CATALYTIC OXYGEN REMOVAL FOR THE ABERDEEN COAL MINE METHANE PROJECT IN CARBON COUNTY, UTAH

Gary L. Trotter
Crucible Technologies LLC
Houston, Texas

Q. Zane Rhodes II
Newpoint Gas Services, Inc.
College Station, Texas

ABSTRACT

Oso Oil & Gas Properties LLC installed a system to gather and process coal mine methane gob gas in Carbon County, Utah near the city of Price. Coal mine gob gas is methane gas diluted with various contaminants from the mine air ventilation system. The gob gas comes from the long wall cave areas of the Aberdeen Tower Mine and is brought to the surface with vertical drill holes that have been installed by the mining company to ensure mine safety. Under an exclusive agreement with Andalex Resources, Inc., the mining company that owns the Tower Mine, and the mineral estate owners, Oso collects the gob gas at the mine's vent wells. Oso compresses the gas and removes a small amount of hydrogen sulfide then transports the remaining gas five miles to a facility where oxygen and nitrogen are removed. The oxygen removal system is based on a catalytic combustion process. This oxygen removal process allows the gathering of the gob gas at a vacuum allowing a maximum amount of gas to be recovered. The resulting gas is then transported to the Pioneer Castle Gate Field processing plant where Oso and Pioneer gas is commingled and carbon dioxide and water is removed. The combined streams are then sold to Questar at the Whitmore Park interconnect approximately twelve miles from the Castle Gate Field. This project makes economic and environmental sense by allowing the recovery of a valuable gas stream that would otherwise be vented into the atmosphere.

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COMPANY INTRODUCTIONS

Oso Oil & Gas Properties LLC

Oso Oil & Gas Properties LLC is located in Denver, Colorado and is an independent oil and gas company specializing in the generation of coalbed methane projects. Gary Trotter, the presenter of this paper, was the former Vice President Operations of Oso. The company has worked extensively in the San Juan and Uinta Basins. The Aberdeen CMM Project in Carbon County, Utah was generated by Oso after learning of the high volumes of gas being vented into the atmosphere by Andalex Resources, Inc. during the mining of the Aberdeen seam in the Tower Mine.

Newpoint Gas Services, Inc.

Newpoint Gas Services, Inc. is located in College Station, Texas and specializes in designing and manufacturing a full range of standard and custom-engineered gas processing and treating units. The company provides installation, start-up support, and training for the operation of these facilities as well as contract treating. The company minimizes costs and reduces delivery and commissioning times by pre-engineering plants in modular standard sizes. The company has delivered gas processing and treating units to almost every continent.

OVERVIEW OF THE PROJECT

In 2005, Oso Oil & Gas Properties, LLC (Oso), in cooperation with Andalex Resources Inc. (Andalex), embarked on a coal mine methane (CMM) recovery project designed to capture mine gas continuously vented to the atmosphere at the Tower Mine in Carbon County, Utah. The Tower Mine is located approximately 90 miles southeast of Salt Lake City. The gas was being vented from gas vent holes (GVH's) drilled into the coal, sandstone, and shale formations above the main Aberdeen coal seam to be mined (see Figure 1). Gas production begins when the long wall cutting machine reaches the area beneath the GVH and continues for many years after mining has finished. The drainage of this gas is an operational and economic necessity for the mine due to the danger of methane explosion. Andalex had no interest in the investment to capture, process, and sell this gas. Oso acquired the mineral leases and regulatory permits and installed the infrastructure to capture, transport, process, and sell this gas into a local interstate pipeline.

Due to the gas content of the coals, the conventional air ventilation system was incapable of maintaining the methane content below the required limits set by the Mining Safety and Health Administration (MSHA), the mining equivalent of OSHA. The GVHs extract methane from the gob and allow the ventilation air to maintain safe methane levels in the mine while mining ensues.

