SHALESAFE – A 'FIRST ALERT' SYSTEM FOR SAFER SHALE OIL AND GAS EXTRACTION

The ShaleSafe project aims to develop an automated, real-time, in-situ aquifer monitoring system which enables immediate detection of any contamination related to the shale gas extraction process. Key parameters such as methane and volatile organic compounds (VOCs) can be monitored several times a day, alerting the shale gas operator when any pollution is detected.

Introduction

Unconventional hydrocarbons such as shale oil and gas are found trapped in fine-grained sedimentary rocks, called shale, characterised by their very low permeability. Unless natural fractures exist in the shale rock, oil and gas cannot move readily within it. Therefore, they cannot be extracted at economically viable flow rates by simply drilling wells, as is the practice for producing oil and gas from permeable sandstone and carbonate rocks.

To access shale oil and gas, the industry currently uses two technologies, namely hydraulic fracturing and horizontal drilling. Hydraulic fracturing, or 'fracking', is a process in which the shale formation is mechanically stimulated to create additional permeability. This is done by pumping a mixture of water, sand and chemicals under high pressure into the rock to break it up and release the hydrocarbons. The use of horizontal drilling allows for an increase in well deliverability by maximising the amount of shale available from fracking.

A frequently expressed concern associated with shale gas extraction is that the underground water can become polluted by methane gas or the chemicals used during the fracking process. This can occur through subsurface pathways from the fractured shale layer or as a result of a loss of integrity of the wellbore. There is also the potential for contamination if the flow back water leaks from the surface due to it not being properly contained prior to disposal.

The oil and gas industry in Europe must demonstrate, and guarantee, safe exploration and exploitation by meeting monitoring requirements set by environmental regulators. There is, therefore, an industry wide need to develop and implement technologies that can continuously, reliably and cost effectively monitor the underground water quality, specific to shale oil and gas sub-surface activities. Towards this purpose, a European consortium comprising TWI Ltd (UK), Danish Technological Institute (Denmark), META Group S.R.L. (Italy), HGL Dynamics Limited (UK) and ZELENA INFRASTRUKTURA (Croatia) has embarked on a project called ShaleSafe with the aim of developing such a technology. The project started in October 2016 and will run until September 2018.

The ShaleSafe concept

ShaleSafe is an instrumentation system which will provide automated, regular monitoring of a broad range of targeted contaminants in hydrogeological monitoring wells, via an on-board sampling, analysis sensor and electronics package.

Figure 1 shows the basic concept of the system deployed in the vicinity of a typical shale gas drilling site. The system comprises four main modules: the Sub-Surface Sensor Package; the Surface Package; the Site Controller Package; and the Central Remote Server Package.

Sub-Surface Sensor packages sit within the aquifer at the bottom of monitoring wells. Wells with diameters as small as 50 mm can be monitored. The maximum drilling depth is 300m. These sensor packages contain modern sensors that continuously detect possible contamination of the aquifer by chemicals related to the shale gas industry. Each sub-surface sensor package is connected to a Surface Package at the top of the well via an umbilical cable. This is so that adequate power is supplied to the sensor package and the data is transmitted to the surface package. All surface packages, in turn, are wirelessly linked to a Site Controller Package which handles collection and storage of all the data received. The site controller package has a user interface to enable configuration of the surface packages, which allows the recorded data to be viewed and analysed locally. Data from potentially many sites are communicated to the outside world via a Central Remote Server Package located offsite, which is able to generate warnings and alarms for each site within minutes of measurements being taken.

