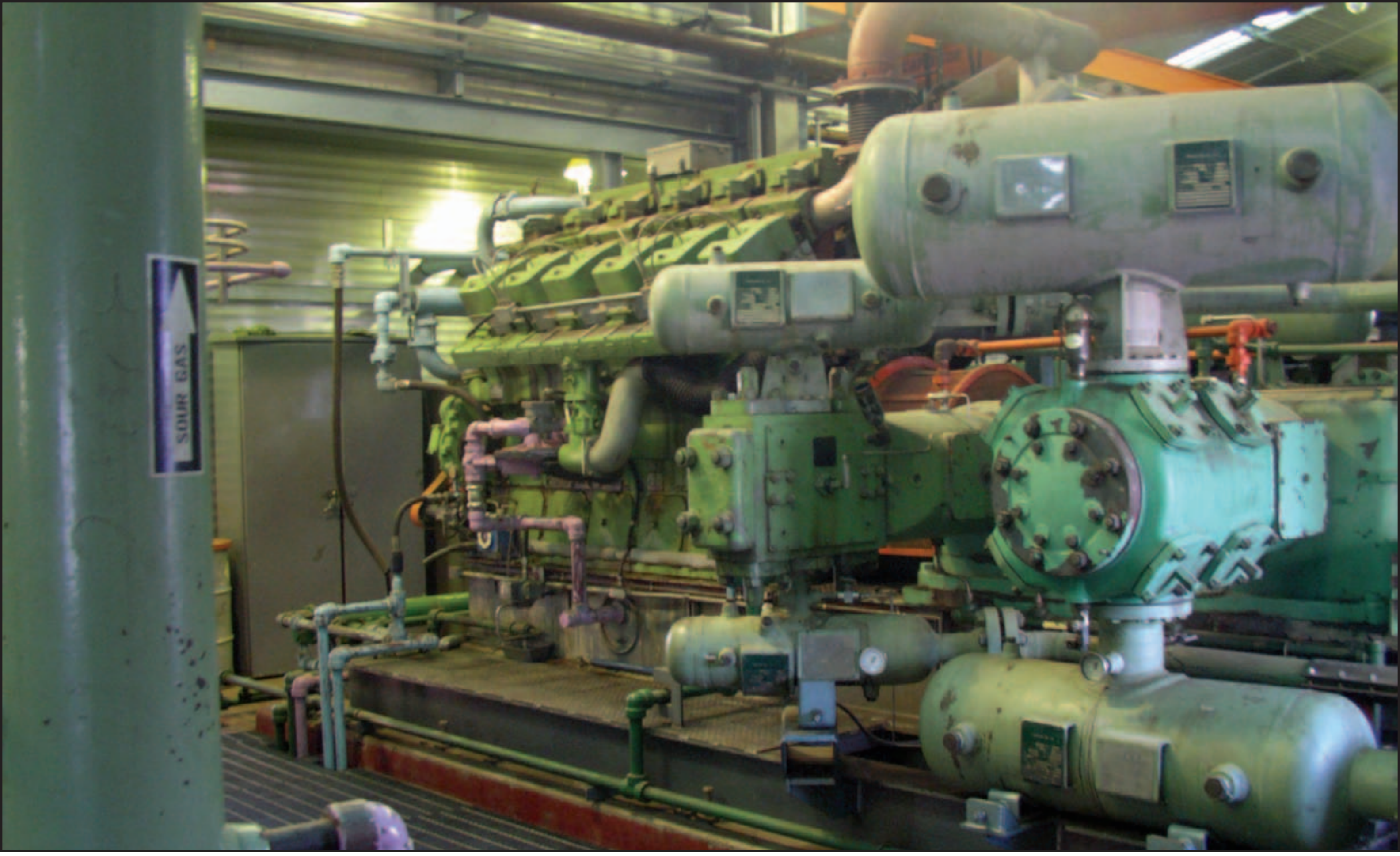


■ Unit C308 includes a Clark CFB compressor and a 604 hp (450 kW) Waukesha L5108 GU engine. This gas processing facility has been designed to use large compressors with low-pressure capabilities, and as such, the first stage of compression requires very large 24 in. (609.6 mm) cylinders.