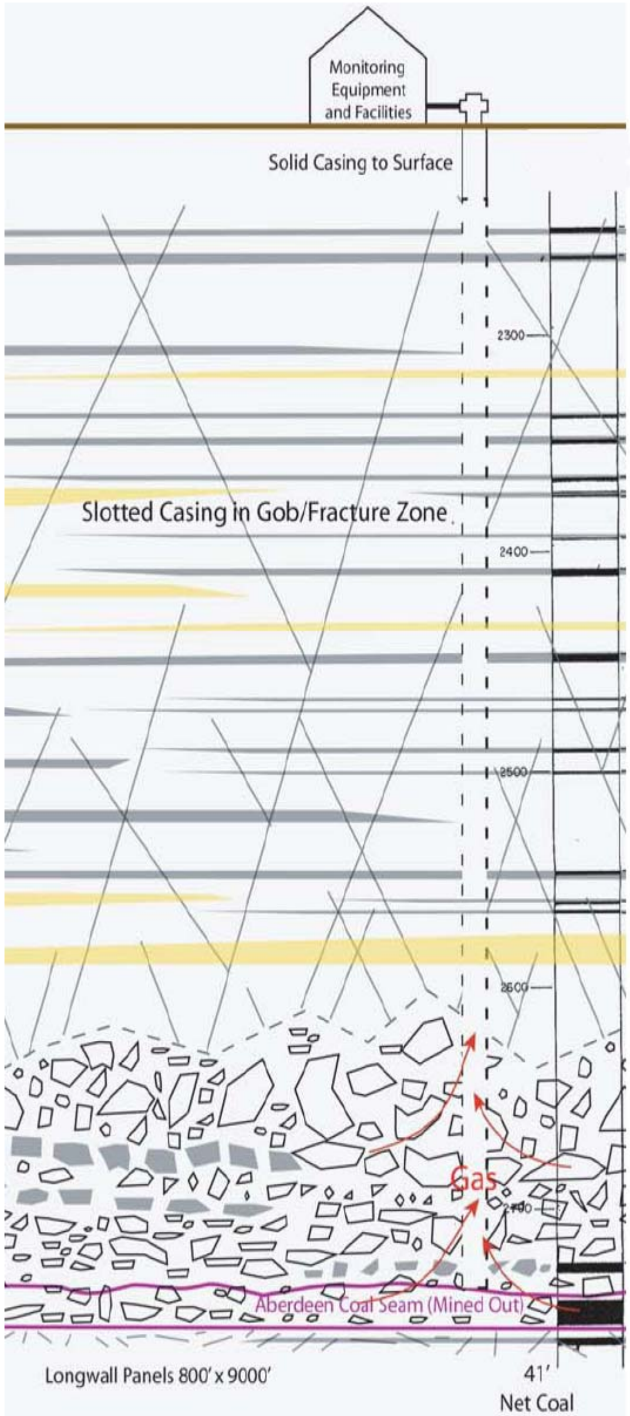

Figure 1: Cross Section of Gas Well and Mine

The coal is extracted by the long wall mining technique which achieves high resource recovery. The long wall panels are approximately 8,000 feet long, 800 feet wide and 10 feet thick. As the panel is mined, it is known as an "active panel;" once the mining is complete; it is called a "sealed panel." However, as previously stated, the long wall mining process releases significant volumes of methane into the mine workings. 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 approximately 360 feet above and 50 feet below the mined seam. The gas stored in this fractured zone 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.

Once the panel is mined and sealed, it continues to vent high Btu methane, although at lesser rates than when the long wall panel is active. The average methane content of the gas vented from active panels is 75% while the gas from sealed panels is 94%. These two gas streams are gathered, compressed, and transported approximately five miles via pipeline to a processing plant. Oxygen, hydrogen sulfide, nitrogen, and carbon dioxide are removed from the gas prior to sale. See Figures 2 and 3 for schematic drawings depicting the gathering pipelines, compression facilities, and the processing plant.

