From:	Peters, Howard S
To:	Wilson, Aimee; Robinson, Jeffrey; Javier Garza (javier.garza@tceq.texas.gov)
Cc:	Lundgren, Andrew A.; Trebatoski, Robert J.; Sharma, Rohit K
Subject:	Equistar Corpus Christi Olefins Expansion - GHG Additional Information
Date:	Wednesday, January 29, 2014 4:53:06 PM
Attachments:	Steam Superheater Information.pdf Technical Infeasibility of Carbon Capture and Storage.pdf Chain of Events Caused by Back Pressure.pdf Flue Gas Composition.pdf Leakless Fugitive Components.pdf MSS Flare Discussion.pdf

Aimee,

Per our telephone conversation on January 24, 2014 Equistar Corpus Christi is providing the attached information in support of the GHG PSD Permit Application. The attached information is in response the following information requests/clarifications:

- Technical infeasibility of Carbon Capture and Storage (CCS) for the modified Cracking Furnaces and Steam Superheaters
- Additional description of the Steam Superheaters
- Clarification of Maintenance, Startup and Shutdown (MSS) flare emissions for the project
- Additional discussion of fugitive components and leakless technology
- Chain of events due to back pressure on the Cracking Furnaces and Steam Superheaters
- Flue gas composition for the Cracking Furnaces and Steam Superheaters

Please review the attached information and if you have any questions or concerns please do not hesitate to contact me.

Thank you,

H. Scott Peters
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Steam Superheater Carbon Capture and Storage (CCS) BACT Determinations

In the revised "*Olefins Plant Expansion Project Application for Prevention of Significant Deterioration Greenhouse Gas Emissions ("GHG") Air Permit*" submitted on October 7, 2013 the Carbon Capture and Storage ("CCS") BACT analysis for the Steam Superheaters referenced the Cracking Furnaces CCS BACT analysis. A separate CCS BACT discussion could have been added to the GHG Permit Application, but would have been a duplicate of the same information presented in Cracking Furnace CCS BACT discussion which may have added confusion to the application. The Steam Superheaters CCS BACT discussion referenced the Cracking Furnaces CCS BACT discussion for the following reasons:

- The design of a Steam Superheater is similar to that of a Cracking Furnace in that both are "furnaces" that have radiant and convection sections.
- Neither the Steam Superheaters nor the Cracking Furnaces are designed to allow for back pressure during operation.
- Both the Steam Superheaters and Cracking Furances have induced draft (ID) fans.
- Both the Steam Superheaters and the Cracking Furnaces have the same fuel gas source.
- The flue gas composition of both the Steam Superheaters and the Cracking Furnaces are the same.
- Both the Steam Superheater and Cracking Furnaces are existing structures with the same physical limitations for retrofitting an add on CCS system (such as designing for high wind loads, i.e. hurricanes and adding duct work)
- The GHG emission factors for both sources are the same, i.e. CO2 is calculated using Equation C-5 from 40 CFR 98 Chapter C.

CCS is technically infeasible for the existing Steam Superheaters for the same reasons as the existing Cracking Furnaces; hence the CCS BACT discussion for the Steam Superheaters referenced the discussion for the Cracking Furnaces.

Technical Infeasibility of Carbon Capture and Storage (CCS)

Equistar rejects CCS as a control technology for the project based on technical infeasibility. Equistar has determined that CCS should be rejected in Step 2 of the top-down BACT analysis due to technical infeasibility for both the Cracking Furnaces and Steam Superheaters (the Steam Superheaters are a type of furnace and are included with the Cracking Furnaces in this discussion, which will collectively be referred to as "furnaces"). The proposed project would modify the existing furnaces and would not involve the construction of a new furnace.

The current stage of development of the related technologies falls short of having CCS being "demonstrated" for control of CO2 from large furnaces' flue gas with the CCS being installed as a retrofit. In spite of much effort, Equistar has been unsuccessful in identifying any installation of carbon capture technologies for control of CO2 emissions from olefins plant cracking furnaces, let alone any retrofit installation. The technology is not demonstrated for this application.

There are multiple issues with a retrofit of CCS as a control for CO2 from furnaces at this facility that render CCS technically infeasible. These are discussed below and include, but are not limited to:

- Construction of necessary elevated flue gas ductwork.
- CCS turndown capability.
- Having four types of combustion devices served by a single carbon capture system.
- Flue gas carbon dioxide concentration.
- Chain of events due to back pressure on the furnaces.

