Todd, Robert

From: Bergmann, Edwin [EJBERGMANN@eprod.com]
Sent: Friday, February 21, 2014 3:11 PM
To: Todd, Robert
Cc: Sartor, Rodney; Steve Langevin
Subject: Enterprise additional informationresponse and comments on draft Statement of Basis and GHG Permit for PDH Plant, Chambers County,TX, TX-021414
Attachments: PDH Emission Calcs - Feb 21 2014 Revisions.pdf.pdf; Enterprise PDH GHG Draft Permit Mont Belvieu Tx- 021414 SAL Redline2 (4).docx; Enterprise PDH SOB Mont Belvieu-021414 - SAL Redline.docx

Robert M. Todd, P.E.
US EPA Region 6
1445 Ross Ave.
Dallas, Tx, 75202

Robert:

Please find a response to the questions/observations you had during a recent conversation. These were:

- Please account for the natural gas stream shown in the Process Diagram Figure 4-2

  This stream is used as a supplemental fuel gas stream during the regeneration phase to enhance the burn off of coke from the reactor catalyst and ensuring that oxygen is removed from the reactors prior to re-inventory with raw material. The emissions from the Reactor Injection Gas contribution had not been previously accounted for and results in additional CO2 emissions to the previous represented plant total. The addition of this stream has been included in the revised Tables A-1 and Table 5-1 attached to this e-mail.

- Please account for the coke in the regeneration process by showing an emission factor in lb/mmbtu for this stream.

  Attached is an accounting of the 60,000 tons per year of CO2e treated as fuel with the resulting emission rate in lb/mmbtu. This was arrived at by calculation the carbon value of this stream and using EPA Coke (Petroleum) factors to calculate lb/mmbtu emission rates. The calculation is shown in the attached Table A-1.

Also, attached are the comments on the Statement of Basis and the draft GHG Permit. This is in a word track changes mode. Enterprise included comments for clarification when necessary.

If you have any questions, please feel free to call me at any of the numbers below.

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Table 5-1 Proposed GHG Emission Limits

EPN	Description	CO_2 Emission Rate (tpy)	CH_4 Emission Rate (tpy)	N_2O Emission Rate (tpy)	CO_2e Emission Rate (tpy)
Individual Combustion Unit Limits					
HR15.101	Reactor Charge Heater	280,168	12.99	2.54	281,250
DW37.101	Waste Heat Boiler Burner	19,522	0.98	0.20	19,605
	Regeneration Air Heater	650,704	23.89	4.25	652,568
	Regen Air Comp. Gas Turbine A	124,897	2.32	0.23	125,024
	Regen Air Comp. Gas Turbine B	124,897	2.32	0.23	125,024
	Reactor Injection Gas	46,047	0.86	0.09	46,093
	Reactor Effluent VOC	5,580	0.26	0.05	5,580
	Reactor Decoking	60,000	-	-	60,000
BO10.103A	Auxiliary Boiler A	16,321	0.82	0.16	16,390
BO10.103B	Auxiliary Boiler B				
Combustion Unit Cap		**1,317,432**	**64.31**	**12.86**	**1,322,872**
Other					
FUG-PDH	Process Fugitives	-	0.25	-	6
FUG-NGAS	Nat. Gas Pipeline Fugitives	-	13.04	-	326
SK25.801	Process Flare, Routine	2,818	0.04	0.01	2,821
	Process Flare, MSS	4,426	0.16	0.03	5,940
PM18.803	Fire Water Pump Engine	16	0.0007	0.0001	16
PM18.850C	Raw Water Pump Engine	8	0.0003	0.0001	8
Total GHG Emissions		**1,324,701**	**77.79**	**12.90**	**1,331,989**

Tables from EI Bergman
rec'd via email
2/21/2014
PDH Emission Calcs - Feb. 21 2014.pdf

Table A-1 GHG Emission Calculations

Enterprise Operating Products LLC
Mont Belvieu Complex - PDH Unit
GHG Emissions - Individual Combustion Unit Limts

