PSUsing Ultrasensitive Hydrocarbon Detection to Elucidate Nascent Pipeline Leaks

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Search and Discovery Article #70352 (2018)**
Posted July 30, 2018

*Adapted from poster presentation given at 2018 AAPG Annual Convention & Exhibition, Salt Lake City, Utah, May 20-23, 2018

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Abstract

Underground and above ground hydrocarbon transport pipelines often contain CO_2 and water which cause corrosion. Corrosion often begins as pinpoint leaks that expand over time. The difficulty lies in the fact these leaks are often difficult to detect until a major event occurs.

Pressure testing can determine a leak to be present, but does not pinpoint the location of the leak. Pipeline pigs normally only detect leaks after they become significant and costly. The use of methane detectors has also been utilized with the recent popularity of drones. However, the use of airborne methane detectors has been less than successful due to the limited linear range of the methane detectors and poor low-end sensitivity.

However, passive ultrasensitive sorbent modules have been used to detect nascent leaks at ppb levels, which is 1000 times more sensitive than traditional methods. Passive ultrasensitive sorbent modules contain a specially engineered oleophilic (i.e., oil-loving) adsorbent encased in a microporous membrane. These membrane pores are small enough to prevent the entrance of soil particles or water, but are large enough to allow hydrocarbon vapor molecules to pass through and concentrate on the adsorbent material within. The results is a 1000-fold increase in concentration that allows for parts per billion (ppb)-level detection.

The Columbia natural gas condensate pipeline case study took place south of Pittsburgh and was buried at a depth of approximately 6 ft. Ultrasensitive passive modules were installed equidistance along the pipeline. A battery-operated hand drill was used to drill a 1 inch hole in the ground to an approximate depth of 3 ft. The module was inserted into the hole, covered with dirt, and left for 5 days. After retrieval the modules were analyzed by thermal desorption / mass spectrometry.

The objectives of the survey were to:

- examine potential fingerprints for evidence of gas condensate leakage,
- determine if nascent leaks could be distinguished from baseline readings,
- compare results with pipeline maintenance records for ground-truthing purposes.

The results of the project showed:

- several locations along the pipeline exhibited strong potential as leakage points,
- the results were ground-truthed with a known leak point along the pipeline,
- the data helped to monitor the efficiency of prior pipeline repair work,
- baseline levels of hydrocarbons were determined,
- potential nascent leak points were identified along the pipeline.

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Using Ultrasensitive Hydrocarbon Detection to Elucidate Nascent Pipeline Leaks

Underground and above ground hydrocarbon transport pipelines often encounter common constituents like CO_2 and water which cause corrosion. This corrosion begins as pinpoint leaks which expand over time. The difficulty lies in the fact that these leaks are often difficult to detect until a major event occurs. Pressure testing can identify if a leak may be present, but does not pinpoint the location of the leak. If leaking hydrocarbons infiltrate the groundwater, serious ramifications can occur. Thus, **there is an absolute need for the ability to identify leaks early in the process**.

AGI's proprietary passive surface detection and hydrocarbon mapping technology provides a unique ability to detect hydrocarbons at parts per billion (ppb) levels **which is 1000 times more sensitive than traditional methods**.

The AGI passive sampler, **Figure 1**, contains a specially engineered oleophilic (i.e., oil-loving) adsorbent encased in a microporous membrane. These membrane pores are small enough to prevent soil particles and water from entering, but large enough to allow hydrocarbon molecules to pass through and concentrate on the adsorbent material. Additionally, the AGI method measures ~100 compounds, from C_2 – C_{20}. This expansive carbon range allows AGI the ability to set-up specific methods for gas, condensate or liquid petroleum products.