Construction of necessary elevated flue gas ductwork in an already congested area and at a location that experiences occasional hurricane force winds, which requires a designed wind load basis of 120 mph, makes this aspect of installation practicably infeasible. The area where the support for ductwork would be needed is already congested. Each of the furnaces has a relatively short stack. To route the flue gas to a suitable carbon capture system, the stacks would have to be run horizontally along the furnace row, individually or in some combination. The size of the ducting would subject a supporting structure to high wind loads, necessitating a robust structure within an already congested area.

The olefins plant is constructed with 17 existing furnaces that can be individually fired at varying rates based operating conditions, market conditions, maintenance activities and feedstock slate. Engineering and installing a CCS system that could manage the robust and varying flow rates (which could range anywhere from zero to maximum firing of all 17 furnaces) would not be technically feasible for this project.

Projects that have been considered for CCS have been new construction on a single stack; again none have been identified in an olefins plant. The subject of this permit is the modification 4 different furnace types. Engineering and installing a CCS system that could control CO2 for varying types of furnaces would be technically infeasible.

The furnaces may be fueled with a variety of gas streams ranging from natural gas to plant produced fuel gases, and some of the fuels may contain a large fraction of hydrogen. As a result, the carbon dioxide volumetric concentration in the flue gas can range from approximately 4% to 8.3%. Post combustion flue gas where CCS would be considered technically feasible would be expected to have a minimum volumetric CO2 concentration of 12%.

The flue gas containing the post combustion CO2 from the proposed modified fired sources originates from the existing furnace stacks. The flue gasses at these elevated furnace stacks are at atmospheric pressure, and no motive force is available to direct these gasses to any desired location. The induced draft ("ID") fans on these sources are designed to maintain the furnaces at a slight vacuum while discharging to atmospheric pressure. Any increase in discharge pressure, such as venting to a carbon capture and storage system, will result in furnace pressure higher that atmospheric. The greater than 1900 ^{o}F combustion gasses generated within the furnace are easily capable destroying the furnace and surrounding equipment in very short order upon failure of the ID fan that is designed to remove these hot gasses as they are generated. Failure of the ID fan closes all fuel gas to the affected furnace to prevent critical failure of the equipment. Any operation of the furnaces at a positive pressure, even for short durations, will result in flame escaping the furnace with the possibility of damaging adjacent piping (hydrocarbon containing), instrumentation, personnel, and structures. High enough pressures will result in furnace wall damage, with eventual uncontrolled furnace fire and furnace collapse with potential impact to the environment and community.

Chain of Events Caused by Back Pressure on Cracking Furnaces and Steam Superheaters

The flue gas containing the post combustion CO2 from the proposed modified fired sources originates from the existing Cracking Furnace and Steam Superheater ("furnace") stacks. The flue gasses at these elevated furnace stacks are at atmospheric pressure, and no motive force is available to direct these gasses to any desired location. The induced draft ("ID") fans on these sources are designed to maintain the furnaces at a slight vacuum while discharging to atmospheric pressure. Any increase in discharge pressure, such as venting to a carbon capture and storage system, will result in furnace pressure higher that atmospheric. The greater than 1900 ^oF combustion gasses generated within the furnace are easily capable destroying the furnace and surrounding equipment in very short order upon failure of the ID fan that is designed to remove these hot gasses as they are generated. Failure of the ID fan closes all fuel gas to the affected furnace to prevent critical failure of the equipment. Any operation of the furnaces at a positive pressure, even for short durations, will result in flame escaping the furnace with the possibility of damaging adjacent piping (hydrocarbon containing), instrumentation, personnel, and structures. High enough pressures will result in furnace wall damage, with eventual uncontrolled furnace fire and furnace collapse with potential impact to the environment and community.

