NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Membrane Separation of CO_2 and Hydrocarbons

Reference Flow: 1 kg of carbon dioxide ready for reinjection

Brief Description: Separation of CO_2 and hydrocarbons using membrane technology

Section I: Meta Data

Geographical Coverage: United States **Region:** United States

Year Data Best Represents: 2012

Process Type: Basic Process (BP)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: No

Completeness: All Relevant Flows Captured

Flows Aggregated in Data Set:

☑ Process ☐ Energy Use ☐ Energy P&D ☐ Material P&D

Relevant Output Flows Included in Data Set:

Releases to Air:	☐ Greenhouse Gases	☐ Criteria Air	☐ Other
Releases to Water:	☐ Inorganic	☐ Organic Emissions	☐ Other
Water Usage:	☐ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

None

Tracked Input Flows:

Feed gas	*Feed stream that is received from a pretreatment system with compression*

Tracked Output Flows:

Carbon dioxide ready for reinjection	*Reference flow*
Product hydrocarbon stream	*Mixed hydrocarbon stream that is sent to an acid gas removal unit*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_Membrane_Separation_2012.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process provides a summary of relevant input and output flows associated with the operation of a membrane separation unit at an EOR (Enhanced Oil Recovery) gas separation plant. The input is a feed stream containing CO_2 (carbon dioxide) and hydrocarbons. The outputs are separate CO_2 and hydrocarbon streams. The compression of the feed stream occurs in an upstream unit process. The reference flow of this unit process is: 1 kg of carbon dioxide stream ready for reinjection.

Boundary and Description

This unit process provides a summary of relevant input and output flows associated with the operation of a membrane separation unit at an EOR (Enhanced Oil Recovery) gas separation plant. The input is a feed stream containing CO_2 (carbon dioxide) and hydrocarbons. The outputs are separate CO_2 and hydrocarbon streams. The compression of the feed stream occurs in an upstream unit process, so it is not accounted for in this unit process.

The composition of the feed gas stream is based on data from a refrigeration process analysis to be consistent with other separation unit processes(Vargas, 2010). The components include carbon dioxide, hydrogen, methane and higher hydrocarbons, and hydrogen sulfide. The composition of the feed gas stream was converted from molar flow rates to mass flow rates using the mole weights of each component. The feed gas stream has a CO_2 composition of 93 percent (by mass). The inlet and reinjection streams were normalized based on the EOR gas composition of an average well in the Permian Basin (NETL, 2010). The three salable streams were also scaled so that they are representative of the change in the inlet composition.

Membrane separation technology separates two types of gases based on differences between their diffusion rates through a polymer membrane. The selectivity of a membrane is a comparison of the permeability rates of two components. The composition of the output streams from this unit process is based on a selectivity of 15, which means that CO_2 passes through the membrane 15 times faster than methane. This selectivity is representative of the properties of cellulose acetate, a material that is commonly used in separation systems that remove CO_2 from gas streams (Baker and Lokhandwala, 2007; Oil and Gas Journal, 2002). A typical scheme for membrane separation at an EOR site is a hybrid approach between membrane and amine-based CO_2 removal. A hybrid scheme is ideal for high flow rates of gas streams with high concentrations of CO_2, which is the case at EOR gas processing facilities. The membrane unit removes two-thirds of the CO_2 in the inlet stream, and the remaining CO_2 is removed by the amine-based CO_2 removal process downstream from the membrane unit (Baker and Lokhandwala, 2007).

The retentate stream, which is a mix of CO_2 and hydrocarbon, from the unit process is sent to an amine-based acid gas removal unit for additional CO_2 removal. The environmental burdens for the operation of the amine-based acid gas removal unit are accounted for by another unit process outside of the boundaries of this unit process.