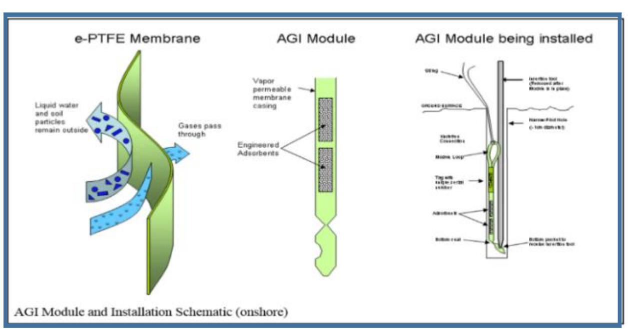

Figure 1.

The Columbia pipeline case study took place in early 2007 in Washington County, PA, just south of Pittsburgh. Approximately 85 passive samplers were placed at the surface in 1" diameter holes about 3 ft deep along a one mile section of pipeline. The natural gas pipeline was an underground pipeline buried at a depth of about 6 ft.

The objectives of the survey were to:

- examine the variation of compound patterns along the pipeline for evidence of natural gas leakage,
- determine if nascent leaks could be distinguished from baseline readings,
- compare results with pipeline maintenance records for ground-truthing purposes.

Since the contents of the pipeline were natural gas, 99.9% of the detected compounds ranged from C_2 – C_5. Thus the hydrocarbons from C_2 – C_5 were summed for each sample and plotted on a log scale, as seen in **Figure 2**.

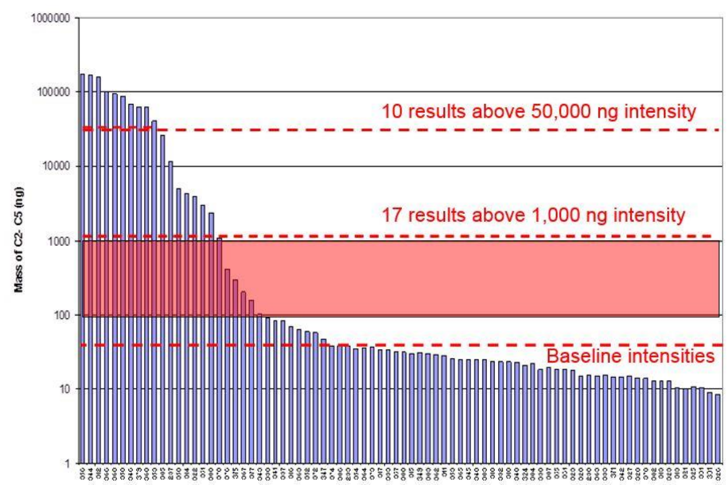

Figure 2.

The Y-axis denotes sample hydrocarbon intensity while the X-axis indicates the sample ID. Note the data is plotted on a log scale. Thus, **there is a 2000-fold difference in intensity between baseline samples** ranging from ~10 ng – 80 ng **and the highest level samples** at ~120,000 ng. The plot illuminates several points:

- baseline intensities can be measured at any site,
- There appears to be 10 high level samples >50,000 ng which may indicate strong leaks,
- There appear to be 7 samples between 1000 – 50,000 ng which may indicate moderate leaks,
- **There are 4 samples in the red shaded area between 100 – 1000 ng which appear to indicate nascent leaks.**

Mapping Nascent Leak Points

Figure 3 shows the hydrocarbon intensities plotted as a bubble map overlaying a map of the pipeline. The small pink shaded diamonds represent baseline hydrocarbon values along the pipeline. The colored circles indicate elevated hydrocarbon levels along the pipeline. The green circles represent very high hydrocarbon levels, the red high hydrocarbon levels, and the blue represent moderate hydrocarbon levels. **The yellow circles represent low level hydrocarbon intensities that may represent early-stage or nascent leaks**