EPN	FIN	Description	Fuel[1]	Firing Rate (mmBtu/yr)	Firing Rate (scf/yr)	Carbon Content (CC)	MW (lb/lbmol)	Emission Rates (tpy)[2]				Emission Rates (lb/mmbtu)	
								CO_2	CH_4	N_2O	CO_2e	CO_2	CO_2e
HR15.101	HR15.101	Reactor Charge Heater	DeEth Offgas	3,758,478	2,503,713,725	0.765	26.66	246,846	12.43	2.49	247,897	131.4	131.9
			Ethane	508,582	287,383,412	0.798	30.07	33,322	0.56	0.06	33,353	131.0	131.2
			Natural Gas		494,432,362	0.723	17.46	30,139	0.56	0.06	30,170	118.5	118.6
		Reactor Charge Heater Total/Max[3]		4,267,060				280,168	12.99	2.54	281,250	131.3	131.8
DMV7.101	All of Below.	Waste Heat Boiler:	All	16,317,004				1,031,645	30.6	5.0	1,033,894		
	HR15.103	Waste Heat Boiler Burner	Ethane	297,241	167,961,130	0.798	30.07	19,475	0.33	0.03	19,493	131.0	131.2
			DeEth Offgas	297,241	198,007,252	0.765	26.66	19,522	0.98	0.20	19,605	131.4	131.9
			Natural Gas	297,241	288,970,814	0.723	17.46	17,615	0.33	0.03	17,633	118.5	118.6
			PSA Tail Gas	297,241	599,900,478	0.443	11.14	14,315	0.33	0.03	14,333	96.3	96.4
			LTRU Offgas[4]	-	-	0.270	4.03	-	-	-	-		
		WHB Burner Total/Max[5]		297,241				19,522	0.98	0.20	19,605	131.4	131.9
		Reactor Injection Gas	Natural Gas	777,012	755,393,543	0.723	17.46	46,047	0.86	0.09	46,093	118.5	118.6
		Reactor Effluent VOC	Reactor Effluen	77,868	13,333,556	0.847	102.22	5,580	0.26	0.05	5,580	143.3	143.3
		Reactor Decoking	Coke[6]	531,742				60,000	-	-	60,000	225.7	225.7
	HR15.102	Regeneration Air Heater	Ethane	4,789,100	2,706,164,815	0.798	30.07	313,779	5.28	0.53	314,068	131.0	131.2
			DeEth Offgas	3,758,478	2,503,713,725	0.765	26.66	246,846	12.43	2.49	247,897	131.4	131.9
			PSA Tail Gas	1,870,421	3,774,941,116	0.443	11.14	90,079	6.19	1.24	90,602	96.3	96.9
			Natural Gas	4,789,100	4,655,854,889	0.723	17.46	283,807	5.28	0.53	284,096	118.5	118.6
			LTRU Offgas[4]	-	-	0.270	4.03	-	-	-	-		
		Regeneration Air Heater Total/Max[7]		10,417,999				650,704	23.89	4.25	652,568	124.9	125.3
	GT26.101A	Regen Air Comp. Gas Turbine A	Natural Gas	2,107,571	2,048,933,053	0.723	17.46	124,897	2.32	0.23	125,024	118.5	118.6
	GT26.101B	Regen Air Comp. Gas Turbine B	Natural Gas	2,107,571	2,048,933,053	0.723	17.46	124,897	2.32	0.23	125,024	118.5	118.6
BO10.103A	BO10.103A	Auxiliary Boiler A	Ethane	248,500	140,419,280	0.798	30.07	16,282	0.27	0.03	16,297	131.0	131.2
BO10.103B	BO10.103B	Auxiliary Boiler B	Natural Gas	248,500	241,586,096	0.723	17.46	14,726	0.27	0.03	14,741	118.5	118.6
			PSA Tail Gas	248,500	501,530,283	0.443	11.14	11,968	0.82	0.16	12,037	96.3	96.9
			DeEth Offgas	248,500	165,538,513	0.765	26.66	16,321	0.82	0.16	16,390	131.4	131.9
		Auxiliary Boiler Total/Max[8]		248,500				16,321	0.82	0.16	16,390	131.4	131.9
		Plantwide										127.5	127.8

1 Listed fuels are the fuels that may be burned in each facility. All available DeEth Offgas and PSA Tail Gas will be used, and balance of required fuel will be natural gas and/or ethane. The fuel firing rates used for each facility are based on burning all available DeEth Offgas and PSA Tail Gas in the preferred facility, up to the required heat demand on that facility. Any remaining off/tail gas will be used in other facilities as shown. As such, the individual fuel usage rates used in the calculations are not maximum annual rates for each facility.