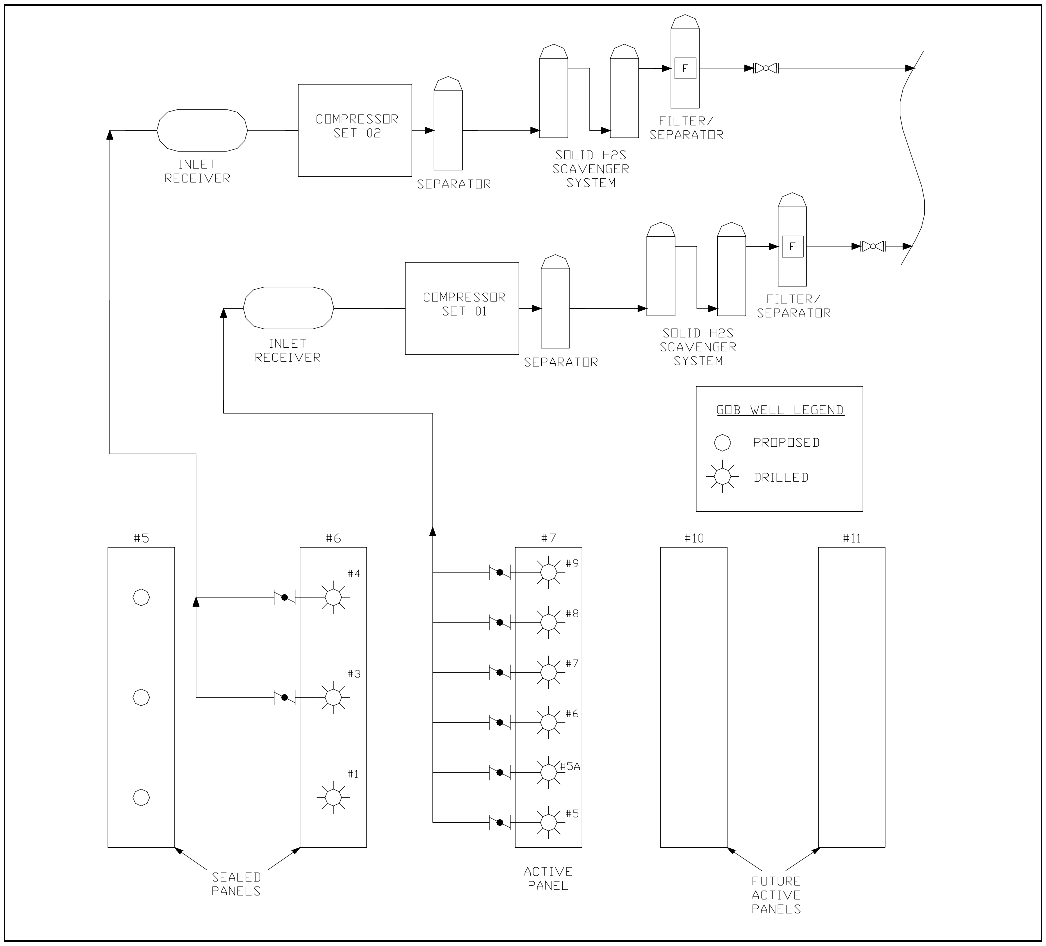

Figure 2: Wells and Compressor Station

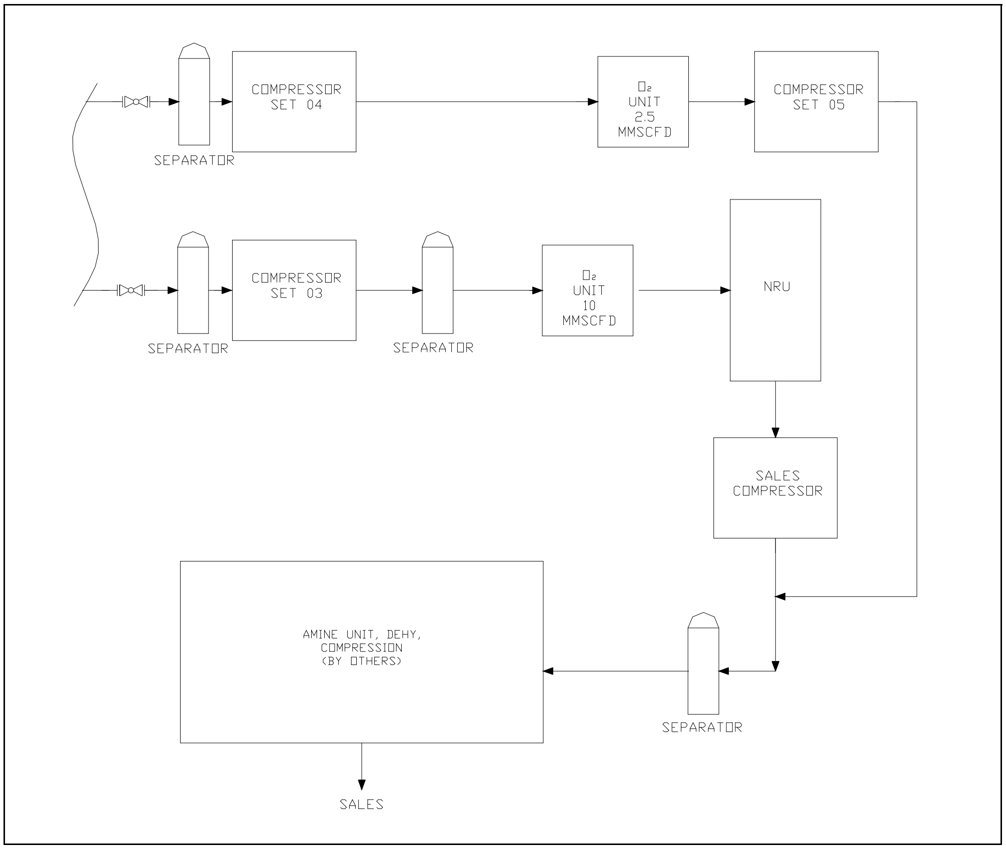

Figure 3: Plant Site

During 2006, Oso installed a gathering system, field compression station, and approximately five miles of two - ten inch pipelines to the processing plant. The plant was completed in early 2007. The project is currently selling gas to the local natural gas pipeline while Andalex is preparing to begin mining a new long wall panel.

Gas sales have increased from an average of 130 thousand standard cubic feet per day (Mscfd) in January 2007 to almost 2,000 Mscfd in 7/07. The start up of the nitrogen rejection unit (NRU) in mid-July 2007, has allowed for the processing of high nitrogen content gas. The processing capacity of the NRU is 8,000 Mscfd and sales in this range are expected during the mining of the next active long wall panel. The expected life of the mine is at least another eleven (11) years with gas production expected for eighteen (18) years.

An important revenue stream expected to add significant economic value to this project is the greenhouse gas emission reduction credits, also known as voluntary emission reduction credits (VERs). The methane, which would otherwise be emitted into the atmosphere, is recovered and used as a clean-burning energy resource. As a result, the project qualifies as a verifiable greenhouse gas emissions reduction project.

A project design document (PDD) has been prepared by Ruby Canyon Engineering for this project. The document describes the baseline emissions from the Tower Mine and the resulting emission 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 DESCRIPTION

The oxygen removal system is based on the catalytic combustion of oxygen. The gas stream in this project contains a significant amount of C_3^+ hydrocarbons. This lowers the ignition temperatures of the system when compared to a pure methane stream. Lower ignition temperatures reduce the maximum temperature required by the system when the heat of combustion is considered constant.

