



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

Annual Report

Contract Number DE-FC26-99FT40723
Report Period: January 1, 2000 to December 31, 2000

by

Membrane Technology and Research, Inc.
1360 Willow Road
Menlo Park, CA 94025

January 11, 2001

prepared for

the U.S. Department of Energy
Morgantown Energy Technology Center
Morgantown, WV

Contributors to this Report:

R. Baker
T. Hofmann
J. Kaschemekat
K.A. Lokhandwala
Membrane Group
Module Group
Systems Group

1. INTRODUCTION

The objective of this project is to design, construct and field demonstrate a 3-MMscfd 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 is required to convince industry users of the efficiency and reliability of the process. The system will be designed and fabricated by Membrane Technology and Research, Inc. (MTR) and then 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 2000

This two-year project started on September 30, 1999. The work accomplished during the period January 1 to December 31, 2000 is summarized by task below.

Task 4.0 Develop Field Test Plan

The BP-Amoco gas processing plant in Pascagoula, MS was finalized as the location for the field demonstration. We submitted detailed drawings of the MTR membrane skid (already constructed) to the plant in February 2000. An additional meeting was held at the MW Kellogg Engineering Company's Houston offices in January to mobilize the various participants in this project. The meeting was attended by about 20 people and was organized by GRI and MW Kellogg as part of their ongoing programs. Attendees included Chevron, BP-Amoco, Texaco, Statoil, Shell Production USA, MTR, GRI, and MW Kellogg. MTR made a detailed presentation on the demonstration project goals, needs and potential results. Following this presentation, GRI requested commitments from all interested participants to provide the required funding to conduct the test at the Pascagoula facility. Chevron, Texaco, BP-Amoco and Statoil gave favorable responses but Shell requested time for management approval. After this meeting MTR received a go-ahead to order the compressor for the demonstration system. The BP-Amoco representatives instructed MTR to coordinate the determination of compressor specifications with their Houston-based compressor specialist.

However, the test start-up date has been delayed considerably due to the problems associated with the very onerous compressor specifications imposed by BP-Amoco and the resulting delays in finalizing these specifications and selecting a compressor supplier. A detailed test plan will be prepared in the first quarter of 2001; the test is expected to commence in the summer of 2001.

Task 5.1 Prepare Membranes and Modules

The order for module manufacture was placed with MTR's manufacturing group, and all required hardware for the 12 modules has been fabricated. However, module production was put on hold during the final half of 2000, due to the delays in ordering the compressor. The compressor issues are now resolved, and module production will commence in January 2001. All modules will be ready by March 2001.

Task 5.2 Design and Construct Field Demonstration System

Detailed instructions on the required modification of the existing membrane system were given to MTR's systems group in February 2000. These include

- Change piping to move module housing inlet close to coalescer
- Remove feed flow control needle valves
- Upgrade flow monitoring instrumentation
- Modify level gauges on two-phase separator to allow control of liquids discharge
- Fix auto drain on coalescer into skid
- Tie in heat tracing to allow single connection from site
- Incorporate particulate filter on skid

Several activities listed in the previous report have been completed. These include

- Prepare new P&ID
- Confirm size of coalescer for new duty
- Confirm size of two-phase separator for new duty
- Purchase new compressor

As described under Task 4.0, a significant portion of this past year was dedicated to determining the specifications and negotiating the purchase of the permeate compressor. The following companies provided bids for the compressor:

1. Allen-Stuart/Gardner Denver, Houston, TX
2. EDTI, Corona, CA
3. VR Systems, Corpus Christi, TX
4. Enerflex, Houston, TX
5. Hanover Company, Houston, TX
6. Dresser Rand, Houston, TX

At the start of the project MTR had allocated approximately US \$150,000 for the compressor. Initial quotations from the suppliers listed above were between \$160,000 and \$186,000 for prepackaged units. However, after reviewing these bids in April 2000, BP-Amoco rejected all compressor suppliers except Dresser Rand, because this was the only supplier they have dealt

with in the past. Dresser Rand provided a quote in the range \$185,000 - 190,000 for a prepackaged system.

BP-Amoco's compressor specialist Mr. Jim McCraw required several significant modifications to the standard system to meet BP-Amoco's codes. Negotiations between MTR and Dresser Rand took 4 to 5 months, as new quotes were prepared and submitted for approval. During this time, Dresser Rand was purchased by Hanover Compression. BP-Amoco strongly indicated that they do not trust Hanover. Therefore, selection of a new compressor supplier was now required, thereby wasting several months of work. Enerflex, which was MTR's first choice, was finally selected as the supplier, and the specifications were submitted to them for a requote. It took three additional months for BP-Amoco to define all the specifications and to provide MTR with a finalized list of all the requirements for the Enerflex compressor. The modifications to the prepackaged unit were so extensive that Enerflex had to quote on a custom compressor. This increased the overall price significantly; the final quote was \$275,000 - 285,000. BP-Amoco has instructed us that a detailed Hazop will now be done on the compressor; this will occur in January 2001. Enerflex was requested to supply the detailed drawings of the compressor required for this Hazop in November, 2000. Provided no significant additions are requested by BP-Amoco after the Hazop, a finalized order for the compressor will be placed in January, 2001. The expected delivery schedule for the compressor is 12-14 weeks.

Task 5.3 Install System at Site/Initial Evaluation

No activity during this reporting period.

Task 5.4 Operate System Continuously

No activity during this reporting period.