REUTILIZATION OF COMPRESSION ASSETS AT THE CLIVE PROCESSING PLANT

Concise Design Helps Fairborne Energy Trust Reutilize Gas Compression Facility

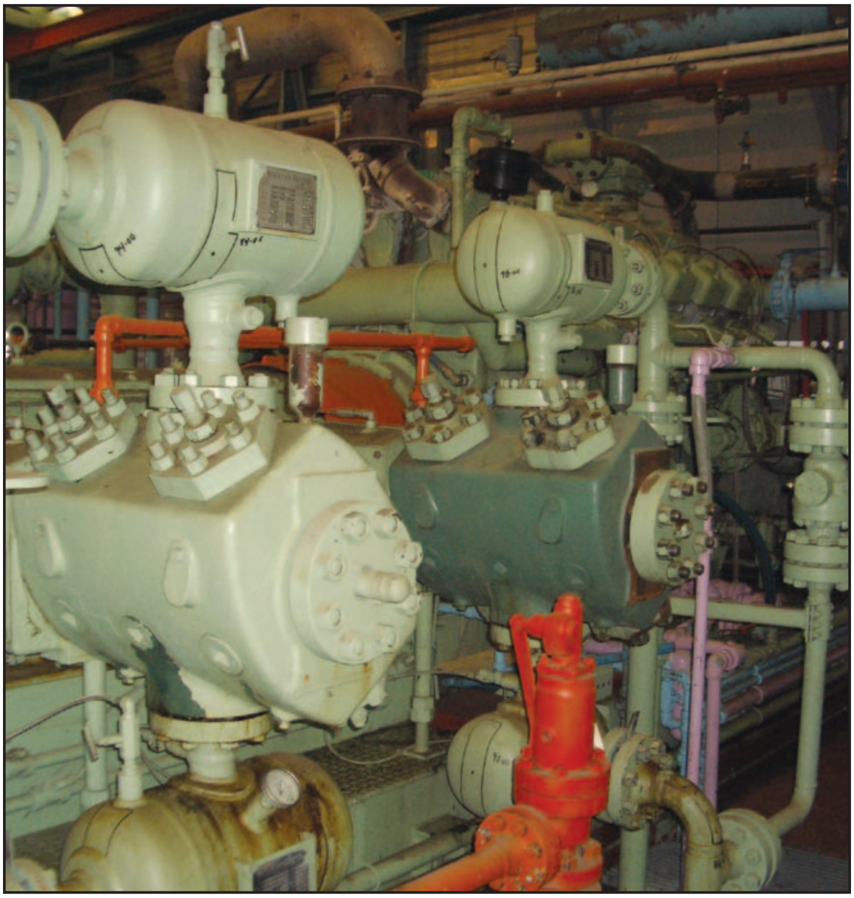
By Neil Purslow

The concept of reutilizing existing compression assets to process unconventional gas is slowly gaining momentum in Canada. When Fairborne Energy Trust called Concise Design and asked for help to determine if Fairborne could reutilize part of an existing gas compression facility to process coalbed methane (CBM) in Clive, Alberta, Concise responded with "can do," said Rod Phipps, managing partner for Concise. "There are a large number of gas compressors sitting idle or underutilized in southern Alberta because of production declines. Redeploying these assets to process unconventional gas not only makes good economic business sense, but also gets the gas to market quickly," he added.

Concise Design is a medium-sized engineering company located in Calgary, Alberta. It specializes in multidisciplinary engineering for the hydrocarbon processing industry, including all types of projects from wellhead to sales point. As an EPCM company with about 120 employees, Concise provides extensive experience in oil and gas, and pipeline projects with proven expertise in fast-tracked solutions. Although successfully completing many international projects, the company's primary focus is the Western Canadian Sedimentary Basin. Concise has expertise in compression, gas processing, pipelines, oil treating and enhanced oil recovery, electrical and instrumentation, and control systems and SCADA.

The Clive area is located in central Alberta, approximately 30 mi. (50 km) northeast of Red Deer. Fairborne's interests in this area consist of two units — the Clive Leduc and Clive Nisku Units — and production from a number of uphole gas zones. Fairborne operates both units, as well as an oil processing and gas compression facility that handles up to 16,500 bbl/d of crude oil and 25 MMscfd (7.1 x 10^5 m^3/d) of natural gas.

The gas processing facility was constructed in 1962 using two reciprocating compressors and a desiccant dehydration system to process sour solution gas from the units. The compression facility has since been modified a number of times, but has remained a sour solution gas facility.



■ **This Ingersoll Rand RDH compressor is driven by a Waukesha L7042 GU natural gas-fueled engine. The compressor is a four-throw, four-cylinder unit that uses four stages of compression to achieve a delivery pressure of 900 psig (62 bar) for sweet gas or 1100 psig (76 bar) for sour gas.**

The plant now has a total of seven reciprocating compressors. Sweet gas produced from the uphole gas zones is commingled with the sour solution gas, and the combined stream is delivered to the Duke Nevis Gas Plant for further processing and natural gas liquids recovery.

