NETL Life Cycle Inventory Data
Process Documentation File

Process Name: CO2 Pipeline Pigging

Reference Flow: 1 kg of Transported CO_2

Brief Description: The CO_2 emissions from inspection of CO_2 pipelines

Section I: Meta Data

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

Year Data Best Represents: 2010

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:

pipeline_len	*[km] Length of the pipeline. Values are equivalent to 50, 250, and 500 miles.*

Tracked Input Flows:

Carbon dioxide [intermediate product]	*[Technosphere] Captured and transported CO_2*

Tracked Output Flows:

Transported CO_2	*Reference flow*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_CO2_Pipeline_Pigging_2013.01.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

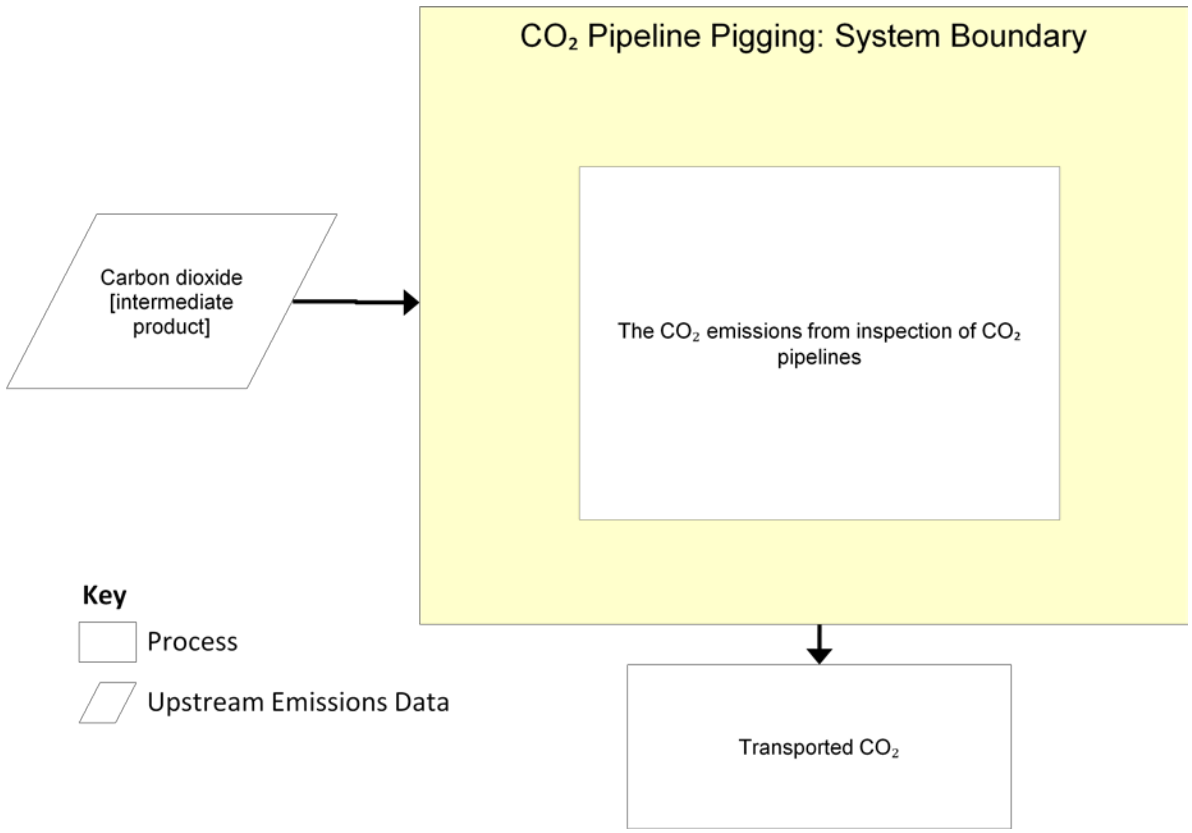
Goal and Scope

This unit process provides a summary of relevant input and output flows associated with inspecting CO_2 pipelines using "pigs". Emissions are episodic but are levelized according to the amount of CO_2 transported between inspection periods. The only emission for this process is CO_2 that is released when the pipeline is vented to allow the insertion of the inspection pig. The reference flow of this unit process is: 1 kg of Transported CO_2.