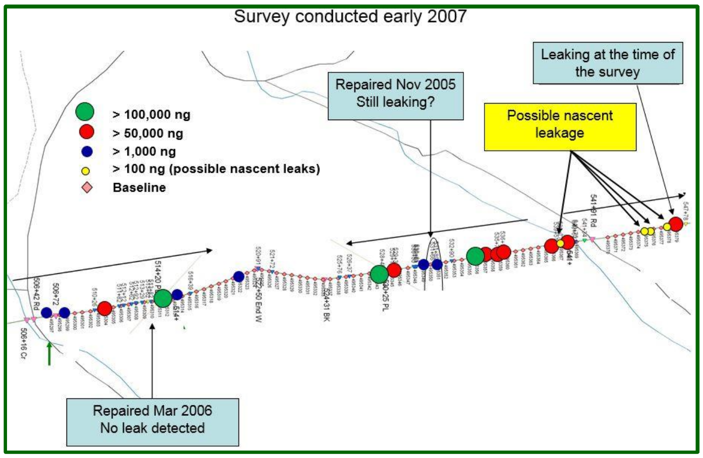

Figure 3.

A review of the maintenance records for the pipeline indicated two prior leaks. One leak was detected and fixed in November of 2005 while the second leak was detected and repaired in March of 2006. As stated previously, the monitoring survey was conducted early in 2007.

The mapped hydrocarbon data indicated the most recent leak; the one fixed in March 2006, appeared to be adequately repaired because the ultrasensitive AGI method detected no hydrocarbons above baseline levels. However, it appears that the prior leak identified in 2005 may not have been satisfactorily repaired.

Additionally, during the survey a leak was noted in one point at the end of the pipeline. This leak was detected by the monitoring survey, **thus ground truthing the results.**

The data were also plotted sequentially as placed along the pipeline, **Figure 4**. The dashed red lines indicate the location of nascent gas levels along the pipeline. The yellow stars indicate 5 sampling locations at which the field crew smelled sulfur. The AGI analysis detected the sulfur containing compound butylmercaptan above baseline levels in 13 samples. Note there were elevated mercaptan levels in more than just 5 samples.

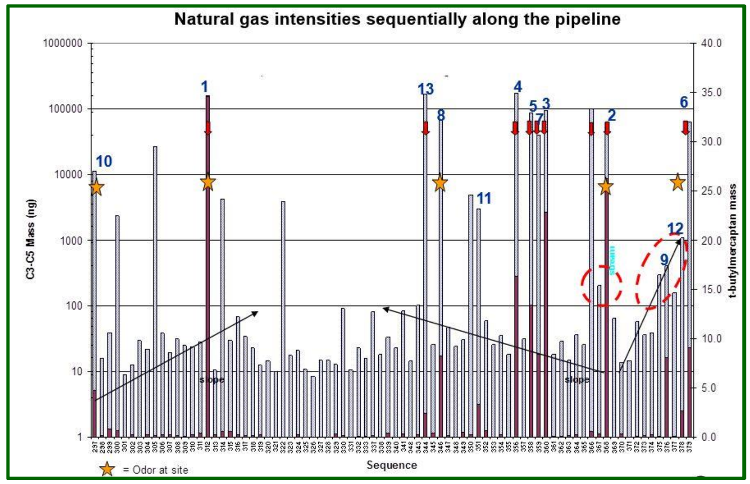

Figure 4.

Also note several of the sample intensities have red coloration. The height of the red color reflects methane concentrations as detected by a hand-held methane sniffer in the field. Appreciable methane concentrations were only detected in the highest level samples and, thus, could not be used to detect nascent pipeline leaks.

Summary:

- Several locations along the pipeline exhibited strong potential as leakage points.
- **Hand-held sniffers** and olfactory receptors were **not adequate for detecting potential leakage** areas.
- The results were ground-truthed with a known leak point at the time of the survey.
- The data **helped to monitor the efficiency of pipeline repair work**.
- Due to the sensitivity of the method, baseline levels of hydrocarbons could be determined and defined areas with no contamination.
- Due to the sensitivity of the method, potential **nascent leak points were identified**.
- Once leaks are identified, a follow-up mini-survey can be implemented to map the extent of contamination and **dramatically reduce remediation costs**.