Enterprise Products

ENTERPRISE PRODUCTS PARTNERS L.P.
ENTERPRISE PRODUCTS HOLDINGS LLC
(General Partner)

ENTERPRISE PRODUCTS OPERATING LLC

August 23, 2013

Sent via e-mail

See notes on #1 & #3

Ms. Erica LeDoux
Director Multimedia Planning and Permitting Division
Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas TX 75202-2733

RE: Enterprise Products Operating LLC
Response to GHG PSD Permit Application Information Request of July 26, 2013
Propane Dehydrogenation Unit: Mont Belvieu Complex
Mont Belvieu, Chambers County, Texas

Dear Ms. LeDoux:

Please find the attached a follow-up to your request for information sent e-mail July 26, 2013 on the Propane Dehydrogenation unit (PDH) at the Enterprise Products Operating LLC (Enterprise) Mont Belvieu Complex. The response is in the attachment to this letter.

The PDH project is important to our business and we want to do everything possible to expedite the issuance of the permit. Should you have any questions, or require additional information regarding this registration, please contact me at (713) 381- 5807 or Chris Benton at (713) 381-5807.

Thank you for your time and consideration in this matter

Sincerely,

Edwin J. Bergmann, P.E.
Sr. Engineer - Environmental Air Permitting

cc: Ms. Wren Stenger, Environmental Protection Agency , Director Multimedia Planning Permitting Division, Dallas

Response to July 26, 2013 Request for Additional Information

1) In addition to the proposed combustion cap for the combustion units, please propose an output-based, or combination output- and input-based limit or efficiency-based BACT limit for the following emission sources:

- Reactor Charge Heater EPN: HR 15.101
- Waste Heat Boiler EPN: DW37.101 (The vents directed to the WHB include Regeneration Heater, Regeneration Air Compressor Gas Turbine A/B, VOC from Reactors, Coke Burn, and WHB Duct Burners)
- Auxiliary Boilers EPN: BO10.103A and BO10.103B

Please include the actual supporting calculations and the basis for the rationale used to derive the proposed limits. In the case of the propose limit for the WHB, please provide an explanation how each vent stream directed to the WHB is apportioned to the proposed limit.

Enterprise proposes the following efficiency standards to be met on a 12-month rolling average basis:

Reactor Charge Heater – 85% thermal efficiency, calculated for each operating hour from ambient temperature, exhaust temperature, fuel temperature, and stack oxygen concentration using Equation G-1 from API method 560 (4th ed.) Annex G.

Waste Heat Boiler- Efficiency of this Waste Heat Boiler (WHB) cannot be calculated using traditional methods that involve the steam produced versus fuel input to the system. Such a calculation would result in efficiencies greater than 100% the majority of the time for this system. In this system, most of the heat used to produce steam is recovered heat from the turbine exhaust, reactor ejector effluent exhaust, and oxidation of VOCs from the Catofin Reactors over two separate catalyst beds. Firing of fuel in the WHB duct burners will be intermittent as required to supplement recovered heat to produce sufficient steam and heat condensate to operate the unit. For these reasons, there is no practical method to calculate or monitor the thermal efficiency of the system; therefore, Enterprise is not proposing an efficiency standard for this system.

Note to permit writer: in original application proposed 125 lb CO_2/MMB for DW37. page 6-11

Auxiliary Boiler - The purpose of the auxiliary boiler on hot standby is to reduce the restart time after a unit trip. The auxiliary boiler not only makes steam at the higher rates required for startup efficiently (approximately 80%), it also reduces the steam system reheat time by 8-12 hours. Alternatively, if no auxiliary boiler is utilized, each trip event requires an extra 8-12 (total time of 16-25 hours) hours of time where energy is not used to make product, in other words, steam for restart would be generated in a very inefficient manner. Finally, if the Air Compressors are used to make auxiliary, or reheat, steam, that steam is made with a very inefficient 14% excess O2.