In mid-2003, Fairborne identified the potential for further natural gas production in the Clive area by using multiple coalbeds within the Horseshoe Canyon formation. With a plan to drill over 200 CBM wells with an anticipated average production rate of 140 Mscfd (4.0 x 10^3 m^3/d) per well, sizeable compression facilities would be required. At that time, the Clive gas compression facility was only using two of the seven compressors to process sour solution gas, and production from the units was not anticipated to increase significantly. By using the other five compressors, a significant amount of capacity was available to process CBM.

The gas compression facilities were constructed using the California model of the '40s, '50s and '60s. Six of the compressors were mounted on skinny skids, lined up in a row and grouted onto large concrete blocks inside a single building. The seventh was semi-modular and located outside the main building, but tied directly in with the other six compressors. Separate common manifolds were used for compressor suction and for each stage of the four-stage compression process. Gas discharged from each stage was first equalized in the manifold, and then delivered to the appropriate section in the horizontal cooler. After cooling, the gas was returned for the next stage of compression. All the auxiliary equipment, including coolers, filters, scrubbers and dehydrators, were off skid and located long distances from the compressors.

Concise worked closely with Fairborne to define the project and to develop three phases of implementation. The first phase involved swinging some of the existing sweet gas away from the sour solution gas stream utilizing the stand-alone modular compressor. By doing so, an im-

Unit Number	Driver	Compressor Frame	Throws	Cylinders	Stages	Maximum RPM	Maximum Horsepower (kW)
C301	Waukesha L7042 GU	Ingersoll Rand RDH	4	4	4	1000	896 (668)
C302	Waukesha L7042 GU	Ingersoll Rand RDH	4	4	4	1000	896 (668)
C303	Waukesha L7042 GSIU	Cooper Bessmer AMA	4	4	4	1000	1232 (919)
C304	Waukesha L7042 GSIU	Ingersoll RDH Rand	4	4	4	1000	1232 (919)
C305	Waukesha L7042 GSIU	Ingersoll Rand RDH	6	4	4	1000	1232 (919)
C306	Electric Motor	Joy WBF	3	3	3	900	650* (485)
C308	Waukesha L5108 GU	Clark CFB	4	4	4	1000	601 (448)

* Electric motor on unit C306 upgraded to 900 hp (671 kW) to match speed of compressor frame.

■ The Clive area is located in central Alberta, Canada, approximately 30 mi. (50 km) northeast of Red Deer. Fairborne Energy Trust operates this oil processing and gas compression facility, which handles up to 16,500 bbl/d (2625 m^3/d) of crude oil and 25 MMscfd (7.1 x 10^5 m^3/d) of natural gas. This photo was taken before modifications to the plant commenced.

mediate cash savings could be realized by Fairborne due to reduced processing fees as a result of the sweet gas no longer being processed as sour gas. The second phase involved decoupling the sweet gas entirely from the sour gas stream. This would enable the sweet gas to continue to be processed and delivered to market during periods when the sour stream was shut down. The third and final phase involved bringing CBM production on stream and processing it for sale.

The existing facility was extensively analyzed by Concise and a design was developed to create two different processes within the one plant — the first would continue to process sour solution gas and the second would handle sweet gas and CBM. Since the existing facility was already designed for sour solution gas, that equipment and processes would be left "as is" and would continue to process the sour stream.

To create each stand-alone process, the compressors were evaluated and assigned to either the sweet or the sour process. Coupled with a review of present and future well production, it was decided that two of the seven compressors would be dedicated to the sour process, while the remaining units would switch to processing sweet gas. The goal of the project was to make the existing processes work, without modifying or restaging the compressors.

Selecting the compressors for sour processing was easy for the first one, but more difficult for the second. On one compressor, the suction inlet and discharge outlet were mounted away from the suction and discharge of the scrubbers, making it only suitable for sour service. It then made sense to pick an adjacent compressor, but which one? A large table was compiled containing the various attributes of each compressor. From that information, a second sour gas compressor was selected.

"Modeling these compressors to work together was a big challenge," stated Frank Zahner, compression consultant from Accurata Inc. "Normally when you model more than one compressor in parallel where each stage shares a common manifold, the same compressor frame, numbers of throws and cylinders, and cylinder sizes are used. But in this instance, the plant has undergone a number of changes over the years and the compressors and set-ups were different. We also observed that a number of vibration and pulsation issues had occurred in the past, but appeared to be resolved. These issues were likely caused by adding the different compressors to the plant at the various times."

