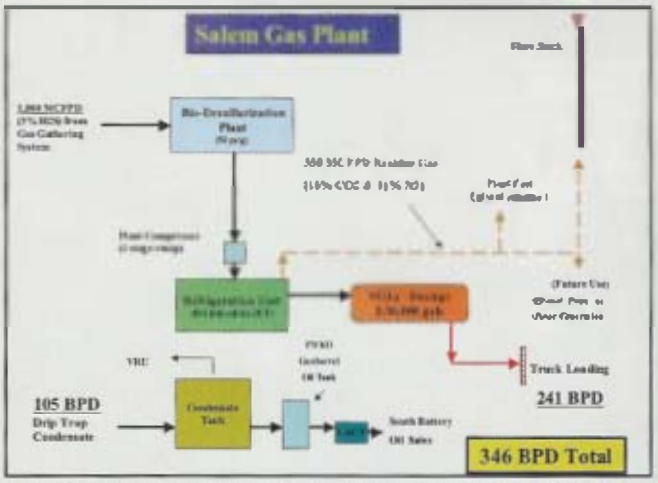
■ Salem Plant's bio-desulfurization plant uses microbes to digest and convert H_2S into elemental sulfur.



■ The Salem Plant schematic indicating the equipment and flow of gas.

THE SALEM GAS PROJECT

The Salem Plant is Only One of Five Plants in North America to Employ the Bio-Desulfurization Approach to Gas Sweetening in an Oilfield Application

By Ellen Hopkins

Citation Oil & Gas Corp., headquartered in Houston, Texas, U.S.A., selected Hy-Bon Engineering Co. in Midland, Texas, to provide the design, manufacturing and installation of the compression equipment for its Salem Unit in southern Illinois, U.S.A. The Salem Gas Project resulted in the use of three completely different types of compression — Gemini reciprocating, Leroi rotary screw and GE RoFlow rotary vane. This project involves the gathering and processing of approximately 700 Mcfd (19,821 m^3/d) of sour casinghead gas from 234 wells.

Citation acquired the Salem Unit from Texaco in 1998 and the original Salem oilfield was discovered in 1938. Over the years, a considerable amount of casinghead gas had been flared. Approximately 1200 tons (1088 tonne) per year of sulfur dioxide is eliminated from the local atmosphere by no longer having wellhead flares. The Salem Plant is only one of five plants in North America to employ the bio-desulfurization approach to gas sweetening in an oilfield application.

Eight LeROI screw compressor packages were strategically positioned throughout the field to gather the gas and to pull the casinghead pressure down to a slight vacuum. These compressors discharge the gas at 50 psig (3.44 bar) into a polyethylene pipeline gathering system. The gathered gas is sent to a new gas plant for sweetening to less than 4 ppm H_2S. Inside the plant, the sweet gas is compressed to 900 psig (34.47 bar) and refrigerated to -20°F (-28°C) to produce natural gas liquids (NGLs). The Shell Paques bio-desulfurization process as licensed by Natco is used for sweetening the gas.

"We're currently making 95 barrels per day of NGLs from our refrigeration unit plus another 27 barrels per day condensate from the pipeline drip traps, and having the field on a vacuum seems to help our daily oil production," said Clyde Finch, facilities engineer with Citation. "In addition, we have approx. 545 Mcfd (15,432 m^3/d) of residue gas for potential sale to a future ethanol plant that may be built nearby. With this project, Citation has made a significant difference in one area and one field in the U.S."

Larry Richards, president of Hy-Bon Engineering, agrees that a significant potential market exists, not only in the U.S. but on an international scope. He said the international market for casinghead gas was almost nonexistent until recently when LNG plants were installed. The gas is now produced and the liquids are captured.

"The initial focus of this Salem project was enhancing natural gas liquids from casinghead gas on 234 wells, from which approximately 700 Mcfd (19,821 m^3/d) was previously vented and that contained about 4% H_2S," said Richards. "This is just one example of so many across the U.S. and internationally where casinghead gas has been vented or flared for decades, and we see opportunities to make use of that gas. In many places, the production has been focused on oil, not gas. The gas is vented in order to relieve pressure on the well and improve the flow of oil into the wellbore.

"By using these compressors to further reduce the pressure on these wellbores, we've been able to boost oil production," Richards added. "That is a benefit that wasn't part of the original economics of this project, which only involved capturing the liquid condensate from the gas."