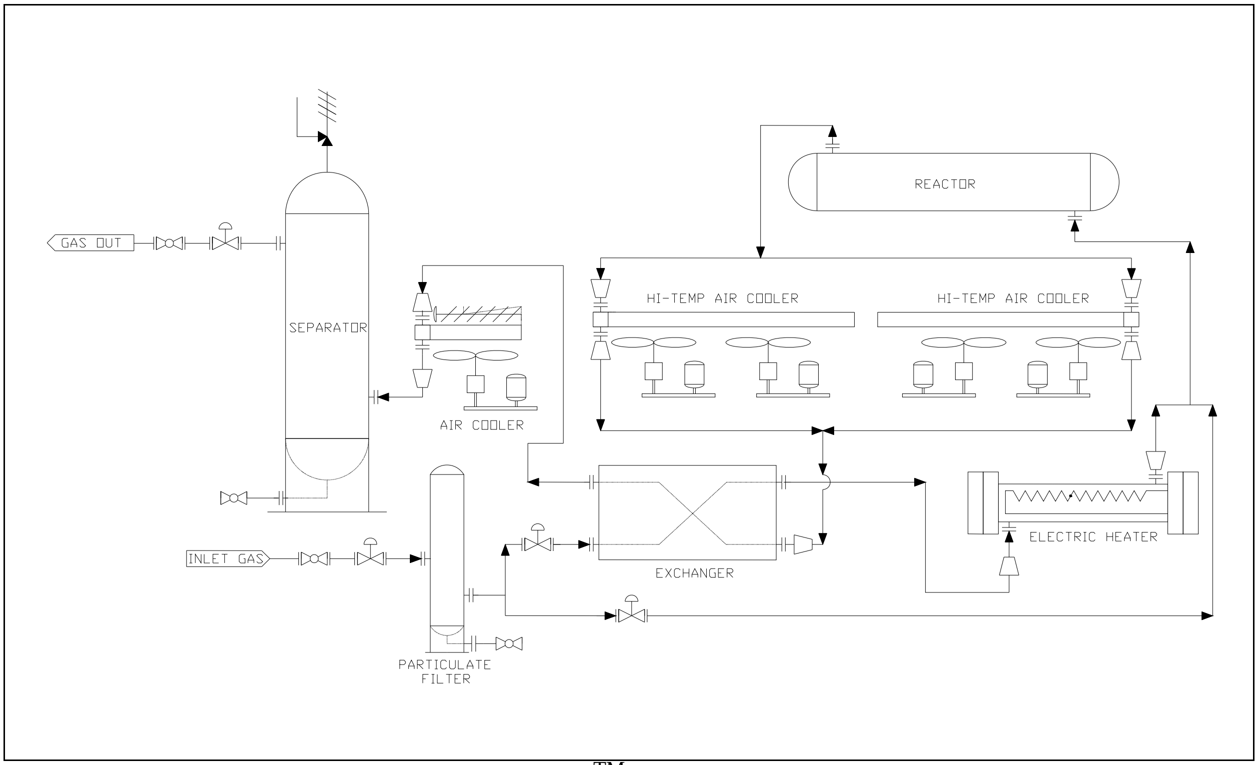

Figure 4: 10 MMscfd X-O_2™ Unit – 3% Maximum Oxygen

The inlet gas is introduced into a particulate filter after liquid separation. The removal of fine particulates prevents the clogging of the catalyst. The gas goes through a heat exchanger where the gas is heated to the required reaction temperature during steady state operation. There is a cool gas bypass to allow for the control of the temperature going to the reactor. During startup, an electric heater is used to heat the gas to the required reaction temperature. The heater can also be used continuously when there is not enough oxygen to maintain inlet reactor temperatures. 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 which have two Variable Frequency Drive (VFD) fans each. These coolers are small with dimensions of approximately 2' X 4'. They cool the gas leaving the reactor to reduce the temperature rating of the heat exchanger as well as the temperature difference in the exchanger to the desired 100 degrees F (the VFD drive allows this level of control). The gas flows through the heat exchanger where it is cooled further and is then introduced into the final air cooler. Condensed water is removed in a separator, and the gas exits the system. The combustion of the oxygen yields water and CO_2 and, depending on inlet oxygen levels, can make the gas saturated and increase the CO_2 levels significantly.

