A BRIEF HISTORY OF NATURAL GAS

and AAI's analyzers in Natural Gas applications

AROUND 1,000 B.C., a natural gas deposit in Mount Parnassus, Greece ignited and spewed flames into the air through rock fissures. The people of Delphi believed this hydrocarbon-fueled spectacle to have divine origins; they constructed a temple for Apollo, god of prophecy, at the site of the fire. It is thought that the priestesses of the temple would inhale the fumes from the fissures, which may have emitted trance-inducing ethylene along with mostly methane-comprised natural gas. The prophecies that these women gave in their hallucinogenic state would advise the Spartans, Athenians, and Romans for over a millennium, manipulating politics and war throughout classical Europe.

In the modern world, natural gas has a more direct relationship with international politics as a result of its utility as an energy source. In the late 18th century, Britain pioneered the commercialization of natural gas by using the abundant resource to light houses and power streetlights. The 1885 invention of the Bunsen burner and concurrent efforts to construct efficient pipelines created new markets and potential uses; before the installation of major pipeline networks, natural gas that was found coincidentally at oil fields or other resource deposits was regularly burned on-site—a practice known as "flaring"—because it was too difficult and expensive to transport. In the 1920's, seismological instruments were first applied to the search for undiscovered oil and gas reservoirs, leading to increased gas speculation and production.

When cooled to -160° C, natural gas enters the liquid phase, in which it occupies six hundred times less volume than in its gaseous state. The importance of liquefied natural gas (LNG) thus lies in transportation: whereas natural gas requires long, expensive pipelines for global export and import, LNG can be transferred in secure tanks by ship or truck. The first commercial natural gas liquefaction plant opened in West Virginia in 1917, a century after Michael Faraday first succeeded in liquefying carbon dioxide and hydrogen sulfide. In 1959, a converted WWII Liberty freighter named the *Methane Pioneer* became the first LNG tanker, shipping a large cargo of the valuable resource safely across the Atlantic Ocean.


An offshore natural gas platform.

While LNG has obvious advantages, the costs associated with liquefaction and regasification can outweigh the benefits. This explains why new pipelines are being constructed, such as the recently completed project between Turkey and Greece. However, building a pipeline is sometimes not a viable transportation method, particularly when natural gas exporters and their customers are separated by ocean. As the global natural gas market grows, major exporters are increasingly using liquefaction to serve customers worldwide; LNG plants have recently been constructed in Equatorial Guinea, Yemen, Qatar, Egypt, and elsewhere.

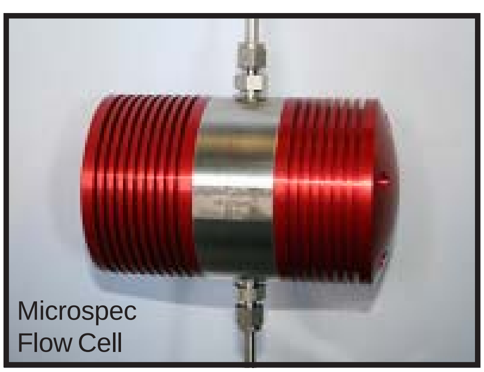
In an atmosphere of soaring energy demand, natural gas is becoming critically important as a resource that can reduce international reliance on petroleum. Worldwide natural gas consumption is projected to nearly double by 2025, increasing annually at a rate of 2.2%. The efficiency of natural gas processing is therefore an issue of major concern to both exporters and consumers. Determining efficiency in the preparation of end-user natural gas requires continuous, reliable monitoring throughout the involved processes.

SWEETENING PROCESS

A critical stage in the preparation of end-user natural gas is the removal of H_2S, CO_2, and mercaptans, all of which are naturally occurring in the feed gas. Hydrogen sulfide is both toxic to humans and corrosive to carbon steels, causing damage to natural gas pipelines and handling equipment. Carbon dioxide is similarly corrosive and also lowers the heat value of natural gas as a fuel.

This process--industrially known as 'sweetening'--is especially important in the production of LNG. Since the melting points of H_2S, CO_2, water, and other undesirable components are higher than the boiling point of methane, they can potentially freeze during the cryogenic process. Freezing can lead to clogged LNG transport pipes and storage vessels, producing various maintenance issues and hindering overall process efficiency.

For decades, various aqueous amine solutions have been used as solvents in natural gas sweetening processes. Methyldiethanolamine (MDEA) is one amine developed to selectively remove H_2S from "sour" gas; it can be used in conjunction with less selective amines like monoethanolamine (MEA) to ensure that CO_2 is also separated from the feed gas. The Sulfinol process, created by Shell Global Solutions, uses an aqueous solution of MDEA, other amines like diisopropanolamine (DIPA), and sulfolane (captures acid gases and mercaptans) to effectively sweeten natural gas.