2 Note all emission rates are in units of short tons. Eq. C-5 in 40 CFR Part 98 Chapter C yields emissions in metric tons. Metric tons were converted to short tons by multiplying by 1.102311 short tons per metric ton.

3 All available DeEth Offgas will be burned in Reactor Charge Heater with balance of fuel being either natural gas or ethane. Total maximum emission rate is emissions from DeEth Offgas plus maximum from ethane or natural gas.

4 LTRU Offgas will only be burned if the PSA Unit is down, which is a proposed alternate operating mode for which emission rates are not shown as it does not represent the permit basis.

5 PSA Tail Gas is primary fuel for WHB Burner. Natural gas and ethane are alternate fuels. Maximum emission rate shown is based on burning 100% ethane.

6 CO2 factor for deckoking is 40 CFR Part 98 Table C-1 facor for Petroleum Coke.

7 Regeneration Air Heater will burn any DeEth Offgas and PSA Tail Gas not consumed in the Charge Heater and WHB Burner. Total/Max emissions are based on burning PSA Tail Gas not used in WHB Burner with balance of fuel from Ethane/DeEth Offgas. (Note that CO2 emission factor in lb/mmbtu for Ethane and DeEth Offgas are the same (see table below)).

8 Auxiliary Boilers will be in hot standby under normal conditions and will be used interchangeably; thus, the firing rates shown are totals for the two together. They are capable of burning each of the fuels listed, and maximum emissions are based on burning all DeEth Offgas, which results in the highest CO2 emisions.

Table A-1 GHG Emission Calculations

Enterprise Operating Products LLC
Mont Belvieu Complex - PDH Unit
GHG Emissions - Individual Combustion Unit Limts

Carbon Factor Calculations:

Component	Molecular Weight (lb/lb-mol)	Number of Carbons per mole	Composition (mole %) Natural Gas[1]	DeEth Offgas (SOR)[2]	PSA Tail Gas (SOR)[2]	LTRU Offgas[2]	Import Ethane	MSS Flaring	Reactor VOC
Nitrogen	28.013	0	0.683	0.490	6.760	1.490	0.000	0.000	0.000
Carbon Dioxide	44.010	1	1.797	2.200	0.520	0.120	0.000	0.000	0.000
Carbon Monoxide	28.010	1	0.035	1.630	12.470	2.750	0.000	0.000	0.000
Helium	4.003	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Argon	39.95	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydrogen	2.02	0	0.000	8.860	60.070	91.190	0.000	0.000	0.000
Methane	16.04	1	93.361	7.680	13.960	3.080	0.000	0.000	0.000
Ethane	30.07	2	3.043	71.330	3.470	0.770	100.000	0.000	1.530
Propane	44.10	3	0.557	0.060	0.760	0.170	0.000	50.000	8.113
Iso-Butane	58.12	4	0.191	0.000	0.000	0.000	0.000	0.000	0.000
n-Butane	58.12	4	0.143	0.000	0.000	0.000	0.000	0.000	9.672
Iso-Pentane	72.15	5	0.039	0.000	0.000	0.000	0.000	0.000	0.000
n-Pentane	72.15	5	0.027	0.000	0.000	0.000	0.000	0.000	7.792
n-Hexane	86.18	6	0.088	0.000	0.000	0.000	0.000	0.000	14.234
n-Heptane	100.20	7	0.000	0.000	0.000	0.000	0.000	0.000	12.241
C10+	140.00	10	0.000	0.000	0.000	0.000	0.000	0.000	43.807
Ethylene	28.05	2	0.000	7.170	0.970	0.210	0.000	0.000	0.182
Propylene	42.08	3	0.000	0.310	1.010	0.220	0.000	50.000	2.429
neo-Pentane	72.15	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Acetylene	26.04	2	0.000	0.220	0.010	0.000	0.000	0.000	0.000
Hydrogen Sulfide	34.00	0	0.000	0.050	0.000	0.000	0.000	0.000	0.000
Oxygen	32.00	0	0.037	0.000	0.000	0.000	0.000	0.000	0.000
Water	18.02	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		MW (lb/lbmole):	**17.46**	**26.66**	**11.14**	**4.03**	**30.07**	**43.09**	**102.22**
		Carbon Content (kg C/kg Fuel):	**0.723**	**0.765**	**0.443**	**0.270**	**0.798**	**0.835**	**0.847**
		Heating Value (btu/scf, HHV):	**1028.6**	**1501.2**	**495.5**	**362.0**	**1769.7**	**NA**	**5840.0**
		CO2 emission factor (lb/mmbtu,HHV):	118.5	131.4	96.3	29.1	131.0		143.3

