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O_2 Removal Key To Tower Mine Project

By Q. Zane Rhodes II

COLLEGE STATION, TX.–Oso Oil & Gas Properties LLC, in cooperation with Andalex Resources Inc., has embarked on a coal mine methane recovery project designed to capture mine gas continuously vented to the atmosphere at the Tower Mine in Carbon County, Ut.

The gas was being vented from gas vent holes (GVHs) drilled into the coal, sandstone and shale formations above the main Aberdeen Coal seam. Gas production begins when a long-wall cutting machine reaches the area beneath the GVH and continues for many years after mining has finished. The drainage of the gas is an operational and economic necessity for the mine because of the danger of methane explosion. Andalex, the mining company that owns Tower Mine, had no

FIGURE 1

Cross-Section of Gas Well and Mine

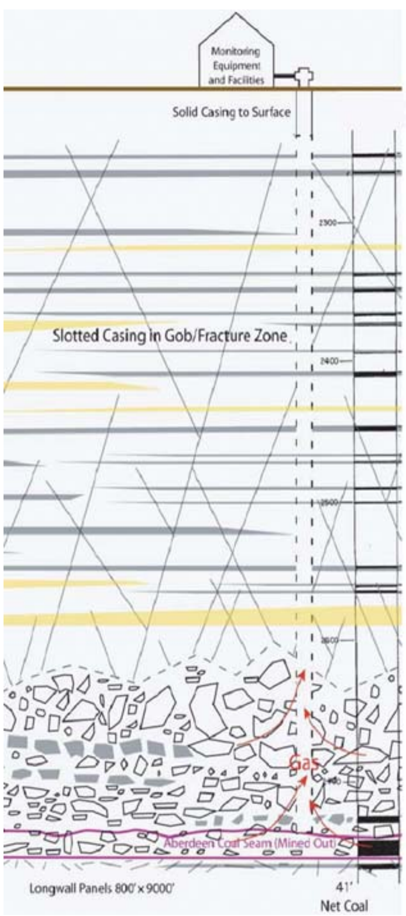

FIGURE 2

Wells and Compressor Station

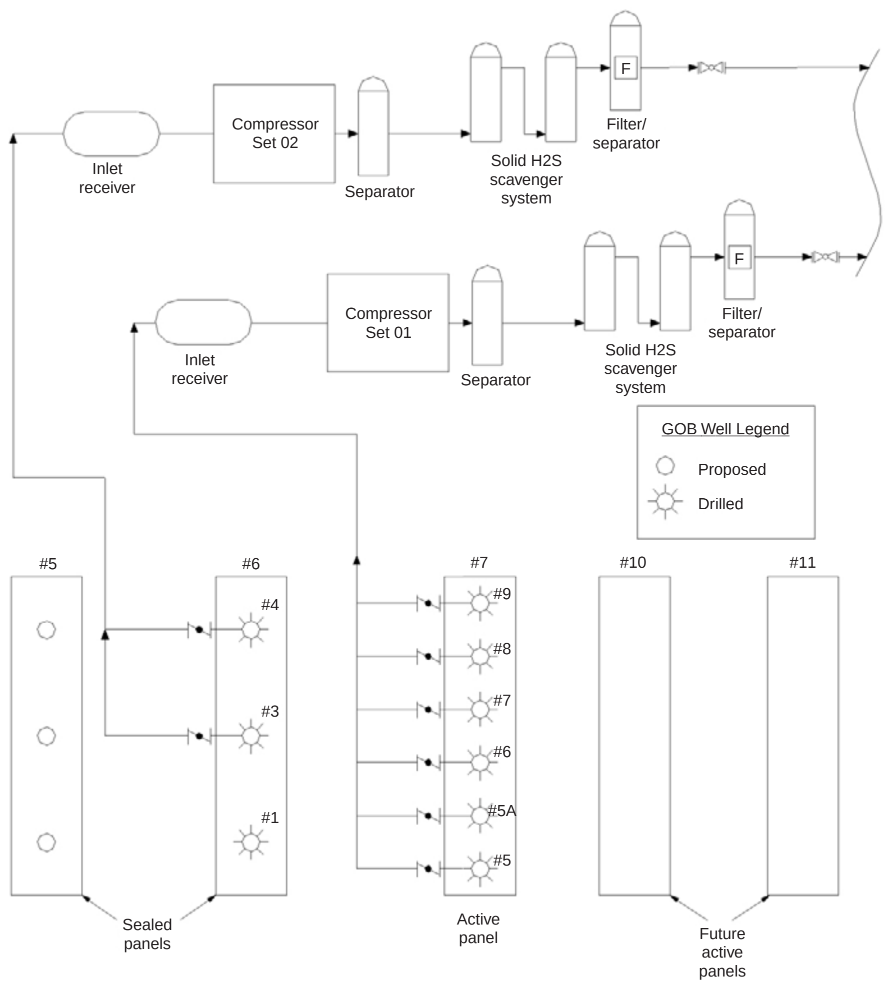

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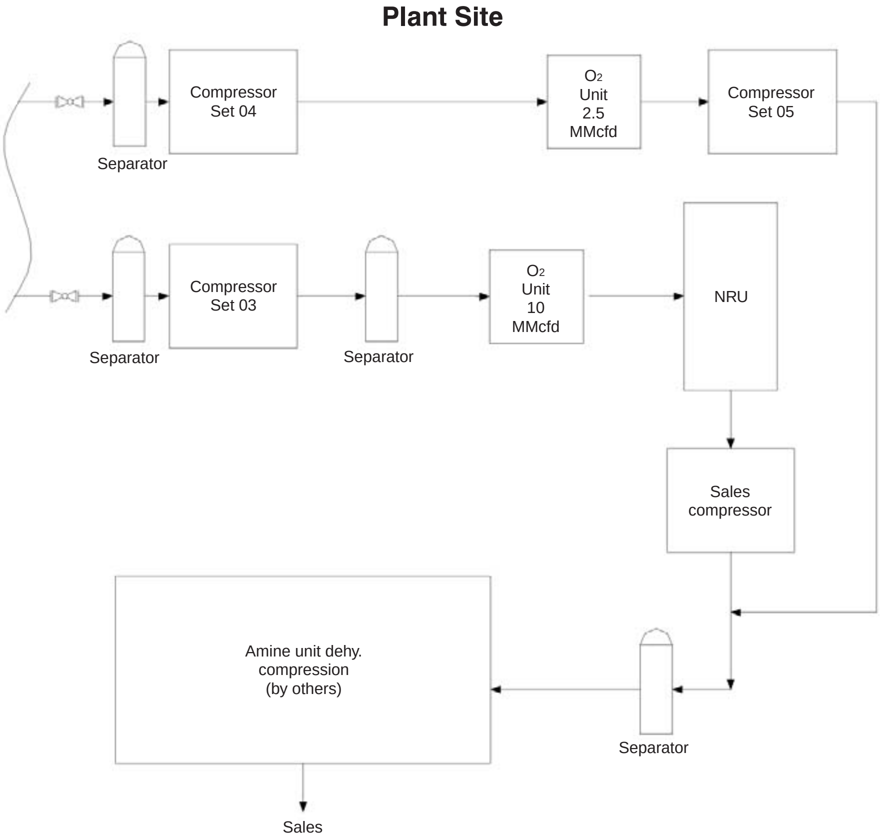
FIGURE 3



interest in capturing and selling this "gob gas," so Oso acquired the mineral leases and regulatory permits, and installed the infrastructure to capture, transport, process and sell the gas into a local interstate pipeline.