Task 5.5 Survey Industry Users/Analyze Economics

The contacts made with potential industry users regarding the MTR VaporSep process were described in the last Annual report. This activity continued during this year at a rapid pace. Table 1 lists the companies that were contacted to gain information on the market and applications of our technology.

Table 1. Selected List of Companies Contacted by MTR to Introduce MTR Natural Gas Products Related to This Project.

Company Name	Type of Application	Current Contact Level
Chevron-Nigeria	Dewpoint Control/Associated Gas Offshore	+++++
Dresser-Rand	Fuel gas Conditioning	+++++
Fluor Daniel, Inc.	Dewpoint Control	+
Husky Oil	NGL Recovery/Fuel gas Conditioning	+
Renaissance Energy LTD	Fuel gas Conditioning	+
Technip	Gas Processing - Various	+++
Agip Oil	Dewpoint Control	+++
Anadarko Petroleum Corp	Fuel Gas Conditioning	+++
Arco/Parsons	Fuel Gas Conditioning	+
BHP Petroleum	NGL Vapor Recovery	+
BP West Africa	Dewpoint Control	+
Brunei Shell Petroleum Co.	Fuel gas Conditioning	+++
Calahoo Petroleum	NGL Recovery	+
Fluor Daniel	Dewpoint Control	+
Marathon Upstream	Dewpoint Control	+++++
Mobil Technology Co.	Gas Processing - various	+++++
Statoil	Gas Processing - Various	+++++
The Process Group	Gas processing	+
ABB Lummus Global - Randall	Gas Processing - various	+++++
Arco	Gas Processing - Various	+
Berry Petroleum/Case Engineering	Fuel gas conditioning	+++++
Chevron	Fuel Gas Conditioning	+++++
Compression Leasing	Fuel Gas Conditioning	+++++
Exxon	Fuel Gas Conditioning	+++++
Murugappa Group	Fuel Gas Conditioning	+++++
Occidental - El Shargi	Associated gas Processing	+
Patriot Energy, LLC	Fuel Gas Conditioning	+++++
PEMEX	Fuel Gas Conditioning	+++++
Shell Deepwater	Dewpoint Control	+++
SOCAL Gas Company	Fuel Gas Conditioning	+++++

+ Low Level of Interaction; +++ Moderate Level of Interaction; +++++ High Level of Interaction

Based on these contacts we believe that several good potential applications for MTR membrane technology exist in the gas patch. In general we conclude that applications such as fuel gas conditioning and wellhead gas processing are the most suitable. Therefore, we have invested more effort in evaluating these applications to gain greater understanding of the potential market sizes and sales figures. A brief analysis of these is shown in Table 2.

Table 2. Market Analysis: System Sales and Total Market Size Projections

Application	Currently Installed Units	Projected Annual Installations	% Suitable for Membrane Systems	Approximate Price/system (US \$)	Potential Market Size for New Installation Systems
Wellhead Natural Gas Conditioning	12,700	800	20	300,000	48,000,000
Fuel Gas Conditioning - Gas Turbines	3,700	250	50	400,000	50,000,000
Fuel Gas Conditioning Gas Engines	3,100	330	20	150,000	9,900,000

Data for this analysis were taken from various sources, including publications such as CompressorTech and Gas and Diesel Turbines, and also from company reports of compressor suppliers. The total market size is substantial, of the order of about \$100 million annually. A conservative market capture rate of 20-30% of this total would be a significant business opportunity for MTR.

Task 5.6 Develop Commercialization Plan

Technology commercialization efforts are ongoing, and future plans have been formulated. As described under Task 5.5, we have continued to accumulate valuable information on potential applications of MTR’s membrane process in the natural gas processing industry. During the past year we have submitted between 120 and 150 design and price quotations and evaluations to various companies in the natural gas industry, and we have received equipment orders or rental requests from Statoil, Norway and Marathon Oil, TX. We are expecting purchase orders from Dynegy/Pertamina (two fuel gas conditioning systems in Indonesia) and Exxon-Mobil (one fuel gas conditioning system) for Offshore Gulf of Mexico in January 2001.

We have focused on marketing MTR’s technology through our website at www.mtrinc.com. We have seen regular increases in traffic to the website since the natural gas products were listed there and an increase in the number of application submissions. Over the last 6 months we have received between 16 and 20 new application submissions related to natural gas through this medium. Based on the website statistics, the most viewed pages are those related to fuel gas conditioning and NGL recovery. We will continue to update the site with the latest developments in this area to further promote the technology being developed in this project.

Future marketing efforts will focus on the following areas

- Selective ad placement in other sites frequented by natural gas professionals
- New product release announcements in at least two or three natural-gas-related publications

- Publication of at least two new articles in Oil and Gas Journal and other natural gas focus magazines
- Participation in one or two trade shows related predominantly to natural gas topics
- Development and dispatch of targeted direct mail pieces to natural gas professionals
- Publication of an online newsletter featuring membrane technology and its use in the natural gas industry

Task 6.0 Final Report/Conference Presentation

During the past year we made the following presentations at important Natural Gas Conferences

- GPA North Texas Regional Meeting, Dallas, TX, February, 2000
- Gas Processors Association (GPA) National Conference, San Antonio, TX, March 2000
- European GPA, Barcelona, Spain, September 2000.

At the GPA National Conference, we received one of the three best-overall-presentation awards. A plaque will be presented to Dr. Lokhandwala at the March 2001 GPA conference.

Future plans include presentations at natural gas utilization meetings such as Powergen and at gas-turbine-related conferences to promote the fuel gas conditioning products.