To correct the problems of the past and to avoid vibration and pulsation issues with the proposed changes, the services of AP Dynamics of Calgary were engaged to assist in the modeling of the compressors and equipment. Paul Alves of AP Dynamics stated that when groups of compressors are run in parallel, many complexities arise. AP Dynamics has a model that encompasses all of the suction systems of a gas plant up to the cylinders in each compressor. Simulations are then run against the model to identify areas where pressure pulsations occur. Each compressor is run in turn in the model with the results added together. This creates the worst possible scenario for the forces generated by the compressors.

This process is then applied to the interstages of the compressors in much the same way. Incorporated into the analysis is the unique process used by each stage, which includes discharging gas from the cylinders; flowing gas through pulsation bottles, coolers and scrubbers; and entering gas into the inlet suction of the next stage. Cylinder passages are carefully modeled, with pulsation from machine performance determined and evaluated for a range of operating conditions. The results are then analyzed with corrective action identified, such as lengthening a pipe section to reduce vibration in a unit.

Since the compressors were older-styled machines, clearance adjustments were generally fixed capacity and fixed volume. These were eliminated because additional clearances were not required. As well, variable volume pockets did not exist because of the age of the units. "All the compressors were well maintained," said Zahner, "and because of that, we were able to make the required adjustments without changing a single piece of equipment. These units probably have at least another 15 years of life."

The group manifolds were modified

■ This compressor plant is operated manually. Each compressor has its own control system to monitor its operation, including speed control and safety shutdown. The control systems are independent and mainly pneumatic.

■ **The gas compression facilities were constructed using the California model of the '40s, '50s and '60s. One feature of that design is the location of the auxiliary equipment, such as the coolers, filters, scrubbers and dehydrators, which are far away from the compressors.**

so that the gas could be segregated and processed on the appropriate side of the plant. For example, the two sour compressors are now fed in parallel by one common inlet manifold and the five sweet units are fed in parallel by a second manifold. Similar changes were completed on the manifolds for the interstages.

New process equipment, including scrubbers, coolers and glycol dehydration system, were provided for the sweet side. Piping was pre-fabricated and then installed on-site because modular pipe racks were not feasible. Suction scrubbers were built as a modular unit including building, then transported to site and installed.

"In conjunction with delivering each phase, our goal was to minimize processing disruptions," said Phipps. "We had a window where the Nevis Gas Plant was to be shut down for a planned turnaround, which meant that the Clive plant would be down for the same period. Through careful planning, we were able to coordinate all required process and piping changes to the sour side during the downtime period at the plant without disrupting the processing of diverted first phase sweet gas."

The compressor drivers were also reviewed. Unit C306 was upgraded with a 900 hp (671 kW) electric motor, replacing the previous 650 hp (485 kW) motor. This change was made to obtain a better match in horsepower between the motor and compressor frame. The switchgear was also changed to match the new motor. AP Dynamics completed the torsional analysis for the equipment.

Utilities cooling for the six Waukesha engines remained the same, with the cooler sections on the sour side of the plant continuing to be used.

In the past, fuel for the Waukesha engines was obtained from two sources. In summer, sweet gas from the uphole gas zones was used. But in winter, this gas could not be used because the water content was too high and the line would freeze. When that occurred, fuel gas was purchased from a nearby pipeline. As part of the project, fuel gas would now be sourced from the sweet gas stream after dehydration, thereby making it useable year-round and eliminating the need to buy fuel.

This change allowed the fuel gas line to the plant to be converted to a sales gas line for sweet gas deliveries. Two local cooperatives currently draw natural gas from the line to meet their needs. Therefore, if the line was to change, the gas needs of the co-ops would still have to be met. To ensure that end, the individual gas streams entering the Clive plant were analyzed to ensure that required BTU ratings could be maintained. The result was that some of the sweet gas inlet streams had to be redirected to the sour process, since they were too rich to be used as fuel gas for domestic use.

The sales gas line conversion was designed so that it could be converted back to a fuel gas line, if necessary. This provides the option of continuing to operate the sour side of the plant, even if the sweet side is interrupted.

All compressors at the plant are operated manually. Each compressor has its own unique control system to monitor a unit's operation, and comes with its own speed control and safety shutdown. Some minor changes were performed to the existing PLCs to obtain more I/Os, but the control systems continue to be independent and largely pneumatic.

"We used an innovative design to provide maximum flexibility," said Phipps. "The plant has been designed so that if demand for sour compression increases, some or all of the five sweet compressors can be redeployed as sour. And by not changing the sour processes, all of the auxiliary equipment is capable of handling the increased volume. In addition, one of the sour compressors can be switched to sweet gas.

"Because of the complexity of the project and the age of the equipment in the plant, it puts our ingenuity to the test. Engineering solutions for these old-style compressors and facilities is a challenge, but fun too." ■

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