Boundary and Description

Figure 1 provides an overview of the boundary of this unit process. Rectangular boxes represent relevant sub-processes, while parallelograms indicate upstream data that are outside of the boundary of this unit process. As shown, the upstream emissions from electricity are calculated in another unit process. The methods for calculating these operating activities are described below.

Figure 1: Unit Process Scope and Boundary



CO_2 pipeline operators periodically need to inspect the pipeline. This is normally performed by inserting inspection devices known as "pigs" into the pipe. To accomplish this, the portion of the pipe being inspected must be opened resulting in periodic emissions of CO_2. To calculate the amount of CO_2 that is released during this episodic emission, the length and diameter of the pipe and the inspection periodicity must be known. **Table 1** shows the pipe diameter calculated using the NETL "Carbon Dioxide Pipeline Transport, Storage, and Maintenance Cost Model" for combinations of distance and CO_2 flow rate (NETL, 2010). A CO_2 pipeline is inspected internally at least once every five years, and more frequently if necessary (Dakota Gas Company, n.d. and Baker Hughes, n.d.). As an estimate of average inspection frequency, this unit process uses a pigging frequency of once every 4 years.

Once the pipeline diameter is known, the volume of CO_2 in the pipeline can be calculated. This is converted to mass by assuming that the CO_2 pipeline pressure and temperature are allowed to decrease to their critical values, yielding a critical density of 467.6 kg per m^3. The total mass is then assumed to be released to atmosphere during pigging. The total mass emitted for each distance/flow rate is levelized by calculating the total amount of CO_2 transported between inspections and dividing the emission by that number. These results are also shown in **Table 1**.

Table 1: Calculated Pipe Diameters and Emission Factors for Given Transport Distances and CO_2 Flow Rates

Transport Distance (mi)	CO_2 Flow Rate (tonne/day)	Pipe Diameter (in)	Emission (kg CO_2/kg CO_2 transported)	Predicted Emission (kg CO_2/kg CO_2 transported)
50	2500	8	3.34E-04	3.27E-04
50	10000	16	3.34E-04	3.27E-04
50	20000	18	2.11E-04	3.27E-04
250	2500	8	1.67E-03	2.82E-03
250	10000	20	2.61E-03	2.82E-03
250	20000	24	1.88E-03	2.82E-03
500	2500	12	7.52E-03	7.13E-03
500	10000	22	6.32E-03	7.13E-03

Once emissions are known for each of the scenarios, a best fit line is drawn for the maximum values at each distance, yielding the power equation:

$$\frac{CO_{2\ emitted}}{distance_{Transport}} = CO_{2\ transported}$$

Where,

$CO_{2\ emitted}$ is in kilograms

$distance_{Transport}$ is in meters

$CO_{2\ transported}$ is in kilograms

The use of maximum values to generate the curve fit results in an overestimation for most scenarios. The errors are considered acceptable given the magnitude of the emission compared to the greenhouse gas emissions for the electricity used to compress the CO_2 for the same scenario (about 7E-02 kg CO_2 per kg captured) (NETL, 2012).

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Carbon dioxide [intermediate product]	1.0028	kg
Outputs		
Transported CO_2	1.0000	kg
Carbon dioxide [Inorganic emissions to air]	2.8172E-03	kg

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

Embedded Unit Processes

None.

References

Baker Hughes (n.d.). Pipeline Services.Retrieved March 20, 2013 from http://www.bakerhughes.com/products-and-services/process-and-pipeline-services/pipeline-services.

Dakota Gasification Company (no date). "CO2 Pipeline". Retrieved March 20, 2013 from http://www.dakotagas.com/Gas_Pipeline/CO2_Pipeline/index.html.

NETL (2010). Quality Guidelines for Energy Systems Studies: Estimating CO_2 Transport, Storage & Monitoring Costs. U.S. Department of Energy, National Energy Technology Laboratory. DOE/NETL-2010/1447. Retrieved March 20, 2013 from http://www.netl.doe.gov/energy-analyses/pubs/qgesstransport.pdf.

NETL (2012). NETL Life Cycle Inventory Data – Unit Process: CO2 Compression. U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: July 2012 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

Section III: Document Control Information

Date Created: March 7, 2013

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

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