Defined, gob gas is methane diluted with various contaminants from the mine's air ventilation system. The gob gas comes from the long-wall cave areas of Tower Mine and is brought to the surface though the vertical GVHs to ensure mine safety. Oso collects the gob gas at the CVHs, compresses it, and removes a small amount of hydrogen sulfide. A catalytic combustion process-based oxygen removal system was installed to allow the gathering of the gob gas at a vacuum, enabling the maximum amount of gas to be recovered.

The gas is then transported five miles to Pioneer Natural Resources' Castle Gate Field processing plant, where the gas is commingled and carbon dioxide and water are removed, and it is then sold to Questar at its Whitmore Park interconnect 12 miles from Castle Gate.

This project makes economic and environmental sense by allowing the recovery of a valuable gas stream that would otherwise be vented into the atmosphere.

Capturing The Gas

Because of the gas content of the coals, the conventional air ventilation system (using GVHs to extract methane from the gob and ventilating air to maintain safe methane levels during mining operations) was incapable of maintaining the methane content below the required limits set by the Mining Safety & Health Administration, the mining equivalent of the U.S. Occupational Safety & Health Administration.

Each long-wall mining panel measures about 8,000 feet long, 800 feet wide and 10 feet thick. An active long-wall panel releases significant volumes of methane into the mine workings as the coal is being extracted. A "rider" coal seam above the mined seam also contributes to gas production. As the coal is removed from the long-wall face, the roof collapses and the floor heaves, fracturing the rock in the stratigraphic column some 360 feet above and 50 feet below the mined seam. The gas stored in these fractured zones is released and drawn into the mine workings. It is this gas that is targeted by the GVHs with the objective of recovering high concentrations of methane before it enters the mine's ventilation system (Figure 1).

Once the panel is mined and subsequently sealed, it continues to vent high-Btu methane, although at lesser rates than when a long wall panel is active. The average methane content of the gas vented from active panels is 75 percent, while the gas from sealed panels is 94 percent.

In 2006, Oso installed the gathering system, field compression station and five miles of two, 10-inch pipelines to the Castle Gate Field processing plant. Figures 2 and 3 are schematic drawings that depict the gathering pipelines and compression facilities, as well as the processing plant. The plant was completed in early 2007. Oxygen, hydrogen sulfide, nitrogen and carbon dioxide are removed from the gas prior to sale.

The project is selling gas into the Questar pipeline while Andalex is preparing to begin mining a new long-wall panel. Gas sales increased from an average of 130 Mcf a day in January 2007 to almost 2.0 million cubic feet a day by July 2007. Starting a nitrogen rejection unit (NRU) last July has allowed the processing of high-nitrogen content gas. The processing capacity of the NRU is 8.0 MMcf/d and sales in this range are expected during the mining of the next active longwall panel. The expected life of the mine is at least another 11 years, with gas production expected for 18 years.

Greenhouse gas emission reduction credits, also known as voluntary emission reduction credits, are an important revenue stream expected to add significant economic value to this project. Since the methane–which would otherwise be emitted into the atmosphere–is recovered and used as a clean-burning energy resource, the project qualifies as a verifiable greenhouse gas emission reduction project.

A project design document (PDD) has been prepared by Ruby Canyon Engineering for the Tower Mine methane recovery project. The document describes the baseline emissions from the mine and the resulting reductions. The PDD addresses the issues of "additionality," where it is clearly demonstrated that the project is not business-as-usual as a conventional gas production and sales project. Many of the unique aspects of the project are described in the PDD, and a monitoring plan is outlined that describes how Oso is metering and documenting the methane emission reductions generated by the project.

Oxygen Removal System

The O_2 removal system is a key element in the methane production operations. The system is based on the catalytic combustion of oxygen (Figure 4). The gas stream in the project contains a significant amount of propane and heavier (C_3^+) hydrocarbons, which lower the ignition temperature of the system's catalytic reaction compared with a pure methane stream. Lower ignition temperatures reduce the maximum design temperature required when the heat of combustion is considered constant.

