NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Oilfield Gas, Water, and Oil Separation

Reference Flow: 1 kg of crude oil

Brief Description: Separation of wellhead product to gas, oil, and water

Section I: Meta Data

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

Year Data Best Represents: 2010

Process Type: Recovery Process (RP)

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

Allocation Applied: No

Completeness: Individual 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:

Share_oil	*[kg/kg] Share of wellhead product that is oil*
Share_gas	*[kg/kg] Share of wellhead product that is gas (methaneand other gases)*
Share_CO2	*[kg/kg] Share of wellhead product that is CO2*

Share_water	*[kg/kg] Share of wellhead product that is brine water*
EF_VOC	*[kg/kg] Emission factor for VOCs, due to heat treatment of oil and water and pressure changes during separation. This flow represents the mass of VOC prior to vapor recovery and environmental controls.*
NG_heater	*[kg/kg] Natural gas used by heater per unit of crude produced*

Tracked Input Flows:

EOR Crude Oil [Valuable substance]	*Produced crude oil*
EOR Hydrocarbon Gas [Valuable Substance]	*Hydrocarbon gas produced with crude*
Carbon dioxide [intermediate product]	*CO2 produced with crude*
Brine [Water]	*Brine produced with crude*
Natural gas combustion in auxiliary boiler	*Natural gas combustion in firetube heater used by oil/water separation*

Tracked Output Flows:

EOR Crude Oil [Valuable substance]	*Reference flow (crude oil to be sent to low pressure separation)*
EOR Gas [Valuable substance]	*Bulk gas recovered from oilfield separation equipment at the EOR site*
Brine water	*Brine water to treatment or disposal*
NMVOC	*Uncontrolled emission to venting and flaring unit process*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_3Phase_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 three phase separation at an oilfield. The input to the separator is wellhead product (crude, CO_2, hydrocarbon gas, and water; the outputs are oil, gas (CO_2 plus hydrocarbon), and water. Gas is removed in a high pressure vessel that knocks out liquids (oil and water). Liquids are separated using a heated vessel that separates oil and water. Natural gas is consumed by the heater/treater. VOC emissions occur due to pressure changes during separation; vapor recovery is used to recover VOC emissions. The reference flow of this unit process is: 1 kg of crude oil.

Boundary and Description

This unit process provides a summary of relevant input and output flows associated with three phase separation at an oilfield. The input to the separator is wellhead product (crude, CO_2, hydrocarbon gas, and water); the outputs are oil, gas (CO_2 plus hydrocarbon), and water. Gas is removed in a high pressure vessel that knocks out liquids (oil and water). Liquids are separated using a heated vessel that separates oil and water. Natural gas is consumed by the heater/treater. VOC emissions occur due to pressure changes during separation; vapor recovery is used to recover VOC emissions.

Gas is separated from the liquid components (oil and water) using a high pressure vessel that knocks out the liquids in the wellhead product. A back pressure valve is used to maintain pressure in the vessel. The gas that is separated from this process can be sent to a gas processing facility (not within the boundaries of this unit process) for further separation. This is a bulk separation process; the gas output is further purified downstream, and the oil and water outputs contain low concentrations of gas.

The only energy input to this unit process is combustion of natural gas. Natural gas is consumed by a firetube heater, which heats the oil and water mixture and causes the two liquid components to separate. The energy consumed by the firetube heater is based on calculations in NETL's 2010 assessment of CO_2 EOR (enhanced oil recovery) facilities (NETL, 2010). This calculation is a function of the heat capacity of the liquid, a 30 degree Fahrenheit temperature increase, and the throughput of a separation process used for an EOR site with 10 extraction patterns (NETL, 2010). Natural gas is purchased

for onsite heating because the recovered gases from the process are high value products that will be sent to market instead of combusted at the EOR site.

VOC (volatile organic compounds) are released due to pressure changes in the system, including flashing operations and flows that change the volume of product in separation vessels. The VOC emissions from this unit process are based on EOR losses calculated by NETL's 2010 assessment of CO_2 EOR (NETL, 2010). These emissions are converted to the basis of 1 kg of crude oil produced by converting VOC emissions and crude oil production to the same temporal basis. These VOC emissions are recovered by vapor recovery equipment (VRU) and may be flared or released to the atmosphere, depending on the use and efficiency of emission control equipment. The flaring or release of VOC is accounted for by downstream unit processes and is not accounted for in this unit process. The uncertainty in VOC emissions is based on data collected for oilfields in the Southwest U.S. (McKaskle et al, 2008).

