MTR

Field Demonstration of a Membrane Process to Recover Heavy Hydrocarbons and to Remove Water from Natural Gas

2002 Annual Report

Contract Number DE-FC26-99FT40723
Report Period: January 1, 2002 to December 31, 2002

by

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February 14, 2003

prepared for

the U.S. Department of Energy
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1. INTRODUCTION

The objective of this project is to design, construct and field demonstrate a membrane system to recover natural gas liquids (NGL) and remove water from raw natural gas. An extended field test to demonstrate system performance under real-world conditions would convince industry users of the efficiency and reliability of the process. The system has been designed and fabricated by Membrane Technology and Research, Inc. (MTR) and will be installed and operated at British Petroleum (BP)-Amoco's Pascagoula, MS plant. The Gas Research Institute will partially support the field demonstration and BP-Amoco will help install the unit and provide onsite operators and utilities. The gas processed by the membrane system will meet pipeline specifications for dewpoint and Btu value and can be delivered without further treatment to the pipeline. Based on data from prior membrane module tests, the process is likely to be significantly less expensive than glycol dehydration followed by propane refrigeration, the principal competitive technology. At the end of this demonstration project the process will be ready for commercialization. The route to commercialization will be developed during this project and may involve collaboration with other companies already servicing the natural gas processing industry.

2. PROGRESS IN CALENDAR YEAR 2002

Originally, this project was expected to be completed in 2002. However, extensive, protracted negotiations with BP Amoco's personnel on the specifications of a compressor acceptable for placement in their plant, and subsequently working with the compressor manufacturer to ensure that all required codes were in full compliance with these specifications, delayed the project significantly. However, we do now see an end of those negotiations in sight, and expect the field demonstration to start in the second quarter of 2003. MTR requested a no-cost extension to the project during 2002 to account for these unforeseen delays.

The work accomplished during the period January 1 to December 31, 2002 is summarized by task below.

Task 4.0 Develop Field Test Plan

Based on the total available budget at the time of shipment of the system to the site, we will determine the extent and duration of the testing that can be performed. At this point, we anticipate a 4 to 6 month testing period. Table 1 gives a broad outline of the activities planned for the time during which the system will be operated at the BP-Amoco Pascagoula facility. Our prior experience in performing such field demonstrations has shown that variation of key parameters over a wide range is not normally possible due to the potential for disruption in operations in the host facility. Therefore, the estimates of the variation of pressure and flow rates are based on our initial assessments and will have to be confirmed with on-site personnel.

Table 1. Test Plan for NGL Field Demonstration.

Month	Testing Protocol	MTR Personnel Involvement	Site Personnel Involvement
1	Start up/solve teething issues in the unit. Initial testing at plant-available conditions	Yes (1 week) Daily data collection and analysis of all key streams	Throughout test period. Daily data collection including pressure, temperature and flow rate; weekly data collection for gas composition of key streams
2	Parametric testing: Variation in pressure and flow rate	Yes (1 week) Pressure variation: 500-1,000 psia Flow rate variation: 1-3 MMscfd	
3		No	
4	Continuous operation at plant-available conditions	Yes (1 week)Daily Data Collection and analysis of all key streams	
5		No	
6	Parametric testing: Variation in pressure and flow rate	Yes (1 week) Pressure variation: 500-1,000 psia Flow rate variation: 1-3 MMscfd	

Task 5.1 Prepare Membranes and Modules

All required membrane modules have been fabricated. The MTR internal part number and quality assurance data on these modules are shown in Table 2. All modules have passed the MTR QA/QC requirements and are ready for installation into the system. We intend to start up the system with four of these cartridges. The remaining four will held over for future use if required.

Table 2. Membrane Cartridges and QA/QC Data (Product ID VMI-08-2585-F3P4-21035-160).

Cartridge Serial No.	Nominal Area (m^2)	Nominal Flux (GPU)*	Measured N_2 Flux (GPU)*	Measured O_2 Flux (GPU)*	O_2/N_2 Selectivity (-)
2052	16	35	32.4	73.0	2.25
2053	16	35	34.5	76.1	2.21
2054	16	35	35.5	81.7	2.30
2055	16	35	37.8	78.5	2.08
2056	16	35	37.4	81.7	2.18
2057	16	35	46.2	93.0	2.01
2058	16	35	33.6	69.9	2.08
2059	16	35	30.0	63.0	2.10

* 1 GPU = 10^{-6} $cm^3(STP)/cm^2 \cdot s \cdot cmHg$

Task 5.2 Design and Construct Field Demonstration System

The required modifications to the MTR NGL system have been made by a local fabrication shop.