Microspec Flow Cell

In Sulfinol and analogous processes, efficiency hinges on the maintenance of ideal operation conditions. One such condition is the ratio of amine to water in the solution. Water is consistently lost from the system, both in the regenerator and as vapor in the absorber. For various reasons, if the water level becomes too high or too low compared to its original specification in the amine solution, the sweetening process becomes inefficient; an H_2S-contaminated output stream and significant waste of expensive amines are both common consequences of improperly regulated water levels.

AAI TECHNOLOGY

The MCP-200A Microspec Analyzer is our cost-effective, online monitoring solution for water in gas sweetening systems. The core components of this instrument include a high-intensity tungsten light source, a dual pyroelectric IR detector, an optical filter that isolates the specific wavelength to be monitored, a temperature-measuring thermistor, and our proprietary flow cell. The Microspec continuously monitors the absorbance of the sample and calculates concentration from this signal.

In spectroscopy, *transmittance* is defined as the fraction of light at a specific wavelength that passes through a sample without being absorbed or dispersed by the molecules in the sample ($T = I / I_0$, where I_0 is the intensity of light before passing through the sample and I is the intensity after). *Absorbance* is in turn defined as the negative logarithm of transmittance (i.e., $A_l = -\log_{10} T$). Transmittance is reduced by increasing the number of molecules in the sample that absorb the specified wavelength and/or by increasing the path length. Absorbance is therefore directly proportional to concentration and can be used to determine sample composition as long as the path length is kept constant. Using this spectroscopic principle, the Microspec detector measures light intensity at the specified IR wavelength while the user interface provides the results in terms of concentration. The technology is intrinsically versatile in terms of concentration measurement range; the same analyzer can be calibrated to detect water levels anywhere from 0-50 ppm to 0-10% by weight.

At AAI, we design analytical solutions for *specific* applications. Our in-house engineers have commissioned analyzers at natural gas processing sites worldwide; experience has taught us the true needs of a process and how we can apply our proven technology to best complement and sustain an industrial mechanism. The Microspec design centers around solid-state construction and continuous online monitoring because, as our operations have grown, we have learned that these principles are what separate true analytical solutions from less reliable, less integrated approaches.

Monitoring water levels in the amine solution is a percent-by-weight application. If the water content in the sweetening solvent drifts more than a few percentage points, efficiency is compromised; more drastic changes can jeopardize general functionality. FTIR (Fourier Transformation Infrared Spectroscopy) can be used to monitor such water concentrations, but when compared to the Microspec, the instrumentation is needlessly comprehensive and significantly more expensive. Other technologies employ moving-part mechanisms such as filter wheels for wavelength adjustment, requiring frequent maintenance and service; committing to solid-state AAI systems is an investment in long-term sustainability and reliable performance.

Another water-based application for the Microspec within the natural gas sweetening process is monitoring moisture in the output gas stream at around 0-50 ppm. The feed gas naturally contains water before it is processed, but the reactions and conditions of sweetening which remove acid gases also reduce water content. Monitoring the post-processing water concentration is therefore a useful method of assessing efficiency: anything above trace water levels in the output gas might suggest that contaminants are not being properly absorbed out of the gas mixture. Natural gas that doesn't undergo effective sweetening is both hazardous to equipment in later processing phases and unsellable with respect to standard customer specifications. When the faulty operation of a process translates so directly to wasted materials and lost revenue, fast-response online monitoring is a necessity.

MCP-200A

The MCP-200A Microspec provides this capacity for natural, transparent process control. Traditional methods used for the same application include Karl Fischer titrations and other offline laboratory procedures, all of which involve large gaps of time between manual sampling and response in which undetected, costly changes can occur. Additionally, these analysis methods are labor-intensive, time-consuming practices relative to the automated, instantaneous response Microspec system. Compared with other online analyzers for this application, our product has the previously mentioned benefit of low-maintenance, solid-state design.

The ability to pinpoint the instant a process becomes inefficient and immediately make the appropriate physical corrections is paramount to maximizing profitability in the industrial realm. We engineer our products to best provide this ability within specific processes; the MCP-200A is our proven monitoring solution for water-based applications. When integrated with our flagship OMA-class sulfur analyzer, the

Microspec is part of the complete monitoring solution for natural gas sweetening. Always working from the plant back to the drawing board, *AAI is committed to building a window into your process.*

Integrated OMA-300 (for H_2S and mercaptans) and Microspec (for water and CO_2)

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