Figure 1 provides an overview of the boundary of this unit process. **Table 1** summarizes emission factors and other parameters that are relevant to this unit process. **Table 2** provides a summary of modeled input and output flows and shows all inputs and outputs on the basis of the reference flow (the production of one kilogram of crude oil). Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Figure 1: Unit Process Scope and Boundary

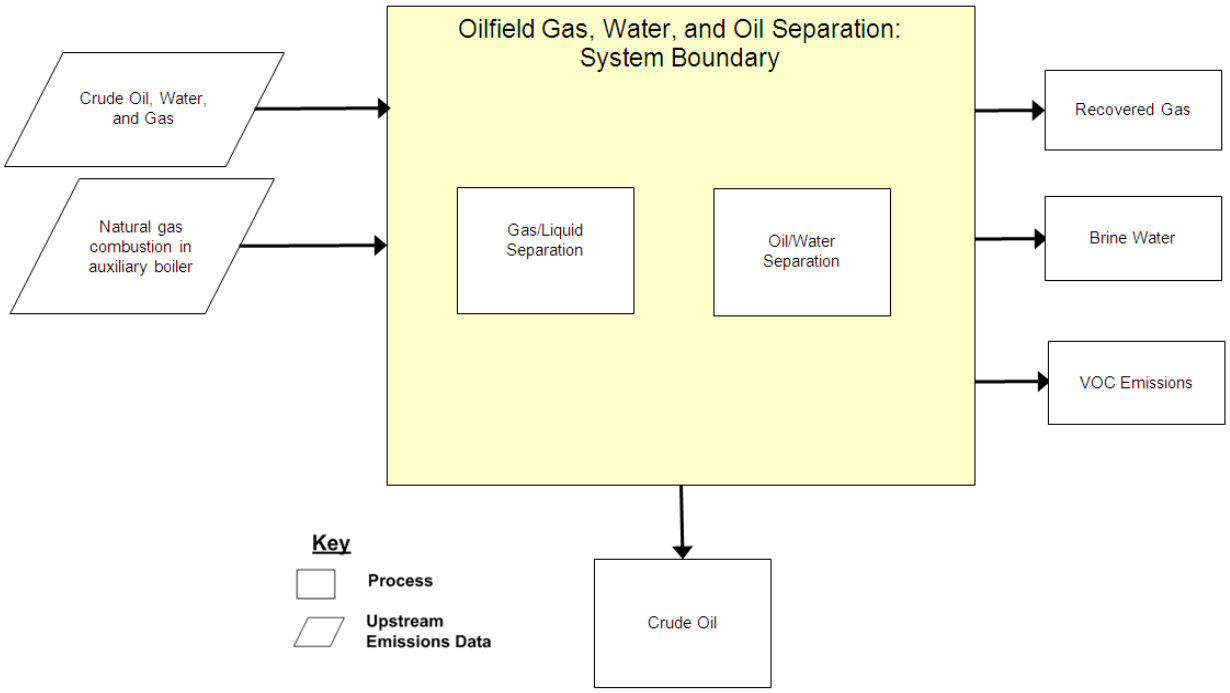

Table 1: Default Parameters and Other Variables for Oil/Gas/Water Separation

Parameter Name	Value	Units
Share of oil in wellhead product	1.000	kg/kg crude
Share of gas in wellhead product	0.143	kg/kg crude
Share of CO_2 in wellhead product	4.166	kg/kg crude
Share of water in wellhead product	13.04	kg/kg crude
Emission factor for VOCs	0.00870	kg VOC/kg crude oil produced
Natural gas used by heater	0.00309	kg natural gas/kg crude oil produced

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
EOR Crude Oil [Valuable substance]	1.00E+00	kg
EOR Hydrocarbon Gas [Valuable Substance]	1.43E-01	kg
Carbon dioxide [intermediate product]	4.17E+00	kg
Brine [Water]	1.30E+01	kg
Natural gas combustion in auxiliary boiler	3.09E-03	kg
Outputs		
EOR Crude Oil [Valuable substance]	1.00	kg
EOR Gas [Valuable substance]	4.30E+00	kg
Brine water	1.30E+01	kg
NMVOC [intermediate product]	8.70E-03	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 CO2-Enhanced Oil Recovery in the Permian Basin, National Energy Technology Laboratory, Pittsburgh, PA. Accessed on September 27, 2012 at http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&PubId=333.

McKaskle et al, 2008 McKaskle, R., Fisher, K., Searcy, K., Rueter, C. 2008. VOC Emissions --1: Study Evaluates Storage-Tank VOC Emissions Reduction, Oil and Gas Journal, Vol. 106, Issue 32. August 25, 2008. PennWell Corporation.Section III: Document Control Information

Date Created: October 12, 2012

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

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