The original membrane skid was designed as a single-stage system. In this design, the feed gas entered the membrane skid and first passed through a filter separator in which the condensate (if any) in the feed gas was removed. The gas from the separator would then enter two parallel pressure vessels each containing up to four membrane cartridges. The permeate gases were routed out of the skid after measuring the flow rate, and the non-permeate gas was also routed out of the system through a pressure control valve.

The modified system will incorporate a permeate-side compressor and a second membrane stage (for optional operation). In this design, the permeated gases will enter the permeate compressor for recompression from about 100 psia to the feed pressure. The compressed gas will be air-cooled and will then enter a gas-gas heat exchanger in which it will be further cooled against the cold residue gas stream exiting the membrane skid. Any condensate will be collected in another filter separator, and the gas stream from this second filter will be recirculated to the inlet side of the membrane skid. The following major changes have been incorporated in the skid:

- Permeate compressor and associated controls
- Permeate pressure control relief system
- Gas-gas heat exchanger for cooling the compressed permeate stream
- Two-stage filter separator coalescer on the second stage
- Single-pressure vessel as a second membrane stage

- Modified skid inlet valve to allow flow control
- Heat tracing and insulation on all cold streams exiting the membrane skid

The membrane system will be shipped to the field site in March, 2003. The compressor will be shipped directly from the manufacturer's fabrication facility to the site.

Task 5.3 Install Systems at Site/Initial Evaluation

To prepare for installation of the system at the plant, MTR and BP-Amoco hired a local contractor to make the required drawings for the concrete padding, etc. These have been completed, and the padding has been installed at the site.

Upon arrival of both the compressor and the membrane skid at the site, the requisite tie-ins to the plant will be performed. This activity is expected to take 1 to 2 weeks from the delivery of the system.

Task 5.4 Operate System Continuously

This activity is expected to begin in April/May 2003.

Task 5.5 Survey Industry Users/Analyze Economics

As described in our previous report, we have identified the following three applications relevant to this project to be focus areas for commercialization of the technology:

- Fuel Gas Conditioning (Gas Engines and Turbines)
- NGL Recovery from Rich Associated Gas Streams (up to 15 MMscfd)
- Gas Processing for Dew-Point Control (up to 20 MMscfd)

We have continued to pursue the development of these applications and have acquired significant insights into both the technical and the marketing areas. A brief analysis is shown in Table 3.

Table 3. Selected List of Companies Contacted by MTR to Introduce MTR Natural Gas Products Related to This Project.

Company	Location	Application
ABB Statoil	Mongstad, Norway	Fuel Gas Conditioning
Talisman Energy	Canada	Fuel Gas Conditioning
ChevronTexaco	Angola	NGL Recovery
Bechtel do Brasil	Brazil	Fuel Gas Conditioning
Schlumberger	Colombia	Fuel Gas Conditioning
Woodgroup/Equipo	Colombia	Dewpoint Control
Caterpillar, India	Assam, India	Fuel Gas Conditioning
Texas Systems, Houston	Venezuela	NGL Recovery
Denbury Resources	Gulf of Mexico	NGL Recovery
Devon Resources	Canada	Fuel Gas Conditioning
Gas Services, Dubai	Pakistan	Fuel Gas Conditioning
Duke Energy	USA	Fuel Gas Conditioning
BDR Eng, Canada	Canada	NGL Recovery
Eneria	France	Dewpoint Control
Socal Gas	USA	NGL Recovery
Gas Services, Singapore	Malaysia	Fuel Gas Conditioning
Statoil	Hammerfest, Norway	Fuel Gas Conditioning
Jamike Engineering	Australia	NGL Recovery
Peterson Power	Java Indonesia	Fuel Gas Conditioning
Peterson Power	Kuwait	Dewpoint Control
Peterson Power	Colombia	NGL Recovery
JW Operating	USA	Fuel Gas Conditioning
ONGC India	India	NGL Recovery
Wartsila, FInland	North Sea	Fuel Gas Conditioning
Shell E & P	USA	Fuel Gas Conditioning
Shell Thailand	Thailand	NGL Recovery
SPS	Kazashtan	NGL Recovery
Tata Power	India	Fuel Gas Conditioning
TPC Dubai	Dubai	Fuel Gas Conditioning
Tundra Projects	Alaska, USA	Fuel Gas Conditioning
BDR Eng	Umbach, Canada	Fuel Gas Conditioning
Worley/Adnoc	UAE	NGL Recovery
Chevron, Thailand	Thailand	Fuel Gas Conditioning
W.R. Riggs	Venezuela	Fuel Gas Conditioning