Figure 5: 2,500 Mscfd X-O_2™ Oxygen Removal Unit

Figure 6: 10,000 Mscfd,– X-O_2™ Oxygen Removal Unit

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 outlet specification of 10 parts per million (ppm). Systems used to treat low concentrations of oxygen do not require high temperature air coolers as the reactor temperatures are not required to be as high.

System Performance

The first X-O_2™ oxygen removal plant was leased to Oso and was commissioned in November 2006. This plant was originally designed to remove 4% oxygen and was originally deployed near Stephenville, Texas. The plant was refurbished and modified to remove up to 0.75% 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, as gas with this much oxygen will contain approximately 3% nitrogen. Three percent total inert gas content is the pipeline limitation, 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 2,500 Mscfd. The installation of this plant allowed gas sales to start before the remainder of the plant was complete. This plant is skid mounted and took only one day to install with startup requiring less than one day.

This plant treated the sealed panel gas which has less oxygen content. Initial inlet oxygen concentrations were approximately 1.0% (well above the 0.75% design level), and volumes reached 1,950 Mscfd. The sales gas recipient had considerable trouble accurately measuring oxygen in the ppm range. In fact, the lab hired for this task insisted that the plant was not removing the oxygen below 0.2%. After increasing the reactor temperature several times, the outlet oxygen concentration remained constant. Due to the fact that reactor efficiencies increase with increasing temperature, this was not possible and indicated faulty testing procedures. A new lab with more experience was hired, and the oxygen content was not detectable at less than 1 ppm. This plant remained in service until September 2007 when the full processing system was brought online.

The X-O_2™ oxygen removal plant that was specifically designed for this system can remove up to 3% oxygen at 10,000 Mscfd. The outlet oxygen specification was maintained at less than 10 ppm. The system was designed to be "self-sustaining" at oxygen concentrations over 1%. This means that after startup with oxygen levels above 1%, the electric heater is not used and the plant will consume only the electricity required by the air cooled heat exchangers (23 hp). This plant was delivered in January 2007 and was not started until July when the NRU became available. This system is also skid mounted on two 10' x 30' skids.

As the oxygen content of the gas is determined by the phases of the mining operation, the maximum oxygen content that has been treated is 2.0% at about 4,500 Mscfd. At these levels, the plant has performed well and has not failed to meet treating specifications. During operations, the inlet oxygen concentrations have varied from 0.15% to 2.0%. When the oxygen concentrations are lower than 1%, the electric heater automatically starts to maintain reactor temperatures. If required, a larger heat exchanger could be installed to reduce the self-sustaining oxygen content. Run time for the system is in excess of 99% with the only problem being the failure of the electric heater sheath over temperature controller (OTC). The plant has been able to remain running without problem or operational changes even when troubleshooting other equipment that caused gas flows to be stopped and started repeatedly. The plant has also operated well in the harsh environment on top of the Book Cliff mountains in the area at an altitude of 7,500'. The ambient temperature has reached as low as -40^{o}F in the winter and over 100^{o}F in the summer.

Treating Costs

The plant will use a maximum of 23 hp 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 a three year period at 99% runtime is 10,840 MMcf. This results in a theoretical treating cost of $0.033/Mcf (assuming $0.075 per kWh for purchased power). The catalyst is anticipated to last five to ten years. The resulting treating cost over five years is $0.021/Mcf. The actual treating costs are higher, on an mscf basis, due to the reduced gas flow rates currently being experienced. This reduced gas flow also reduces the electricity used by the air coolers and extends the life of the catalyst in the reactor. Another benefit of this system is that the catalyst is sulfur and chlorine tolerant. This tolerance 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 due to plant upsets.

CONCLUSION

As the price and demand for natural gas remains high, non-conventional gas streams 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. Through Oso's experience at the Tower Mine, oxygen removal can be achieved safely and effectively using a catalytic oxygen removal system. In order to be effective, the designer must be aware of the operation and design of the entire system to ensure that the system is neither over nor under-designed. The ability of Oso and Newpoint to work closely together has made the oxygen removal system a success and an integral part of the gas treating system of the Aberdeen Coal Mine Methane Project in Carbon County, Utah.