Table B-1
Heater Emission Calculations EPN: 1A
Equistar Chemicals LP - Olefins Plant Expansion
Corpus Christi, Nueces County, Texas

Fuel Gas Composition

Component	Fuel Gas (wt%)	Fuel Gas (mol)%	Molecular Weight	LHV (BTU/lbmol)	HHV (BTU/lbmol)
Methane	94.18%	97.03%	16.04	351123	390051
Ethane	4.00%	2.20%	30.07	628629	687213
Ethylene	0.02%	0.01%	28.05	577791	616604
Propane	0.53%	0.20%	44.10	906906	985533
Propylene	0.00%	0.00%	42.08	840921	899082
n-Butane	0.04%	0.01%	58.12	1195204	1298498
n-Pentane	0.00%	0.00%	72.15	1429543	1545170
Hydrogen	0.00%	0.00%	2.02	105529	124955
Nitrogen	0.22%	0.13%	28.01	0	0
Carbon Dioxide	0.85%	0.32%	44.01	0	0
Carbon Monoxide	0.15%	0.09%	28.01	123529	123529
	100.0%	100.0%			

Average Molecular Weight=	16.53 lb/lbmol		Molar Volume	385.43 scf/lbmol
Fuel gas HHV=	395,860 BTU/lbmol	1027 BTU/scf		
Fuel gas LHV=	356,628 BTU/lbmol	925 BTU/scf		
Operating Hours=	8,760 hrs/yr			

Fuel Input

Averaging Period	Duty (HHV) (MMBTU/hr)	Fuel Gas Molar Flowrate (lbmol/hr)	Fuel Gas Vol. Flowrate (scf/hr)	Fuel Gas Vol. Flowrate (scfm)
Hourly	188.0	475	183,044	3,051
Annual	188.0	475	183,044	3,051

Combustion Calculations

Component	Fuel Molar Flowrate (lbmol/hr)	O_2 Stoic. Coeff.	Oxygen Requirement (lbmol/hr)	CO_2 Stoic. Coeff.	CO_2 Production (lbmol/hr)	H_2O Stoic. Coeff.	H_2O Production (lbmol/hr)
Methane	460.8	2.0	921.6	1.0	460.8	2.0	921.6
Ethane	10.5	3.5	36.6	2.0	20.9	3.0	31.4
Ethylene	0.0	3.0	0.1	2.0	0.1	2.0	0.1
Propane	1.0	5.0	4.8	3.0	2.9	4.0	3.8
Propylene	0.0	4.5	0.0	3.0	0.0	3.0	0.0
n-Butane	0.0	6.5	0.3	4.0	0.2	5.0	0.2
n-Pentane	0.0	8.0	0.0	5.0	0.0	6.0	0.0
Hydrogen	0.0	0.5	0.0	0.0	0.0	1.0	0.0
Nitrogen	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Carbon Dioxide	1.5	0.0	0.0	1.0	1.5	0.0	0.0
Carbon Monoxide	0.4	0.5	0.2	1.0	0.4	0.0	0.0
TOTALS	**474.9**		**963.6**		**486.8**		**957.1**

Air Requirements:

Excess Air 15.0%

Composition of Air					
O2	20.59%	O_2 Flowrate=	(964 lbmol O2/hr)(1 + 0.15)=	1,108	lbmol/hr
N2	76.76%	N_2 Flowrate=	(1,108 lbmol/hr)(0.7676 lbmol N2/0.2059 lbmol O2) =	4,131	lbmol/hr
Ar	0.91%	Ar Flowrate =	(1,108 lbmol/hr)(0.0091 lbmol Ar/0.2059 lbmol O2) =	49	lbmol/hr
H2O	1.71%	H2O Flowrate =	(1,108 lbmol/hr)(0.0171 lbmol H2O/0.2059 lbmol O2) =	92	lbmol/hr
CO2	0.03%	CO2 Flowrate =	(1,108 lbmol/hr)(0.0003 lbmol CO2/0.2059 lbmol O2) =	2	lbmol/hr
		Air Flowrate=		5,382	lbmol/hr

Exhaust Emissions

Component	Emission Basis		Emission Rate (lb/hr)	Emission Rate (tpy)	Emission Rate (lbmol/hr)	Emission Rate, dry @ 3% O_2 (lbmol/hr)	Conc. (% vol)	Conc. (% vol, dry @ 3%O_2)
	Emission Factor	Units						
N_2					4,131	4,131	70.5%	85.8%
Ar					49	49	0.8%	1.0%
O_2					145	144	2.5%	3.0%
H_2O					1,049	NA	17.9%	
CO_2					488	488	8.3%	10.1%
PM10/PM2.5	0.0050	lb/MMBtu	0.94	4.12	NA	NA	NA	NA
VOC	0.0054	lb/MMBtu	1.01	4.44	0.063	0.063	0.0011%	0.0013%
NOx	0.06	lb/MMBtu	11.28	49.41	0.245	0.245	0.0042%	0.0051%
NOx (decoking)	0.10	lb/MMBtu	9.40	-	0.204	0.204	0.0035%	0.0042%
CO	0.036	lb/MMBtu	6.74	29.52	0.24	0.24	0.0041%	0.0050%
SO_2	0.00059	lb/MMBtu	0.11	0.48	0.00	0.00	0.0001%	0.0001%
Totals					5,862	4,812	100%	100%

Notes:
1. Emission Factors for VOC, PM10/PM2.5, SO2 and CO from AP-42 Table 1.4-1.
2. NOx emissions factor based on vendor guarantee.