Task 5.6 Develop Commercialization Plan

In developing the commercialization plan for the technology, we identified several key issues that must be tackled to ensure success in bringing the technology into general use in the natural gas industry. These include, but may not be limited to:

1. Access to markets and consistent collection of valid qualified leads and prospects related to the focus applications.

2. Ability to provide a technically adequate solution for the problem.

3. Ability to inspire confidence in the customer and an adequate comfort level with the new technology.

4. Ability to correctly price the systems to meet the customer expectation and expected competition.

5. Ability to deliver systems in the shortest possible time from placement of orders.

6. Ability to predict and control costs to ensure profitability.

During 2001 and 2002, MTR explored the possibility of cooperating with a large multinational company as a potential partner for developing and growing the natural gas related products at MTR, particularly marketing and sales. In September, 2002 MTR signed a marketing agreement with ABB Lummus Global, the U.S. Division of the ABB group of companies, headquartered in Switzerland. ABB Lummus Global and its Randall Gas Technologies Group, located in Houston, TX, have been leaders in supplying technology and equipment for large projects related to natural gas processing worldwide. With the signing of this cooperative agreement, MTR will have access to their marketing channels and also to their process and engineering staffs. We anticipate that this will increase the total number of qualified leads, and that the co-marketing of the products will make customers more comfortable because the entity selling the product is a large, multinational company.

MTR and ABB personnel have been working together closely to facilitate the transfer of technology under the agreement and have built up very good rapport. Commercialization of the products related to this project is a first priority for the alliance. Several key steps have already been taken:

1. Development of a complete standard membrane skid package, including all necessary engineering work. The development of this standard platform will facilitate quicker delivery times and help in defining and controlling costs to ensure consistent profit margins.

2. Incorporation of MTR's membrane module into the software used by ABB in developing process designs. This will allow several process engineers from ABB to start handling incoming inquiries, thereby increasing the number of proposals and bids.

3. Training ABB engineering, process, and sales groups in the relevant features and benefits of the MTR technology.

Several other marketing activities related to this project are also planned for 2003, including:

1. Discussions and meetings with key manufacturers of gas engines and turbines in order to explore the possibilities of cooperation and co-marketing of MTR membrane fuel gas conditioning systems. These include Caterpillar, Waukesha, GE, Siemens, and Solar Turbines.

2. Meetings with several key equipment packagers that install and operate equipment using the gas engines and turbines from the manufacturers listed in Table 3.

3. Direct customer contact within several large gas and pipeline companies to introduce the products and to determine possible multiple unit installations in their facilities.

4. Organization of seminars or user group meetings at several key locations worldwide in order to further propagate the use of the membrane technology in gas processing.

5. Building two or more membrane skids for use as test units and/or lease units for quick deployment in the field.

6. Conference presentations to introduce the technology and the relationship to the gas industry in general. MTR's technology will be featured in the ABB hospitality suite at the March Gas Processor's Association Meeting in San Antonio, TX.

During 2002, we have submitted between 50 and 60 design and price quotations and evaluations to various companies in the natural gas industry. During 2002 we also secured our first order for a fuel gas conditioning unit (FGCU) for installation in the North Sea. The FGCU was sold to Wartsila, a large Finnish supplier of gas engines in Europe, for installation on an FPSO (Floating Platform) operated by PGS for Statoil. In total, during the course of this project, MTR has sold four systems for a total of U.S. $1,500,000.

MTR's marketing efforts are being focused on the best utilization of our website www.mtrinc.com. The chart below shows the number of "hits" resulting from key website pages.

MTR is currently restructuring the website to make it a better marketing tool for its technologies. This will involve further separation and differentiation of the various industry group products sold by MTR. The natural gas group of products will be then linked to the ABB Lummus Global website for close integration with their marketing efforts in this area. We envision that this will increase the exposure of MTR's products worldwide and increase the number of inquiries flowing in through the website.

The following additional methods of marketing MTR's technologies and increasing the lead pipelines are also being actively considered:

1. Selective ad placement in several oil and gas publications.

2. News releases for all systems installed and operational in cooperation with ABB Lummus Global.

3. Conference presentations in several local chapters of the GPA and other gas societies.

4. Submission of papers in the 2004 GPA and Laurance Reid conferences.

5. Focused user group meetings in various locations worldwide to promote membrane technology in strategic areas, including the Middle East, the Far East and South America.

Task 6.0 Final Report/Conference Presentation

In 2003 we intend to complete the Pascagoula Test; this will provide new data for presentation at several gas conferences in the U.S. and abroad.

We continue to accumulate data on applications and economics, which will be included used in the Final Report.