NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Ryan Holmes Gas Separation

Reference Flow: 1 kg of carbon dioxide ready for reinjection

Brief Description: The operation of a Ryan Holmes gas separation plant

Section I: Meta Data

Geographical Coverage: United States **Region:** Permian Basin

Year Data Best Represents: 2010

Process Type: Extraction Process (EP)

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:

feed_product	*[kg] Mass of feed gas that ends up in product (CO_2 and NGL) streams*
feed_fuel	*[kg] Mass of feed gas that is recovered from de-methanizer and used for process fuel*
feed_total	*[kg] Total mass of input stream*
NGL	*[kg] Mass of NGL produced*

NGEnergy_total	*[kg] Energy required by gas-powered compressors and gas turbine power generator*
NGEnergy_purch	*[kg] Portion of gas energy that is purchased (instead of recovered from the process)*

Tracked Input Flows:

Feed gas	*[Technosphere] Bulk gas from dehydration*
Thermal Energy from Diesel Fuel	*[Technosphere] Diesel (purchased) for emergency generator*
Natural gas combustion in auxiliary boiler	*[Technosphere] Natural gas that is purchased for process energy*

Tracked Output Flows:

Carbon dioxide ready for reinjection [Insert]	*Reference flow (CO_2 ready for reinjection into EOR formation)*
NMVOC (unspecified) [Group NMVOC to air]	*Emission to air (VOC from fugitives, blowdowns, and loading)*
Natural gas combustion in auxiliary boiler	*Gas recovered from process and combusted for process energy*
Natural gas liquids	*Natural gas liquids ready to be sent to a storage tank*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_RyanHolmes.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 Ryan Holmes gas separation plant. The inputs

to the unit process are a mixed stream of carbon dioxide and hydrocarbons that have been through bulk separation and dehydration. The outputs are carbon dioxide (ready for reinjection into an EOR flood) and methane (ready for combustion or sales). A portion of recovered methane is combusted internally for power generation and compression. Diesel fuel is purchased for a backup generator. The reference flow of this unit process is: 1 kg of carbon dioxide ready for reinjection.

Boundary and Description

This unit process provides a summary of relevant input and output flows associated with the operation of a Ryan Holmes gas separation plant. The inputs to the unit process are a mixed stream of carbon dioxide and hydrocarbons that have been through bulk separation and dehydration. The outputs are carbon dioxide (ready for reinjection into an EOR flood) and methane (ready for combustion or sales). A portion of recovered methane is combusted internally for power generation and compression. Diesel fuel is purchased for a backup generator.

The composition of the feed gas stream is based on data for a gas plant in the Permian Basin (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 inlet and reinjection streams were normalized based on the EOR gas composition of an average well in the Permian Basin (NETL, 2010). The three saleable streams were also scaled so that they are representative of the change in the inlet composition.

The feed gas stream is split into three outlet streams: carbon dioxide, natural gas liquids (NGL), and fuel gas. The carbon dioxide is ready for re-injection in the enhanced oil recovery (EOR) reservoir. The NGL are ready for storage and eventual sales. The fuel gas stream is used to produce energy to power process equipment (compressors and gas turbines) used to provide energy to the gas separation process. The compositions of the 3 outlet streams are based on the compositions shown by NETL's 2010 analysis of EOR using, which includes a characterization of the Ryan Holmes process (NETL, 2010).

The Ryan Holmes process has three steps, a refrigerated vessel that separates carbon dioxide, light hydrocarbons, and natural gas liquids; a de-methanizer that recovers methane that can be used as a plant fuel; and a gas/gas separation column that separates light and heavy hydrocarbons. A portion of the hydrocarbons that are recovered from the refrigerated vessel are used within the Ryan Holmes process to break the azeotrope in the gas separation column. When separated into component streams, the hydrocarbon products have high market values, making the Ryan Holmes process worthwhile.

VOC emissions are released as fugitive emissions, during equipment blowdowns, and system loading (NETL, 2010). These emissions were calculated by dividing annual VOC emissions from the Ryan Holmes plant by the carbon dioxide produced annually by the plant.