The auxiliary boilers in the PDH process will be operating the majority of the time in a turned down hot standby mode of about 14MMBtu/hr, or about 3.5% of rated capacity. The low operating rate reduces thermal efficiency as compared to normal operational rates, however calculation of thermal efficiency of these boilers at the turned down condition does not reflect the impact on overall system

Efficiency (%) = Heat Content of Steam Produced/Heat Content of Fuel Fired x 100%

2) Please provide benchmark data that compares the design selection for the Reactor Charge Heater, WHB, Regeneration Heater, Regeneration Air Compressor Gas Turbine, Auxiliary Boilers to similar or existing sources (nationally or internationally) and/or efficiency. It is suggested that Enterprise includes the details to the evaluation performed in the design decisions that are specific and unique to the plant operation (e.g., fuel gas characteristics).

The design thermal efficiency of the Reactor Charge Heater is 90%. Heaters used in this type of application have thermal efficiencies ranging from 75% to 90%, with a theoretical maximum efficiency of 92% (*Energy Efficiency Improvement and Cost Saving Opportunities for the Petrochemical Industry: An ENERGY STAR Guide for Energy Plant Managers* (Environmental Energy Technologies Division, University of California, sponsored by USEPA, June 2008). Thus, the proposed heater incorporates all reasonably available energy efficiency features available, and no alternate heaters with higher design efficiencies were available.

The design thermal efficiency of the Auxiliary Boilers is 83.6% at the rated capacity. This compares to typical ranges of 75% to 85% for other similar boilers. Although there are additional design features that can increase the boiler efficiency that would improve fuel consumption for a base load boiler, operation in the standby mode reduces the benefit of these features to a point where they are not cost effective and do not result in any significant efficiency improvements and corresponding reductions in fuel consumption. For this reason, Enterprise selected the proposed boiler design for the project.

A benchmark for efficiency is shown in Figures 1-3. The ISO efficiency is shown on the last column of Figure 1. However, to properly evaluate efficiency, turbine and compressor combinations must be evaluated at conditions that will approximate operating conditions. This evaluation must consider the available turbine and the horsepower required for the particular application. Also, considerations have to be made to the emissions from the gas turbine, ability of the turbine to maintain required horsepower over time and amount of fuel used per horsepower produced. This total train efficiency is shown in the blue shaded area at the bottom of Figure 1.

Figures 2 is an example of performance curves and power requirements of the compressor/turbine sets evaluated previously in Figure 1. Figure 3 shows an example of a turbine ability to meet power requirements over time when degradation is taken into consideration.

Therefore, various evaluation points were considered to choose the Rolls Royce turbine as being the most suitable for this application.