Discussion of the Use of Leakless Fugitive Components

Equistar evaluated the use of leakless fugitive components for this project. These technologies include, among others, complete elimination of flanges and connectors by substituting welded connections in piping systems, and the use of leakless valves with diaphragms or bellows seals in place of conventional stem glands.

Flanges and Connectors:

Flanges and connectors inherently cannot be leakless, and the facility cannot be properly and effectively constructed, operated or maintained without the use of flanges and connectors. The complete elimination of flanges and connectors in the project would significantly increase the cost and time of initial installation, as well as cause increased downtime for maintenance of the facility. The installation of piping without flanges and connectors would be time consuming and expensive due to the required field fabrication and design. Maintenance activities in the process unit would potentially require a process unit shut down since isolation of the equipment would not be available. Emissions of GHG and conventional pollutants from maintenance activities would be increased due to having to gas free larger sections of piping and perform unit shutdowns. Equistar cannot eliminate the use of flanges and connectors but will use welded piping where practicable in the expansion project.

Valves:

Some leakless valve technologies are technically infeasible. Other leakless valve technologies are impracticable and expensive. For example, diaphragm valves are not available for some high pressure systems. Application of leakless technology is limited by factors stroke length, elevated service temperatures, pressure fluctuations, and pressure retention capability. Size limitations (piping diameters) and envelop dimensions further compound adaptation to existing operations or design.

Period maintenance of leakless technology components may increase the frequency of introduction of ignition sources within the operating areas as any replacement of these components will likely need to be cut out and welded in place. In contrast to shop welding and field bolt up using non-sparking tools. Maintenance or replacement of system components would require literally cutting them out of the piping system, then welding in new or refurbished components with expensive and difficult weld quality checks required in-situ.

Components such as leakless valves are significantly more expensive than typical valves with conventional seals that are currently used in the existing plant. The cost of leakless valves is estimated to be 3 to 10 times higher than comparable high quality valves, per vendor information. The contribution of valves GHG emissions for this project is 3.51 tpy of methane or 73.71 tpy of CO2e (since the flanges and connectors would still have GHG emissions). Using a very conservative estimate that the cost of leakless valves would be 3 times higher than comparable high quality valves, the cost of leakless technologies would be $4.8 million greater than high quality valves alone. Hence the cost effectiveness of the leakless valve technologies does not appear to be reasonable at a cost of $65,120/ton of CO_2e. Equistar will use high quality components and materials for design and construction of the expansion project.

Maintenance Startup and Shutdown (MSS) GHG Emissions for Flare EPN 10

The flaring emissions represented in the revised "*Olefins Plant Expansion Project Application for Prevention of Significant Deterioration Greenhouse Gas Emissions ("GHG") Air Permit*" submitted on October 7, 2013 are Maintenance, Startup and Shutdown (MSS) emissions associated with the proposed new equipment for the expansion project. There are no additional routine process flaring emissions associated with this permit application. The MSS flaring for the new equipment will occur on an existing flare at the plant and the majority of the MSS emissions for this permit application will be generated when the plant is shutdown and subsequently started up during a plant turnaround, normally occurring once every 5 to 6 years. The increase in the proposed MSS GHG emissions are only for equipment that would be installed as part of this project. The plant is already authorized for MSS emissions from existing equipment to the same flare as well as routine emissions. Based on a 5 year turnaround schedule if the MSS GHG emissions are annualized the proposed MSS emissions in this permit application for the project represents about 3% of the total GHG emissions from the existing flare.

The proposed MSS gases generated and routed to the existing flare are not suitable for a flare gas recovery system. The variability in flow and composition of the MSS generated gases would make design and installation of a recovery and compressor system technically infeasible since such a system would require a consistent flow and composition for compressor and recovery system sizing and engineering. Additionally, the bulk of the emissions will be generated when the plant is either being shutdown or started up, meaning there would be no available destination or storage for the MSS gases if recovered.