Figure 1: Unit Process Scope and Boundary

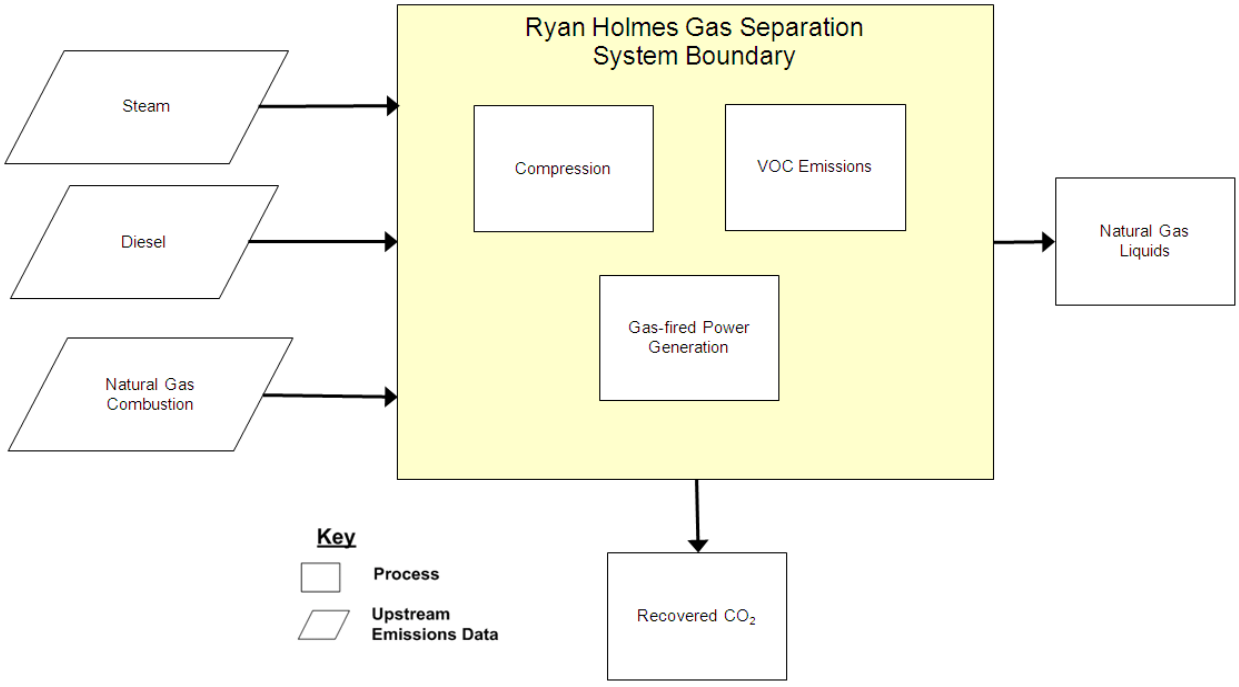

Table 1: Mass Composition of Inlet and Outlet Streams for Ryan Holmes Plant, per kg of Feed Gas

Component	Units	Feed	Gas Recovered for Process Fuel	CO_2 Separated (To EOR Re-injection)	Natural Gas Liquids (To Storage Tank)
H_2	kg	0.00000	0.00000	0.00000	0.00000
N_2	kg	0.00256	0.00256	0.00000	0.00000
CO_2	kg	0.96691	0.00512	0.96562	0.00128
H_2S	kg	0.00321	0.00000	0.00000	0.00000
C1	kg	0.00251	0.00233	0.00018	0.00000
C2	kg	0.00420	0.00000	0.00030	0.00390
C3	kg	0.00731	0.00001	0.00002	0.00728
C4	kg	0.00620	0.00004	0.00000	0.00616
iC5+	kg	0.00711	0.00004	0.00000	0.00707
Total	kg	1.00000	0.01010	0.96612	0.02569

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Feed gas	1.037	kg
Thermal Energy from Diesel Fuel	0.00950	MJ
Natural gas combustion in auxiliary boiler	7.29E-03	kg
Outputs		
Carbon dioxide ready for reinjection [Insert]	1.00	kg
NMVOC (unspecified) [Group NMVOC to air]	1.11E-04	kg
Natural gas combustion in auxiliary boiler	0.0104	kg
Natural gas liquids	0.0266	kg

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

Embedded Unit Processes

None.

References

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.

Vargas, 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

Date Created: October 23, 2012

Point of Contact: Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV

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