

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 CO <sub>2</sub> permeance degradation
Solution:	Installation of Apura™ 2.0C modules
Results:	Stable flux and higher CO <sub>2</sub> /Hydrocarbon selectivity - no module replacement over the past three years and higher hydrocarbon recovery /increased Natural Gas Liquids (NGL) production

Non-Performance of Original 1<sup>st</sup> 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<sub>2</sub> to ~25-28% CO<sub>2</sub>. Cellulose acetate (CA), spiral wound membrane modules were originally installed. The high CO<sub>2</sub> content permeate gas from the 1<sup>st</sup> 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 2<sup>nd</sup> Stage (sequential) membrane skid.

The second stage -a 42-tube/294-module (max) membrane skid - is designed to reduce the CO<sub>2</sub> level

in the 1<sup>st</sup> Stage residue gas to below 10%. Originally, first generation Apura™ 1.5S membrane modules were installed in the 2<sup>nd</sup> Stage membrane skid. The permeate gas from the 2<sup>nd</sup> Stage membrane skid is (1) compressed and reinjected back into the formation or (2) sometimes recycled back to the plant inlet slug catcher.

The 2<sup>nd</sup> 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.

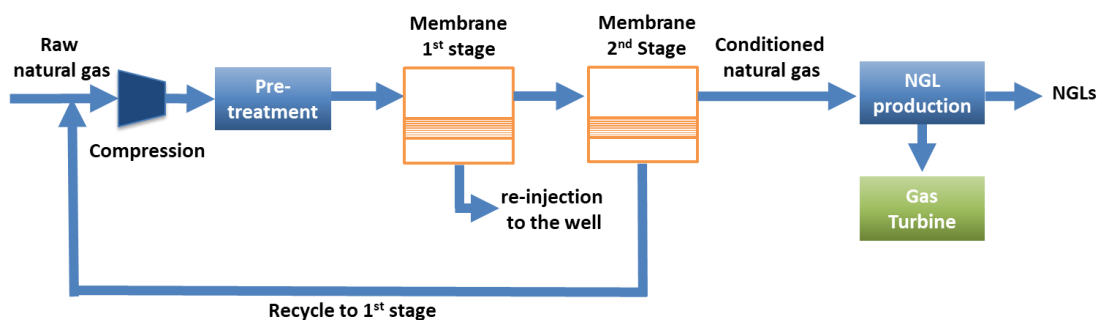


Figure 1: Flow Diagram for High CO<sub>2</sub> EOR Natural Gas Treatment

Within a few months of start-up of the 1<sup>st</sup> 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<sub>2</sub> concentrations with constant feed gas conditions.

Once 1<sup>st</sup> Stage residue CO<sub>2</sub> 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 1<sup>st</sup> Stage membrane skid residue gas CO<sub>2</sub> 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<sub>2</sub> permeance (CO<sub>2</sub> removal capacity) and superior CO<sub>2</sub>/hydrocarbon selectivity over time.

Fujifilm launched Apura™ 2.0C in 2018 to enhance the CO<sub>2</sub> permeance of the original Apura™ 1.5S while maintaining the high CO<sub>2</sub>/Hydrocarbon selectivity of the Apura™ 1.5S.

Fujifilm qualified Apura™ 2.0C in both membrane stages with successful single tube testing over an 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<sub>2</sub> permeance; but that a very high CO<sub>2</sub>/Hydrocarbon (especially C<sub>3</sub>+ hydrocarbon) selectivity was also observed.

After acknowledging the stable CO<sub>2</sub> permeance and superior CO<sub>2</sub>/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<sub>2</sub> permeance (CO<sub>2</sub> removal capacity) of Apura™ 2.0C membrane modules, only less than half of the 1<sup>st</sup> Stage membrane skid maximum capacity of Apura™ 2.0C modules are required to process the full 30+ MMSCFD of 80% CO<sub>2</sub> feed gas to a residue CO<sub>2</sub> concentration of <28%. Further, the 1<sup>st</sup> Stage permeate stream with the original CA membrane contained approximately 60% more hydrocarbons compared with the Apura™ 2.0C, indicating greater hydrocarbon recovery in the 1<sup>st</sup> Stage residue gas stream.

In addition to having substantially increased CO<sub>2</sub> 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