1 Natural gas composition is based on historical analyses of gas received at the Mt. Belvieu Complex.

2 These fuels are process offgases, and compositions were provided by Lummus, the licensor of the proposed technology.

Emission Factors:

Eq. C-5 from 40 CFR Part 98 Chapter C

$$CO_2 = \frac{44}{12} \times Fuel \times CC \times \frac{MW}{MVC} \times 0.001 \quad \text{(Eq. C-5)}$$

CO2 =	CO2 emissions, metric tons/yr
Fuel =	firing rate in mmscf/yr
MVC =	836.6 (per Part 98)
CC =	as calculated above
MW =	as calculated above

CH4 and N2O Emission factors from Table C-2 of Appendix A to 40 CFR Part 98 Chapter C

	kg CH4 /mmBtu	kg N2O/mmBtu
Natural Gas	0.001	0.0001
Process Gas	0.003	0.0006

kg to lb conversion factor: 2.20462

CO2e Equivalents:

CO2	1.0
CH4	25.0
N2O	298.0

Table A-2 GHG Emission Calculations

Enterprise Operating Products LLC
Mont Belvieu Complex - PDH Unit
GHG Emissions - Combustion Unit Caps

EPN	FIN	Description	Firing Rate (mmBtu/yr)
HR15.101	HR15.101	Reactor Charge Heater	4,267,060
DW37.101	All of Below:	Waste Heat Boiler:	
	HR15.103	Waste Heat Boiler Burner	297,241
	HR15.102	Regeneration Air Heater	10,417,999
	GT26.101A	Regen Air Comp. Gas Turbine A	2,107,571
	GT26.101B	Regen Air Comp. Gas Turbine B	2,107,571
BO10.103A	BO10.103A	Auxiliary Boiler A	248,500
BO10.103B	BO10.103B	Auxiliary Boiler B	
Total from Above Combustion Units			**19,445,942**
Other (not input as fuel)			
DW37.101		Reactor Injection Gas	777,012
		Reactor Effluent VOC	77,868
		Reactor Decoking	531,742

Available Fuels:

Fuel[1]	Firing Rate (mmBtu/yr)
DeEth Offgas	3,758,478
PSA Tail Gas	2,167,662
Ethane	8,527,648
Natural Gas	4,992,154
Fuel Total	**19,445,942**

1. DeEth Offgas and PSA Tail Gas firing rates are all of these fuels that are projected to be produced annual in the process. All of these fuel gases will be burned in the PDH Unit combustion devices and the balance of the fuel requirements will be made up with either ethane or natural gas. Natural gas is the only fuel that will be fired in the Gas Turbines, and the natural gas firing rate shown is the fuel required for the two Gas Turbines. For the maximum annual GHG emissions calculations all remaining fuel requirements are assumed to be provided by ethane as ethane results in higher GHG emissions per btu than natural gas.

GHG Emission Calculation

Fuel	Firing Rate (mmBtu/yr)	Firing Rate (scf/yr)	Carbon Content (CC)	MW (lb/lbmol)	Emission Rates (tpy)[2]			
					CO_2	CH_4	N_2O	CO_2e
DeEth Offgas	3,758,478	2,503,713,725	0.765	26.66	246,846	12.43	2.49	247,897
PSA Tail Gas	2,167,662	4,374,841,594	0.443	11.14	104,394	7.17	1.43	105,001
Ethane	8,527,648	4,818,697,122	0.798	30.07	558,726	28.20	5.64	561,111
Natural Gas	4,992,154	4,853,259,648	0.723	17.46	295,840	16.51	3.30	297,237
Fuel Total	**19,445,942**	NA	NA	NA	**1,205,806**	**64.31**	**12.86**	**1,211,246**
Reactor Injection Gas	777,012	755,393,543	0.723	17.46	46,047	-	-	46,047
Reactor Effluent VOC	77,868	13,333,260	0.847	102.22	5,580	-	-	5,580
Dekoking[3]	531,742	NA	NA	NA	60,000	-	-	60,000
Cap Total	NA	NA	NA	NA	**1,317,432**	**64.31**	**12.86**	**1,322,872**

2. Note all emission rates are in units of short tons. Eq. C-5 in 40 CFR Part 98 Chapter C yields emissions in metric tons. Metric tons were converted to short tons by multiplying by 1.102311 short tons per metric ton.