Figure 1

Actual Operating Load Comparisons

		Units	Normal Case 100 % Flow			Design Case 100 % Flow			Normal Case 110 % Flow			Design Case 110 % Flow			GT ONLY*
															ISO
	Air Compressor Discharge Pressure	psia		29.5			29.5			31.7			31.7		
	Ambient Temp	F	95	68.8	10	95	68.8	10	95	68.8	10	95	68.8	10	59 F
COMPRESSOR	**GE (Centrifugal)**														
	Power Required	HP	26582			28801			30596	28521	24613	33022	30999	27030	
	Polytropic Efficiency	%	81			81.7			77.8	79.1	81.1	79.8	80.6	81.8	
	Speed	RPM	3114			3208			3266	3132	2859	3333	3207	2944	
	Siemens (Axial)														
	Power Required	HP	23602	22474	20556	24630	24310	22228	26034	25268	21656	28169	27211	23273	
	Polytropic Efficiency	%	85	84.7	82.4	87.4	87.1	84.7	81.9	82.9	82.3	84.2	85.4	85.6	
	Speed	RPM	3260	3260	3260	3260	3260	3260	3260	3260	3260	3260	3260	3260	
	MAN-RR (Axial)														
	Power Required	HP	23290	21805	19180	25668	23915	21429	26804	24854	21440	28583	26879	23385	
	Polytropic Efficiency	%	89.5	90.2	91	89.9	91.1	91	85.8	87	89.3	89.1	89.2	90.7	
	Speed	RPM	2952	2837	2599	3012	2901	2673	3127	2993	2714	3166	3037	2766	
GAS TURBINE	**GE (LM2500 G4 DLE)**														
	Fuel flow	lb/hr	10624			11014			11386	11221	10524	12061	11632	11016	
	Heat Rate	Btu/hp-hr	7755			7597			7510	7940	8628	7371	7573	8224	6404
	Thermal Efficiency	%	32.8			33.5			33.9	32.1	29.5	34.5	33.6	30.9	39.7
	NoX		22			22			23	23	34	24	24	36	
	CO		13.1			13.6			14.1	13.9	20.78	14.9	14.4	21.75	
	CO2		25385			29424			30412	29972	28100	32209	31075	29416	
	HC		4.4			4.6			4.8	4.7	7.3	5.0	4.9	7.6	
	Siemens (STG 700)														
	Fuel Flow		9824	12208	15222	9824	12208	15222							
	Heat Rate	Btu/hp-hr	8261	8315	8530	8261	8315	8530							6805
	Thermal Efficiency	%	30.8	30.6	29.8	30.8	30.6	29.8							37.4
	Power Available At Cplg	HP	23974	29601	35975	23974	29601	35975							
	NoX		13	18.1	24.0	13	18.1	24.0							
	CO		4.8	45.8	193.4	4.8	45.8	193.4							
	HC														
	VOC		0.6	0.1	1.9	0.6	0.1	1.9							
	Rolls Royce (RB211-GT62)														
	Fuel Flow	lb/hr	9859	9607	8847	10409	10108	9559	10657	10316	9553	11064	10788	10177	
	Heat Rate	Btu/hp-hr	8530	8878	9295	8172	8517	8989	8012	8364	8979	7800	8088	8770	6602
	Thermal Efficiency	%	29.8	28.7	27.4	31.1	29.9	28.3	31.8	30.4	28.3	32.6	31.5	29.0	38.5
	NoX		16.0	15.7	15.4	17.3	16.9	16.7	17.0	23.0	16.7	18.0	17.7	17.0	
	CO		12.1	11.8	191.6	13.0	12.7	90.0	12.7	30.9	89.8	13.5	13.3	37.4	
	HC		1.8	1.8	27.2	2.0	1.9	12.7	2.0	1.8	12.7	2.1	2.0	5.3	
	VOC		0.4	0.3	5.4	0.4	0.4	2.6	0.4	0.7	2.5	0.4	0.4	1.1	
TOTAL TRAIN	**GE TRAIN**														
	Gas Horsepower Required	GHP	21531			23530			23804	22560	19961	26352	24985	22111	
	Total Efficiency	%	25.6			26.9			26.4	25.4	23.9	27.6	27.1	25.3	
	Siemens TRAIN														
	Gas Horsepower Required	GHP	20062			21527									
	Total Efficiency	%	25.8			27.6									
	MAN-RR TRAIN														
	Gas Horsepower Required	GHP	20845	19668	17454	23076	21787	19500	22998	21623	19146	25467	23976	21210	
	Total Efficiency	%	26.7	25.8	24.9	28.0	27.2	25.7	27.2	26.4	25.3	29.0	28.0	26.3	

Siemens efficiencies are not strictly correct since they did not calculate correct part load gas turbine horsepower need to match compressor required horsepower. At lower part load the gas turbine will be less efficient and produce more emissions.

For these 2 cases power at gas turbine coupling is close to required power to drive compressor so estimates should be close.

* Source: Gas Turbine World 2012 Performance Specs" Industry Publication

Guarantee values

Total Train Efficieny = Gas Horespower at Compressor / Heat Input to Gas Turbine

With th more efficient compressor and similar eficiency gas turbine, MAN-RR has the best overall energy usage. With the less efficient GE compressor the GE gas turbine requires more fuel/hour to run.

Figure 2

Additional Note:

Actual Operating Load Comparisons

As shown in the plots below the higher power requirement by the GE compressor allows less room for GE gas turbine degradation over time and ability to meet power demand requirements.