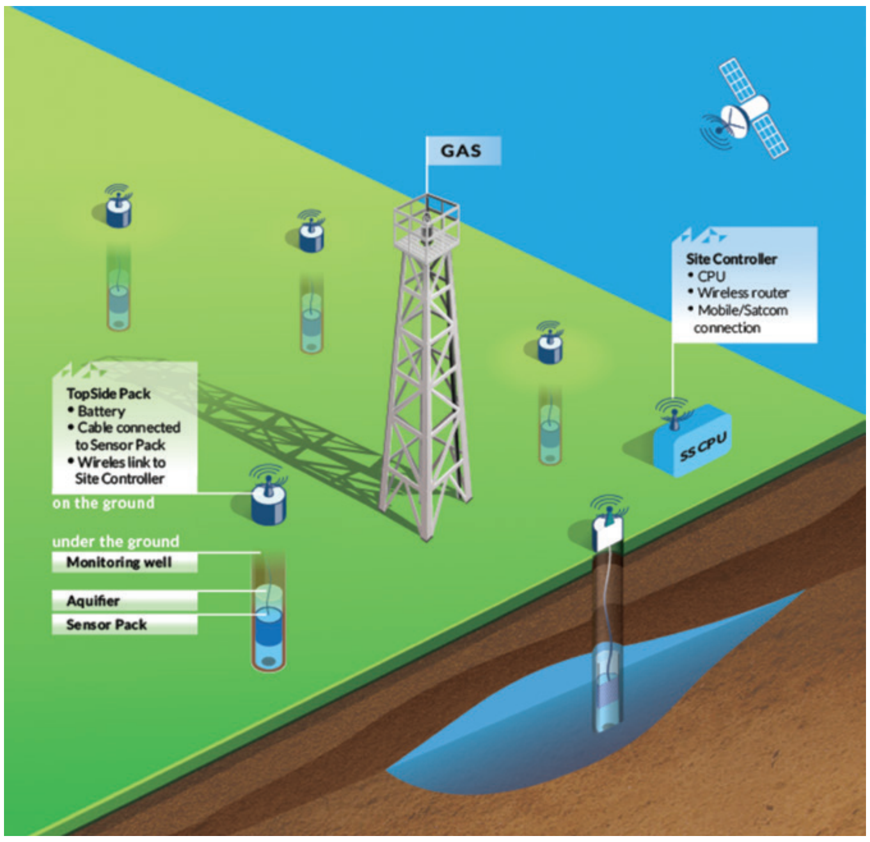

Figure 1: visualisation of ShaleSafe technology deployed in the vicinity of a shale gas well site.

ShaleSafe sensors

The ShaleSafe sensor package employs two technologies to detect methane and volatile organic compounds (VOCs). The VOCs cover a broad range of chemicals including the biocide additives acrylamide and glutaraldehyde used in hydraulic fracturing. A Non Dispersive Infrared Sensor (NDIR) is used for methane detection. The principle of detection relies on the fact that certain molecules (such as methane) have the ability to absorb infrared light at wavelengths determined by the types of bonds present. The NDIR technique targets these wavelength absorptions as a way to

identify particular gases. The methane absorbance band is unique and therefore highly selective. The detection of VOCs is achieved with a Photo-Ionisation Detection Sensor (PID). The sensor uses an Ultraviolet (UV) light source which results in ionisation when absorbed by the gas molecules, and causes temporary loss of electrons and the formation of positively charged ions. The gas becomes electrically charged, leading to the generation of a current that is proportional to the concentration of the VOCs present.

As with most gas sensing, parameters such as relative humidity, temperature and pressure can affect the performance of the PID and NDIR sensors. Hence, each sensor package is equipped with auxiliary sensors to measure relative humidity, temperature and pressure so that the variations of these parameters are taken into account by correcting the readings from the two gas sensors using compensating algorithms.

The technique developed to measure the dissolved methane and VOCs' concentrations follows the general approach of extracting the dissolved gases into the gas phase prior to transduction. This is done by using a membrane characterised by hydrophobic properties, and high permeability to methane and VOCs.

Another important parameter to monitor in groundwater is salinity, as high levels of this indicate groundwater salinization. This can occur if flow back water leaks into the aquifer, either from the surface or from the reservoir/well. Each sensor package is also equipped with an electrical conductivity sensor which measures the electric conductivity of water relative to its ions concentration and salinization. The principle is simple: higher salinity entails higher electric conductivity.

