NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Wellhead Compressor, Gas-Powered, 200 HP

Reference Flow: 1 kg of Natural Gas

Brief Description: This unit process quantifies the amount of electricity required and methane emissions associated with the operation of a 187 horsepower, gas-fired centrifugal wellhead compressor for natural gas wells.

Section I: Meta Data

Geographical Coverage: United States **Region:** N/A

Year Data Best Represents: 2010

Process Type: Extraction Process (EP)

Process Scope: Gate-to-Gate (GG)

Allocation Applied: No

Completeness: All Relevant Flows Recorded

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 Pollutants	☒ Other
Releases to Water:	☐ Inorganic Emissions	☐ 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:

Natural gas	*Raw natural gas received from dehydration process*

Tracked Output Flows:

Natural Gas	*Reference flow; 1 kg of natural gas (NG)*
Vented gas [intermediate product]	*Intermediate product, natural gas to be vented or flared after compression*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_NG_WellCompression_GasCentrif_2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process encompasses the operation of 187 horsepower (HP), gas-powered centrifugal compressors at a natural gas wellhead. The unit process is based on the reference flow of 1 kg of natural gas (NG). It is applicable to all natural gas well types considered, and the proportion of this versus other compressor types are identified in a separate unit process. The process is based on the reference flow of 1 kg of natural gas, and relevant flows of this unit process are described below and shown in **Figure 1.**

This unit process is used under Life Cycle (LC) Stage #1 to prepare extracted natural gas for pipeline distribution. This unit process is combined with other relevant equipment for LC Stage #1 in a separate operations assembly process, DF_Stage1_O_Assembly_Natural_Gas_2011.01.doc. The assembly process quantifies the relevant flows and emissions associated with each portion of the natural gas extraction profile being modeled, in order to complete extraction and in-field processing of 1 kg of natural gas.

Boundary and Description

Compressors are used at the natural gas wellhead to increase the gas pressure for pipeline distribution. The performance of a compressor depends on the natural pressure at the wellhead, which varies from reservoir to reservoir and decreases with increasing well life. This analysis assumes that the inlet pressure to a wellhead compressor is 50 psig and the outlet pressure is 800 psig. The inlet pressure depends on the pressure of the natural gas reservoir and thus introduces uncertainty into the natural gas model. The outlet pressure of 800 psig is a standard pressure for pipeline transport of natural gas.

The energy required for compressor operations is based on manufacturer data that compares power requirements to compression ratios (the ratio of outlet to inlet pressures). A two-stage centrifugal compressor with an inlet pressure of 50 psig and an outlet pressure of 800 psig has a power requirement of 187 horsepower per MMCG of natural gas (GE Oil and Gas 2005). Using a natural gas density of 0.042 lb/scf and converting to SI units gives a compression energy intensity of 1.76E-04 MWh per kg of natural gas. This energy rate represents the required *output* of the compressor shaft; the *input* fuel requirements for compression vary according to compression technology. The two types of compressors used for natural gas extraction operations are reciprocating compressors and gas or electrically-powered centrifugal compressors. Gas powered centrifugal compressors are considered within this unit process, and relevant energy use, efficiency, and other values relevant to gas powered centrifugal compressors are shown in **Table 1**.

Figure 1 provides an overview of the boundary of this unit process. Natural gas, extracted and ready to be pressurized, is the sole input to this unit process. Within the system boundary, compressor energy use is determined as a function of engine power and the energy needed to run the compressor. Air emissions are calculated based on natural gas consumption rates and engine type, and fugitive methane emissions from compressor seals and other components are accounted for. Output from this unit process feeds into a downstream assembly unit process for natural gas, and to a separate natural gas venting and flaring unit process.