Load / Performance Curve

Project
SBEC Enterprise PDH

Service
Regeneration Air Compressor

Item Number
Compressor:52020-CM12.101A/B
Driver:52020-GT26.101A/B

Type
Vendor Comparisons

Site Conditions
Relative Humidity: 50 %
Elevation: 69 ft ASL

GT Power Margins - LUM 2% Margin on Comp Pwr
(No GT or Compressor Degradation)

	Ambient Temperature		
Vendor	95	100	105
M-RR GT62	12%	7.9%	4.1%
M-RR G62	2.2%	-1.3%	-4.7%
GE LM2500	2.3%	-2.5%	-6.8%
Siemens*	13%	6.5%	0.0%
GE MS5000**	-11%	-14%	-17%

(*Note: Based on Siemens' final issued curve)
(**Note: Below 95F curve shape may be different due to insufficient data points)

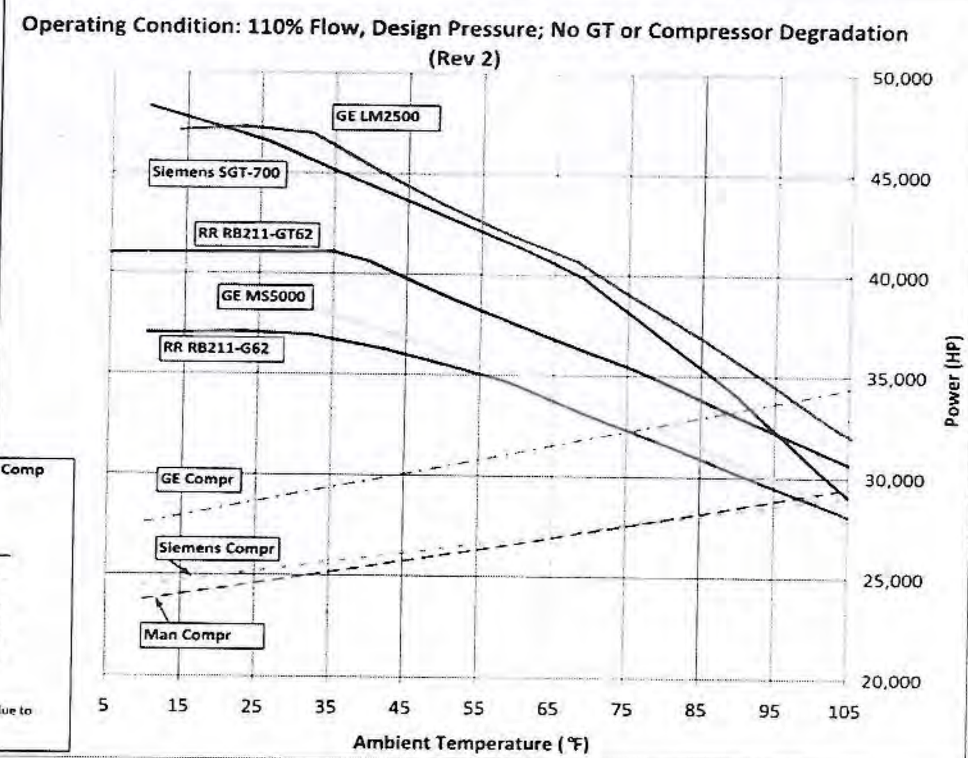
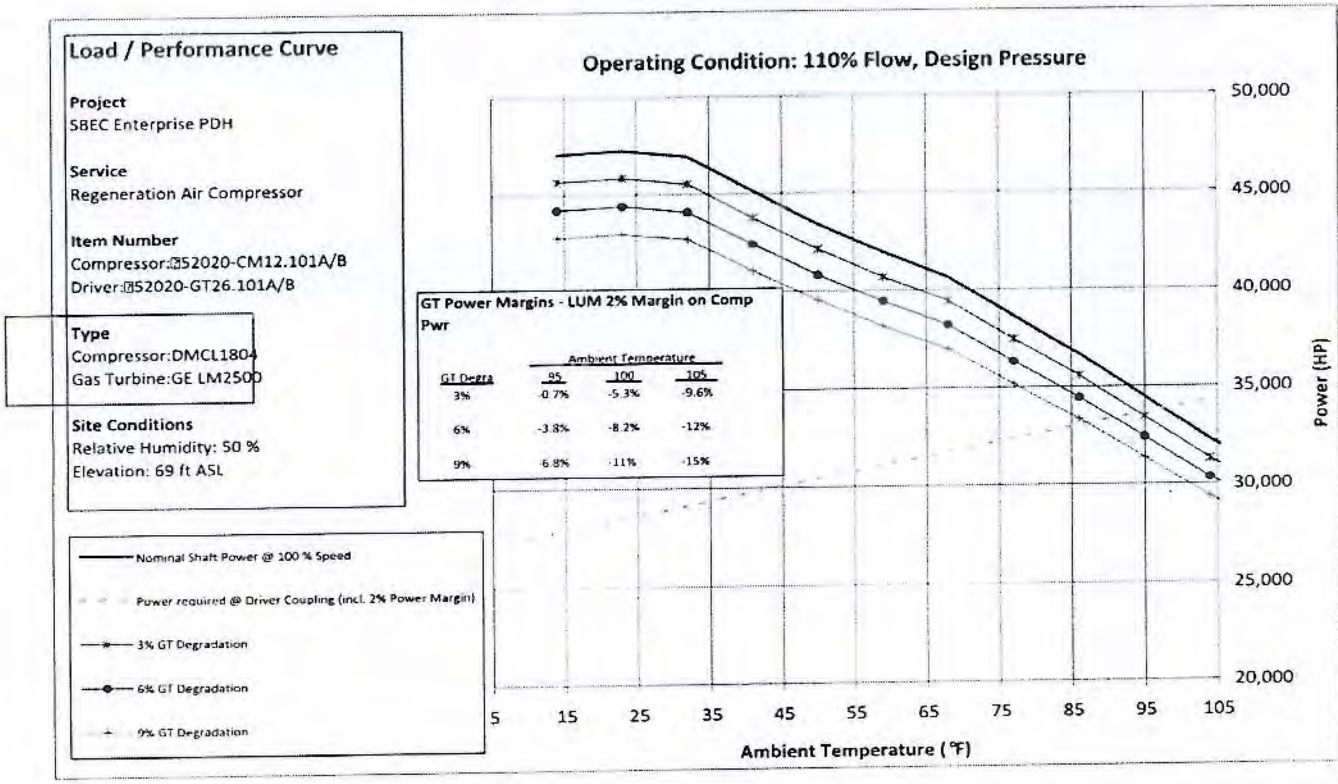