The inlet gas is introduced into a particulate filter after liquid separation, where fine particulates are removed to prevent catalyst clogging. The gas goes through a heat exchanger to heat the gas to the required reaction temperature during steady-state operation. There is a coolgas bypass to allow for temperature control going to the reactor. During startup, an electric heater is used to heat the gas to the required reaction temperature. The heater also can be used continuously when there is not enough oxygen in the inlet gas to generate enough temperature rise across the reactor to maintain inlet reactor temperatures through cross-heat exchange alone.

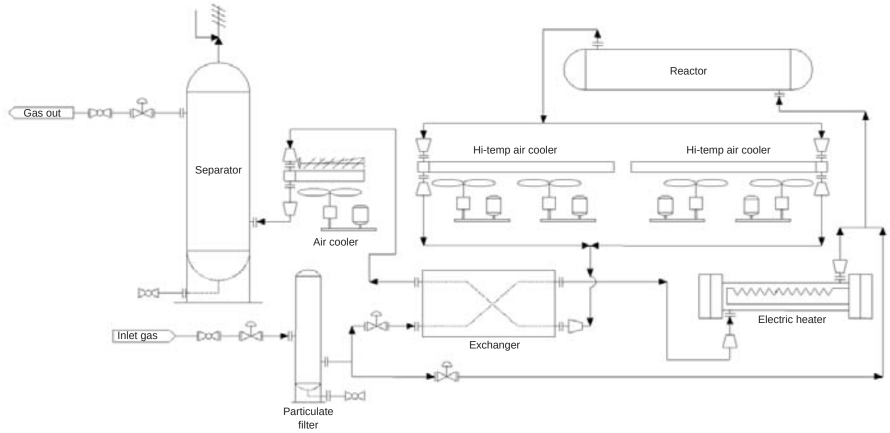
The reactor contains the catalyst and is designed to have sufficient volume of catalyst necessary to "burn" the amount of oxygen required. The gas then flows through two high-temperature, air-cooled heat exchangers equipped with dual variable frequency drive fans. They cool the gas leaving the reactor to reduce the temperature rating of the cross-heat exchanger, as well as the temperature difference in the exchanger to the desired 100 degrees Fahrenheit (the VFD drive allows this level of control).

The gas then flows through the heat exchanger, where it is cooled further and is introduced into the final air cooler. Condensed water is removed in a separator, and the gas exits the system. The combustion of the O_2 yields water and carbon dioxide, and depending on inlet oxygen levels, can make the gas water-saturated and increase the CO_2 levels significantly.

Two oxygen analyzers are used in the system. One analyzer is in the inlet portion of the plant and is used to shut the plant down if the oxygen level exceeds the plant maximum. Another analyzer is located at the outlet of the plant to verify the O_2 outlet specification of 10 parts per million. Systems used to treat low concentrations of oxygen do not require high-temperature air coolers, since the reaction does not generate as great a temperature rise.

FIGURE 4

Oxygen Removal System (10 MMcf/d Unit, 3 percent Maximum Oxygen)



System Performance

The first oxygen removal plant was leased to Oso and commissioned in November 2006. The skid-mounted plant was originally designed to remove 4.0 percent O_2 and was deployed near Stephenville, Tx. The plant was refurbished and modified to remove up to 0.75 percent oxygen from the gas. This change in maximum oxygen content reduced the amount of equipment in the plant and allowed a quick turnaround.

The reduction in the allowable oxygen content also made sense from an operations perspective, because gas with this much O_2 will contain 3.0 percent nitrogen–the pipeline limitation for total inert gas content–and since the NRU was not available, a higher oxygen capacity did not appear necessary at that time. This oxygen plant had a maximum capacity of 2.5 MMcf/d. Installing the plant allowed gas sales to start before the remainder of the plant was complete. It took only one day to install, with startup requiring less than one day.

This plant was used to treat sealed panel gas, which has less oxygen content. Initial inlet O_2 concentrations were 1.0 percent (well above the 0.75 percent design level), and volumes reached 1.950 MMcf/d.