Figure 1: Unit Process Scope and Boundary

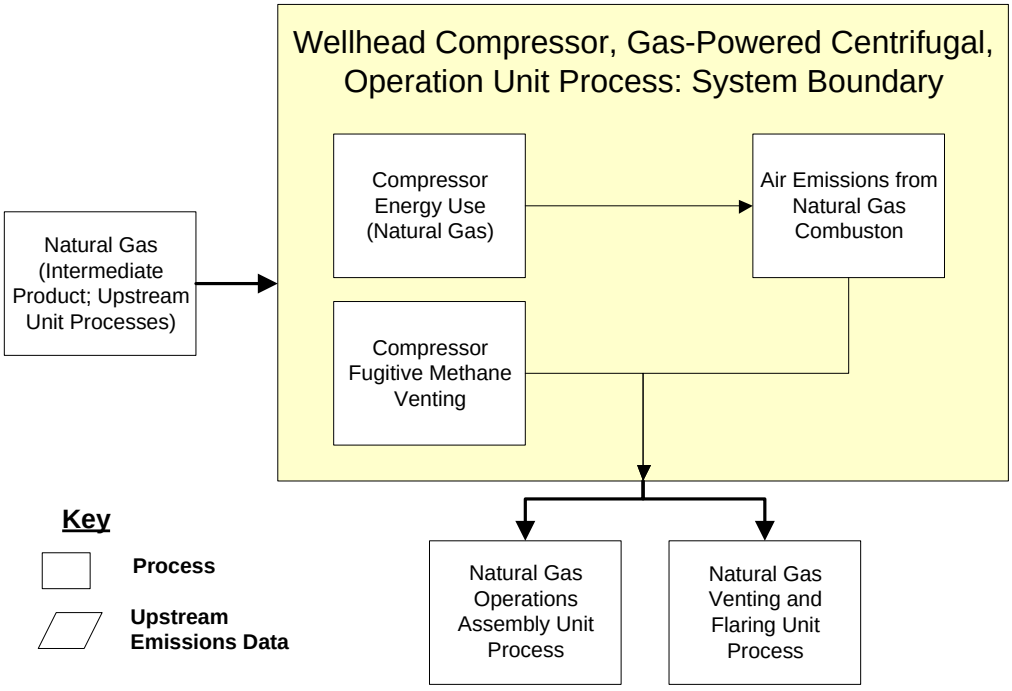

Table 1 summarizes key compressor properties and emissions applied within this unit process. **Table 2** provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Wellhead Compression for a Gas-Powered Centrifugal Compressor

Air Emission Factors (per MMBtu of centrifugal compressor fuel)			
Flow Name	**Value**	**Units**	**Reference**
CO_2	110	lb/MMBTU fuel	EPA 1995
CH_4	8.60E-03	lb/MMBTU fuel	EPA 1995
N_2O	3.00E-03	lb/MMBTU fuel	EPA 1995
NOx	3.20E-01	lb/MMBTU fuel	EPA 1995
CO	8.20E-02	lb/MMBTU fuel	EPA 1995
SO_2	3.40E-03	lb/MMBTU fuel	EPA 1995
PM	6.60E-03	lb/MMBTU fuel	EPA 1995
NMVOC	2.10E-03	lb/MMBTU fuel	EPA 1995
Energy inputs and outputs			
Flow Name	**Value**	**Units**	**Reference**
Output shaft energy	1.76E-04	MWh/kg	GE 2005
Heat rate	201	kg NG/MWh	API 2009
Fuel input[1]	3.53E-02	kg NG/kg NG	NETL Engineering Calculation

[1] The fuel input is the product of output shaft energy and heat rate.

[2] Air emissions are the product of EPA emission factors and compressor fuel input. The emission factors are converted to a metric basis using the following factors: 1 scf NG = 1,027 Btu NG = 0.042 lb NG; 1 MMBTU = 1,000,000 Btu; 1 kg = 2.205 lb.

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Natural Gas [Intermediate Product]	**1.042**	**kg**
Outputs		
Natural Gas [Intermediate Product]	**1.00**	**kg**
Carbon dioxide [Inorganic emissions to air]	9.50E-02	kg
Methane [Organic emissions to air (group VOC)]	7.42E-06	kg
Vented gas [intermediate product]	**6.90E-03**	**kg**
Nitrous oxide (laughing gas) [Inorganic emissions to air]	2.59E-06	kg
Nitrogen oxides [Inorganic emissions to air]	1.12E-04	kg
Sulphur dioxide [Inorganic emissions to air]	2.93E-06	kg
Carbon monoxide [Inorganic emissions to air]	2.59E-05	kg
NMVOC (unspecified) [Group NMVOC to air]	1.81E-06	kg
Dust (PM10) [Particles to air]	5.70E-06	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows were added during the modeling process using GaBi modeling software, as shown in Figure 2.

Embedded Unit Processes

None.

References

API 2009 — American Petroleum Institute. 2009. *Compendium of Greenhouse Gas Emissions for the Oil and Natural Gas Industry.* 2009. http://www.api.org/ehs/climate/new/upload/2009_GHG_COMPENDIUM.pdf (accessed May 18, 2010).

EPA 1995 — US Environmental Protection Agency. 1995. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, AP-42.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1995. http://www.epa.gov/ttnchie1/ap42 (accessed May 18, 2010).

GE Oil and Gas 2005 — GE Oil and Gas. Reciprocating Compressors. Florence, Italy: General Electric Company, 2005.

Section III: Document Control Information

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