Figure 3

Actual Operating Load Comparisons



3) Please expand on the process description given on page 5.1 of the permit application for "Combustion Units" pertaining to how emission rates were calculated.

The first paragraph in Section 5.1 Combustion Units is an introductory and only intended to provide a general description of the emission calculation procedure. The detail that is requested is included in Subsections 5.1.1 through 5.1.4 which describe the calculations for each individual combustion unit. EPA equations from 40 CFR Part 98 were used to calculate the GHG emissions for all combustion units, and the equations used are identified in these sections. In addition, the variables used in each calculation are included in the tables in Appendix C that are referred to in the text. This information fully describes the calculations and there are no further details that could be provided.

Note to permit writer: I still see the statements made in Section 5.1 of original application problematic. Enterprise should remove or fix or explain ???

4) In comparing another PDH permit application with Enterprise, a noted difference was the inclusion of a CO2 removal system for the CO2 present in the process gas. The other PDH unit has a absorption process for sour gas removal which selectively removes CO2 from the process gas. Does Enterprise also have a similar CO2 removal system for CO2 in the process gas? If not, please explain.

The other PDH permit application that you refer to is based on a different process from the process Enterprise has proposed; thus, the two processes cannot be directly compared. Our proposed process does not result in CO2 in the product stream that would require a similar CO2 removal system. It should also be noted that the CO2 removal system that you refer to removes CO2 from the product, and the removed CO2 is ultimately released to the atmosphere and thus is not an emission control strategy.