ~12% error was registered between the real and recorded measurement of H2S. However, this may be much more depending on equipment and process/ambient conditions; furthermore, this value will vary over time, forever casting doubt over the validity of readings obtained.

The ramifications of an uncertainty of this magnitude, as found in a typical sampling system, are profound. Some key specifications and legislation rely on measurements that would be affected by the phenomena described in this report. Such measurements include: hydrogen sulphide and total sulphur content, other impurity measurements such as mercury content and water content, hydrocarbon dewpoint and water dewpoint, calorific value, Wobbe number, and other such gas quality parameters. As well as the possible regulatory issues, there are some potentially very serious financial and safety implications for companies depending on these measurements.

Time alignment of data, as required for effective process control and for flow computers, also becomes a near-impossibility due to the magnitude of delay introduced by the sampling system, and the unknown variance thereof in operation. There are many sources of delay (in responding to change) introduced by the sampling system components, with uncertain relative error contributions in any particular set of conditions (pressure, temperature, velocity, composition, ambient temperature, age of sampling equipment, and others). This has a huge impact on operational efficiency and ultimately revenue. In some cases, mis-aligned data can be more dangerous and costly than no data!

Effective sampling should be of interest and concern to users as sampling error may not be seen, may not be consistent and cannot be calculated in order to adjust analytical results.