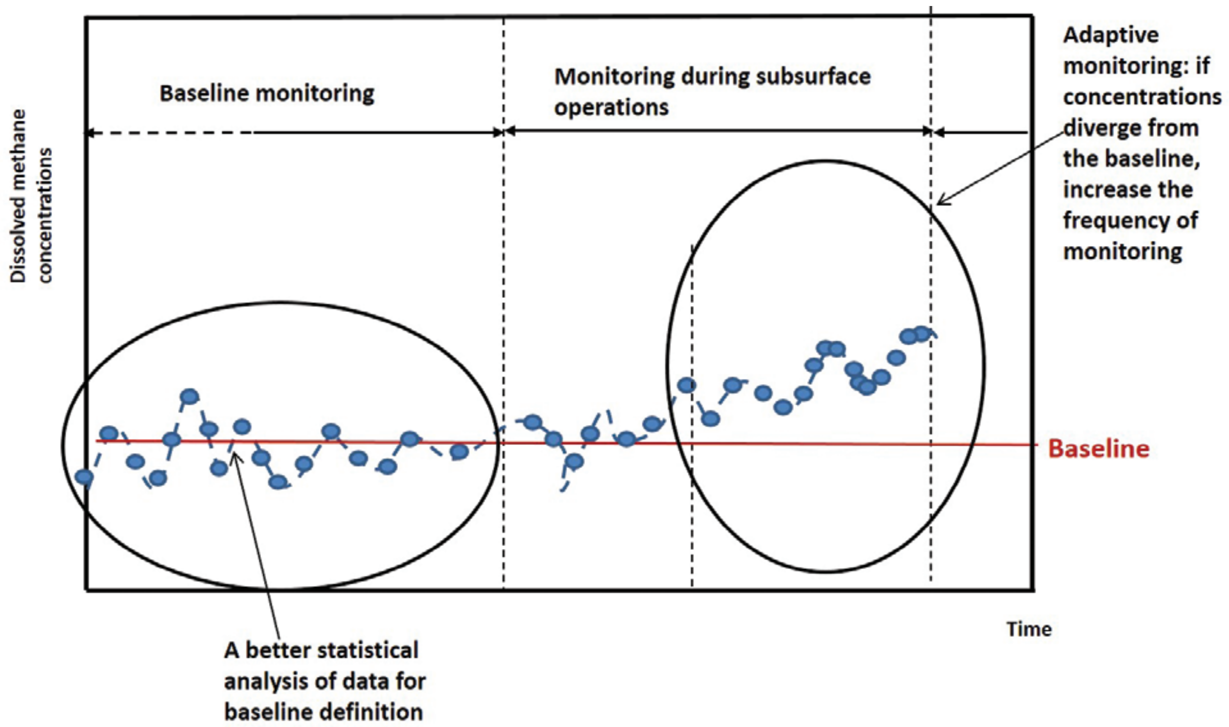

Figure 2: how better evaluation of trends can be obtained using ShaleSafe

Benefits

Existing methods for monitoring the quality of underground water generally rely on manual methods which involve taking samples at hydrogeological boreholes and analysing them in a remote laboratory. The process of collecting, preparing and transporting the samples is labour intensive and prone to errors. Moreover, analysing the samples can take several weeks allowing pollution to go undetected for some time. As natural fluctuations occur in aquifers, the low sampling frequency of current monitoring methods makes it difficult to capture small changes, particularly in the occurrence of methane, which could arise from pollution from fracking.

ShaleSafe uses automated, in-situ technology to continuously and reliably monitor aquifer quality specific to the shale oil and gas industry. Simultaneously it addresses the underground water quality requirements set out by the regulators which include: baseline monitoring for a period of 12 months before commencement of the sub-surface operations; ongoing monitoring during drilling and hydraulic fracturing; and finally monitoring during flow testing, production and well abandonment. As a result, ShaleSafe offers an environmental monitoring solution which is more frequent, accurate and efficient than existing shale gas monitoring systems.

In addition, a better evaluation of the baseline is achieved with ShaleSafe because the high frequency of sampling allows for better statistical analysis of the data (see Figure 2). The technology also allows for adaptive monitoring, both during and after subsurface operations, in order to better capture the divergence of the data from the baseline. The increased frequency of readings that ShaleSafe can provide over manual methods will undoubtedly allow more accurate trending to be obtained, and dramatically decrease the response time in cases of contamination.

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For further information, visit www.shale-safe.com.

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