Figure 1: Unit Process Scope and Boundary

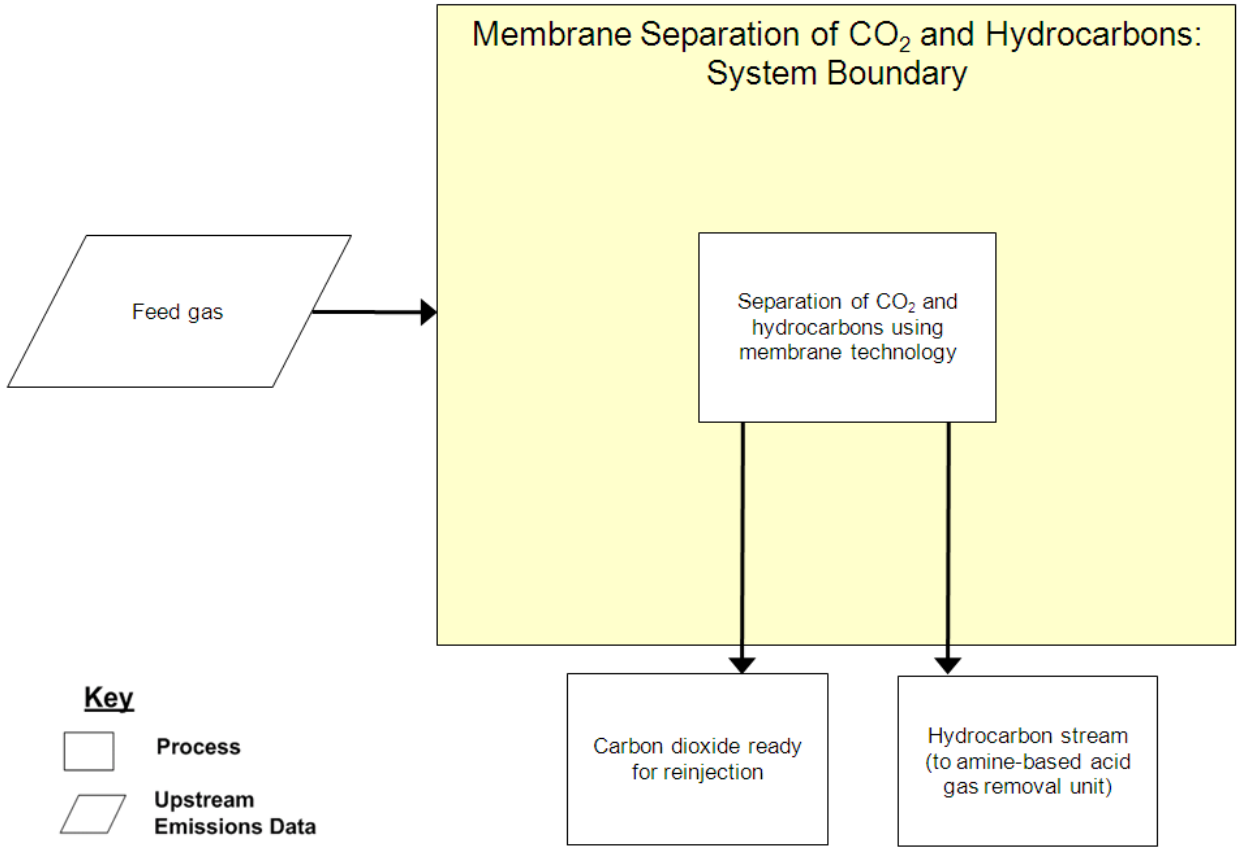

Table 1: Stream Composition

Component	Units	Feed	CO_2 Separated (To EOR Re-injection)	Mixed Hydrocarbon Stream (to additional acid gas removal)
H_2	kg	0.00000	0.00000	0.00000
N_2	kg	0.00262	0.00171	0.00429
CO_2	kg	0.96691	0.99360	0.91760
H2S	kg	0.00329	0.00261	0.00454
C1	kg	0.00257	0.00006	0.00719
C2	kg	0.00430	0.00020	0.01188
C3	kg	0.00748	0.00051	0.02034
iC4	kg	0.00179	0.00016	0.00479
C4	kg	0.00456	0.00041	0.01222
iC5+	kg	0.00650	0.00073	0.01716
Total	kg	1	1	1

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Feed gas	1.5414	kg
Outputs		
Carbon dioxide ready for reinjection	1.0000	kg
Product hydrocarbon stream	0.5414	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows.

Embedded Unit Processes

None.

References

Baker and Lokhandwala, 2007 — Baker, R.W. and Lokhandwala, K. (2007). Natural Gas Processing with Membranes: An Overview. Industrial Engineering and Chemistry Research. Vol 47, Issue 7. American Chemical Society. http://www.aseanenergy.info/abstract/31028885.pdf (Accessed October 24, 2012)

NETL, 2010 — NETL (2010). An Assessment of Gate-to-Gate Environmental Life Cycle Performance of Water-Alternating-Gas CO_2-Enhanced Oil Recovery in the Permian Basin. National Energy Technology Laboratory. Pittsburgh, PA.

Oil & Gas Journal, 2002 — Oil & Gas Journal, 2002. CO2 Membrane Technology Matters. Houston, TX. 2002. http://www.ogj.com/articles/print/volume-100/issue-15/special-report/cosub2-sub-membrane-technology-matures.html (Accessed October 24, 2012)

Vargs, 2010 — Vargas, K. J. (2010). Refrigeration provides economic process for recovering NGL from CO2-EOR recycle gas. Oil & Gas Journal, 108(2).

Section III: Document Control Information

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