3. CO2 from decking based on Lummus EOR estimate of 58,000 tpy, rounded to 60,000 tpy.

Table A-2 GHG Emission Calculations

Enterprise Operating Products LLC
Mont Belvieu Complex - PDH Unit
GHG Emissions - Combustion Unit Caps

Carbon Factor Calculations:

Component	Molecular Weight (lb/lb-mol)	Number of Carbons per mole	Composition (mole %)					
			Natural Gas	DeEth Offgas (SOR)	PSA Tail Gas (SOR)	Import Ethane	Reactor VOC	LTRU Offgas[4]
Nitrogen	28.013	0	0.683	0.490	6.760	0.000	0.000	1.490
Carbon Dioxide	44.010	1	1.797	2.200	0.520	0.000	0.000	0.120
Carbon Monoxide	28.010	1	0.035	1.630	12.470	0.000	0.000	2.750
Helium	4.003	0	0.000	0.000	0.000	0.000	0.000	0.000
Argon	39.95	0	0.000	0.000	0.000	0.000	0.000	0.000
Hydrogen	2.02	0	0.000	8.860	60.070	0.000	0.000	91.190
Methane	16.04	1	93.361	7.680	13.960	0.000	0.000	3.080
Ethane	30.07	2	3.043	71.330	3.470	100.000	1.530	0.770
Propane	44.10	3	0.557	0.060	0.760	0.000	8.113	0.170
Iso-Butane	58.12	4	0.191	0.000	0.000	0.000	0.000	0.000
n-Butane	58.12	4	0.143	0.000	0.000	0.000	9.672	0.000
Iso-Pentane	72.15	5	0.039	0.000	0.000	0.000	0.000	0.000
n-Pentane	72.15	5	0.027	0.000	0.000	0.000	7.792	0.000
n-Hexane	86.18	6	0.088	0.000	0.000	0.000	14.234	0.000
n-Heptane	100.20	7	0.000	0.000	0.000	0.000	12.241	0.000
C10+	140.00	10	0.000	0.000	0.000	0.000	43.807	0.000
Ethylene	28.05	2	0.000	7.170	0.970	0.000	0.182	0.210
Propylene	42.08	3	0.000	0.310	1.010	0.000	2.429	0.220
neo-Pentane	72.15	5	0.000	0.000	0.000	0.000	0.000	0.000
Acetylene	26.04	2	0.000	0.220	0.010	0.000	0.000	0.000
Hydrogen Sulfide	34.00	0	0.000	0.050	0.000	0.000	0.000	0.000
Oxygen	32.00	0	0.037	0.000	0.000	0.000	0.000	0.000
Water	18.02	0	0.000	0.000	0.000	0.000	0.000	0.000
		MW (lb/lbmole):	**17.46**	**26.66**	**11.14**	**30.07**	**102.22**	**4.03**
		Carbon Content (kg C/kg Fuel):	**0.723**	**0.765**	**0.443**	**0.798**	**0.847**	**0.270**
		Heating Value (btu/scf, HHV):	**1028.6**	**1501.2**	**495.5**	**1769.7**	**NA**	**362.0**
		CO2 emission factor (lb/mmbtu,HHV):	**118.55**	**131.39**	**96.35**	**131.04**	**NA**	**29.10**

4 LTRU Offgas will only be burned if the PSA Unit is down, which is a proposed alternate operating mode for which emission rates are not shown as it does not represent the permit basis.

Emission Factors:

Eq. C-5 $CO_2 = \frac{44}{12} * Fuel * CC * \frac{MW}{MVC} * 0.001$ (Eq. C-5)

CO2 = CO2 emissions, metric tons/yr
Fuel = firing rate in mmscf/yr
MVC = 836.6 (per Part 98)
CC = as calculated above
MW = as calculated above

CH4 and N2O Emission factors from Table C-2 of Appendix A to 40 CFR Part 98 Chapter C

	kg CH4 /mmBtu	kg N2O/mmBtu
Natural Gas	0.001	0.0001
Process Gas	0.003	0.0006

kg to lb conversion factor: 2.20462

CO2e Equivalents:

CO2	1.0
CH4	25.0
N2O	298.0