"The eight LeROI rotary screw compressor packages, each with a 100 hp (74.5 kW) motor, were selected because of the machine's versatility in handling sour gas applications," Finch said. "A scrubber vessel and automated liquid transfer system on the skid handle liquids. We always place a drip trap in the piping ahead of the compressor. Each drip trap measures 25 ft. (7.62 m) long by 24 in. (61 cm) in diameter. A filtration vessel is also employed ahead of the compressor to remove any other contaminants such as iron sulfide from the incoming gas down to 0.3 microns to protect compressors. Wind break shields were also installed on the north and west sides to provide each compressor site with freeze protection during the winter months.

"We spent a lot of time designing

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■ The plant compressor is a Gemini A-352, 250 hp (186 kW) electric drive/two-stage recip.

■ The mechanical refrigeration unit chills gas to -20°F (-28°C).

these compressor packages to give us the greatest operating flexibility with three ways to best match the wells' performance to our operational needs,' Finch added. "We can change the speed with sheaves and belts, we have poppet valves that increase or decrease the efficiency of the compressors, and we have a bypass control system."

In addition, Hy-Bon provided an Allis Chalmers 4CC rotary vane compressor package as a vapor recovery unit to capture vapors coming off oil storage tanks. This sour gas is routed into the gas gathering system for processing at the gas plant.

Finch said Citation installed approximately 38 mi. (61 km) of poly-pipe for the gathering system that connects the 234 wells with the field compressors and plant. A 6 in. (15.24 cm) trunkline traverses the field north and south and connects everything.

The sour gas comes into the bio-desulfurization plant with 40,000 ppm H_2S. The microbes devour the H_2S, and the sweet gas stream exits the process at about 4 ppm. Normally amine is used to sweeten gas, but Finch said the EPA air quality restrictions in Illinois limit the use of amine due to the production of excessive sulfur dioxide created in flaring the acid gas. Bio-desulfurization, on the other hand, uses a caustic soda solution, which circulates through contactor towers and pulls the H_2S from the gas stream. Microorganisms, or microbe bugs, digest the H_2S and excrete sulfur into the caustic soda solution.

"To keep the bugs happy we blow air on them and feed them nutrients," said Finch. "Our plant operators joke that they are like zoo keepers for the bugs."

Around 200 to 300 lb. (90 to 136 kg.) of elemental sulfur per day is removed from the caustic soda stream via centrifuge and is taken to a nearby landfill on a periodic basis."

Downstream of the bio-desulfurization plant compressor, a 250 hp (186.42 kW), two-stage reciprocating Gemini A-352 electric drive unit. Suction on the plant compressor is 50 psig (3.44 bar) and discharge is 500 psig (34.47 bar). Additional concrete was used to strengthen the steel skid base and to eliminate any undue vibration. Finch mentioned the plant compressor has variable frequency drive (VFD) that helps save energy. If the gas inflow fluctuates, the VFD tracks the suction pressure to maintain the correct compressor speed and operating parameters.

The 500 psig (34.47 bar) sweet gas then goes to the MRU (mechanical refrigeration unit) where it is chilled to a -20°F (-28°C) to knock out as much natural gas liquid as possible.

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■ The contactor towers for bio-plant are 65 ft. (20 m) tall.

■ The NAOH solution circulation pumps for bio-plant.

The heavier components — propane, butane, natural gasoline — are dropped out and then stabilized to a 120 psia (8.27 bar) Reid vapor pressure. The stabilized NGL flows to one of the two 30,000 gal. (113,562 L), on-site NGL storage tanks. The

to a fractionation plant for further processing. The residue gas stream from the MRU is currently being flared in anticipation of the ethanol plant coming online. The first truckload of NGL product left the plant on July 20, 2006.

It has taken 18 months to complete the project. The AFE was approved in February 2005 and followed by the Natco bio-plant contract award. It took nearly seven months for the 38 mi. (61 km) gathering system installation. All of the Natco equipment was delivered by January 2006 and the gas plant construction was finished in June 2006.

"Building this plant added three plant operator jobs and used a lot of local construction contractors," Finch said.

Salem, Illinois, was considered among several other Midwest sites for the new ethanol plant location. near an oilfield with a good gas source, however, gives the Salem site an advantage said Finch. Ethanol plants naturally produce CO_2.

"Rather than venting the CO_2, it might be feasible at some time in the future to CO_2-flood the nearby oilfield for more oil recovery. If this happens, then a completely closed-loop system in terms of emissions would occur," Finch said. ■

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■ The Salem Plant pump tank and two bioreactors.