Fujifilm Apura™ 2.0C Case Study

West Texas Natural Gas Treatment Site Uses Apura™ 2.0C to Increase NGL Production without Yearly Replacements

Challenge:	Yearly incumbent membrane module replacement frequency very high due to natural membrane CO2 permeance degradation
Solution:	Installation of Apura™ 2.0C modules
Results:	Stable flux and higher CO2/Hydrocarbon selectivity - no module replacement over the past three years and higher hydrocarbon recovery /increased Natural Gas Liquids (NGL) production

Non-Performance of Original 1st Stage Membrane Modules:

A plant operator in West Texas has a 2-stage (sequential) spiral-wound membrane system installed in 2008:

The pre-treatment includes a TEG dehydration unit, followed by a chilling unit, and a gas super-heater.

The first stage -a 42-tube/294-module (max) membrane skid- is designed to treat ~30 MMSCFD of gas from ~80% CO_2 to ~25-28% CO_2. Cellulose acetate (CA), spiral wound membrane modules were originally installed. The high CO_2 content permeate gas from the 1st Stage membrane skid is compressed and re-injected back into the formation for Enhanced Oil Recovery (EOR) while the residue or treated gas is sent to a 2nd Stage (sequential) membrane skid.

The second stage -a 42-tube/294-module (max) membrane skid - is designed to reduce the CO_2 level in the 1st Stage residue gas to below 10%. Originally, first generation Apura™ 1.5S membrane modules were installed in the 2nd Stage membrane skid. The permeate gas from the 2nd Stage membrane skid is (1) compressed and reinjected back in to the formation or (2) sometimes recycled back to the plant inlet slug catcher.

The 2nd Stage membrane residue gas travels to a deep refrigeration unit where NGL is recovered. Gas from the NGL recovery unit is further treated and used as fuel gas to an onsite turbine used for power generation.

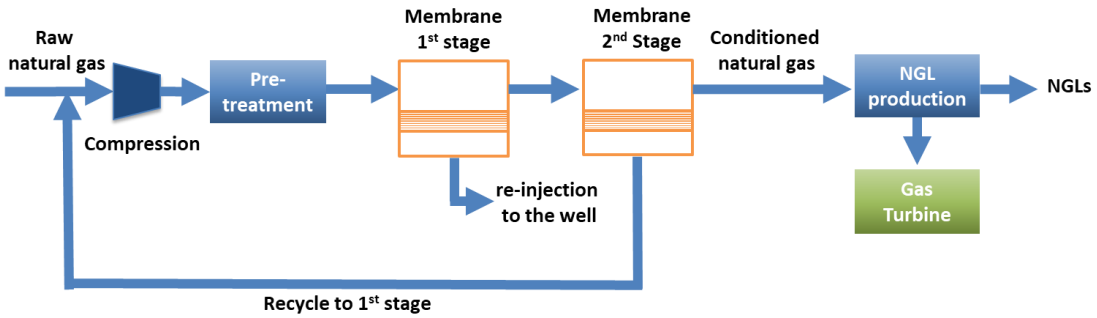

Figure 1: Flow Diagram for High CO_2 EOR Natural Gas Treatment

Within a few months of start-up of the 1st Stage membrane skid, the operator observed gradual flux decline of the originally installed CA membrane modules. This gradual permeance decline over time presented as increasing residue CO_2 concentrations with constant feed gas conditions.

Once 1st Stage residue CO_2 concentrations increased to 35-40%, unstable, problematic operation of the downstream refrigeration unit was observed and new CA membrane modules were added, eventually completely loading the 42-tube membrane skid with (294) CA membrane modules.

As the CA membrane flux continued to naturally decline, and in order to keep the 1st Stage membrane skid residue gas CO_2 concentration below 38-40%, the operator was forced to implement a regular CA membrane replacement program, resulting in approximately more than (80) CA membrane modules replaced each year at a cost higher than 0.5 MM USD each year for several years.

Replace Existing CA Membrane Modules with Apura™ 2.0C Membrane Modules:

Apura™ gas membrane technology was originally commercialised for natural gas sweetening applications in 2014 by Fujifilm. The Apura™ flat sheet membrane is a composite membrane comprising of multiple layers, to include a relatively inert substrate support layer. The composite Apura™ platform, specifically the use of an inert substrate and highly selective top dense active layers, yields a very stable, robust membrane designed to provide very stable CO_2 permeance (CO_2 removal capacity) and superior CO_2/hydrocarbon selectivity over time.

Fujifilm launched Apura™ 2.0C in 2018 to enhance the CO_2 permeance of the original Apura™ 1.5S while maintaining the high CO_2/Hydrocarbon selectivity of the Apura™ 1.5S.

Fujifilm qualified Apura™ 2.0C in both membrane stages with successful single tube testing over a one year period. During the Apura™ 2.0C testing, Fujifilm personnel collected regular performance data (composition data) and regularly presented this performance data to the operator. The performance data not only showed that Apura™ 2.0C modules exhibited a high, and very stable CO_2 permeance; but that a very high CO_2/Hydrocarbon (especially C_3+ hydrocarbon) selectivity was also observed.

After acknowledging the stable CO_2 permeance and superior CO_2/Hydrocarbon selectivity of Apura™ 2.0C as compared to the existing CA membrane modules, the operator decided to fully replace the existing CA membrane modules with Apura™ 2.0C membrane modules. Note the operator decided to replace all of the CA membrane modules even though the operator still had unused CA membrane modules in stock given the additional hydrocarbon/NGLs that could be recovered by immediately installing Apura™ 2.0C modules. Note, more than three years later, these unused CA membrane modules remain in stock, not to be used again by this operator.

Increased NGL Production With No Membrane Replacement Over Three Years:

Given the high and very stable CO_2 permeance (CO_2 removal capacity) of Apura™ 2.0C membrane modules, only less than half of the 1st Stage membrane skid maximum capacity of Apura™ 2.0C modules are required to process the full 30+ MMSCFD of 80% CO_2 feed gas to a residue CO_2 concentration of <28%. Further, the 1st Stage permeate CO_2 concentration with the original CA membrane modules was approximately 90%; however, the 1st Stage permeate CO_2 concentration with the Apura™ 2.0C modules is higher than 95% - indicating much less hydrocarbon in the Apura™ 2.0C permeate stream and greater hydrocarbon recovery in the 1st Stage residue gas stream.

In addition to having substantially increased CO_2 removal capacity from the existing 42-tube membrane skids if needed, since replacing all of the CA membrane modules with Apura™ 2.0C modules (3) years ago, the operator has (1) not observed any membrane performance decline, (2) not replaced any Apura™ 2.0C membrane modules, and (3) has observed increased NGL production by more than 100 Bbl/Day. The payback on the investment to purchase Apura™ 2.0C membrane modules via CA membrane replacement cost savings and additional NGL revenues was less than (12) months.

Figure 2: Membrane Installation at the Customer Site in West Texas