It is worth noting that the sales gas recipient had considerable trouble accurately measuring the outlet oxygen concentration in the parts per million range. In fact, the laboratory hired for this task insisted that the plant was not removing the O_2 below 0.2 percent.

After increasing the reactor temperature several times, the outlet oxygen concentration remained constant. Because reactor efficiencies increase with increasing temperature, a constant oxygen outlet concentration was not possible and indicated faulty testing procedures. A new lab with more experience was hired, and the O_2 content was not detectable at less than one part per million. This plant remained in service until September 2007, when the full processing system was brought on line.

The oxygen removal plant that was specifically designed for the Tower Mine methane recovery system can remove up to 3.0 percent O_2 at 10.0 MMcf/d. The outlet oxygen specification was maintained at less than 10 ppm. The system was designed to be "self-sustaining" at oxygen concentrations above 1.0 percent, meaning that after startup with O_2 levels above 1.0 percent, the electric heater is not used and the plant will consume only the electricity required by the air-cooled heat exchangers (23 horsepower). This plant was delivered in January 2007 but was not started until July, when the NRU became available. This system is mounted on two 10 X 30-foot skids.

The oxygen content of the gas is determined by the phases of the mining operation, and the maximum oxygen content treated to date has been 2.0 percent at 4.50 MMcf/d. At these levels, the plant has performed well and has not failed to meet treating specifications. During operations, the inlet O_2 concentrations have varied from 0.15 to 2.0 percent. When the oxygen concentrations are lower than 1.0 percent, the electric heater automatically starts to maintain the inlet reactor temperature. If required, a larger heat exchanger could be installed to reduce the self-sustaining oxygen content.

Run Time And Costs

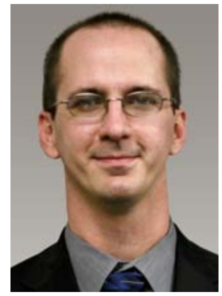
Run time for the system is in excess of 99 percent, with the only problem being the failure of an electric heater sheath over-temperature controller. The plant has been able to remain running without problems or operational changes, even when troubleshooting other equipment has caused gas flows to be stopped and started repeatedly. The plant also has operated well in the harsh environment on top of the Book Cliff Mountains at an altitude of 7,500 feet, where the ambient temperature has reached as low as -40 degrees F in the winter and above 100 degrees in the summer.

The plant uses a maximum of 23 horsepower to drive the electric air cooler motors. The catalyst is guaranteed for three years and has a replacement cost of $320,000. The maximum treating capacity over three years at 99 percent run time is 10.840 billion cubic feet. This results in a theoretical treating cost of $0.033 an Mcf (assuming $0.075 per kWh for purchased power). The catalyst is anticipated to last five to 10 years. The resulting treating cost over five years is $0.021 an Mcf.

The actual treating costs are higher on an Mcf basis because of reduced gas flow rates now being experienced (as a result of Andalex completing the mining of one long-wall panel and preparing to begin mining a new panel). However, the temporarily reduced gas flows also reduce the electricity used by the air coolers and should extend the life of the catalyst in the reactor.

Another benefit of the oxygen removal system is that the catalyst is sulfur and chlorine tolerant, which reduces the possibility of deactivation of the catalyst caused by the unlikely introduction of H_2S into the reactor. This greatly reduces the potential for expensive catalyst replacement caused by plant upsets.

With strong natural gas prices and high demand, "nonconventional" gas streams such as coal mine methane are becoming more and more economically viable. These gas streams require more than an amine plant and a TEG dehydration unit to reach the market. As Oso's experience on the Tower Mine project illustrates, oxygen removal can be achieved safely and effectively using a catalytic O_2 removal system. To be effective, however, the designer must be aware of the operation and design of the entire system to ensure that it is neither over- nor underdesigned. ❒



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