From: Davis, Jarod (D)
To: Toups, Brad
Cc: Davis, Jarod (D)
Subject: FW: Need a couple of updates from you
Date: Wednesday, February 05, 2014 11:37:10 AM
Attachments: TXO Site Netting (LHC 9) CO2e 2014.01.30.pdf
2014-02-04 page 22.pdf
2014-02-04 LHC9 emis summary.pdf

Brad

Please see responses to your questions below. Please note that we are working on finalizing the plot plan and will have it to you this week, if possible.

1) A current plot plan with the TOX on it. Was this sent in hard copy separately? Also on that same plot plan, are the decoking drums emissions points needed any longer for GHG purposes? Do the fuel gas purge vents need to be shown routed to the flare/tox rather than the EPNs on the current plot plan?

   The updated plot plan is pending; we will submit it by the end of the week. The decoking drum and emission points have been removed; the fuel gas purge vents will remain. The fuel vents are part of the NFPA compliant safety system to ensure isolation of fuel sources to the heaters.

2) An updated PSD Table F

   Updated Tables 1F, 2F, and 3F are included as an attachment to this response. We are also submitting updated emission summary tables (Table 3-1 and Table 4-11) which reflect a revised total annual GHG emission. This revision is necessary in order to avoid double-counting emissions by including contributions from both the TOX and the low pressure flare. The low pressure flare is a backup control device for the TOX, therefore waste gas emissions can only be routed to either of the two, but not both at the same time. To present a worst case scenario, emissions from the low pressure flare were included in the summaries as they are higher. This assumes the TOX is down and is not generating emissions.

3) When comparing 12/19/13 Table 4-11 summary with the Sept 2013 Furnace BACT, some updates appear to be needed in the Furnace BACT Section, Sections 4.1 thru 4.1.4.2, specifically,

   a. The furnace temp was updated in Dec to <= 330, up from 271F on Page 20 of 9/12/13. Is the 330 a max instantaneous, and the 271 an hourly average or something else? If so, does this mean that you are now selecting the 1994 value of table 4-3 rather than the "Chosen Design" value of 271? The only explanation provided in the Dec update was " What does this do to the 'Solomon Associates" report validity for the project? Also, are the TCEQ permit representations (Table 1A, April 2, 2013 NOD response, page 70 of 82 of that doc) still showing 300F for the stack temps?

      As the cracking furnaces age, their efficiency will degrade due to fouling in the convection section of the furnaces which results in higher stack temperatures. While the BACT

benchmarking analysis reflects the best case design basis, other permit representations reflect the expected furnace efficiency after years of operation. To set BACT limitations on the 'new' furnace design capability will impose limitations on future furnace operation. Dow selected a maximum exhaust temperature of 330°F to allow for ample operating margin and furnace efficiency degradation over time.

The "Chosen Design" of 271°F in table 4-3 is still valid because it is the design basis of the cracking furnaces and does not reflect efficiency losses over time due to fouling in the furnaces. The cracking furnaces in Dow's new ethylene plant are designed to have stack temperatures ranging from 268 to 290°F depending on fuel composition and feedstock type. The furnace temperature shown in Table 4-3 of the 9/12/13 revised application depicts the design basis for the cracking furnaces. The Solomon Associates letter reflects the design basis of the furnaces making it still valid.

Additionally, the design basis for a new furnace reflects an exhaust temperature of 271°F at 'end of run' conditions (when the furnace is nearing the decoke cycle) for a furnace firing on off-gas and cracking an ethane feed. The corresponding expected exhaust temperature at the 'start of run' in this scenario (when a newly decoked furnace is returned to operation) is 268°F.

The reason for the increase in exhaust temperature is due to coke buildup inside the furnace coils over time, making the coils resistant to heat transfer. In turn, the furnace must be fired harder, generating more heat. Most of this heat goes into steam; however some does not and is reflected in a higher stack exhaust temperature at the end of run. As the furnace ages, the start of run temperatures increase due to fouling in the convection section and the corresponding end of run temperature increases.

The fuel that the furnace is firing on impacts the start of run temperature and corresponding end of run temperature. If the furnace is firing on natural gas, the exhaust temperature is higher. See table below for a comparison of an ethane cracking design case:

Furnace Feed	Furnace Fuel	Start of run temperature	End of run temperature
Ethane	Off-gas	268°F	271°F
Ethane	Natural Gas	286°F	289°F

The TCEQ permit representations (Table 1a Emission Point Parameters) reflect an exhaust temperature of 268°F as this was the exhaust temperature used for air dispersion modeling. Using this lower temperature resulted in a worst case predicted impact of furnace emissions.

b. On Page 22 of 9/12/13, you indicate maximum production of 2,102,100 tpy ethylene and 2,367,999 tpy CO_2e. Seems like both of these numbers might need updating, which may change the ratio found in both the 12/19/13 Table 4-11, page 43 and the 9/12/13 page 22-

23 values.

The nominal plant capacity is 1.5 mmtpy. The permit reflects some margin in the furnace firing rate therefore overall plant capacity also includes the same margin in order to correctly represent the ratio of GHG emissions to ethylene production.

A revised page 22 is included as an attachment to this response.

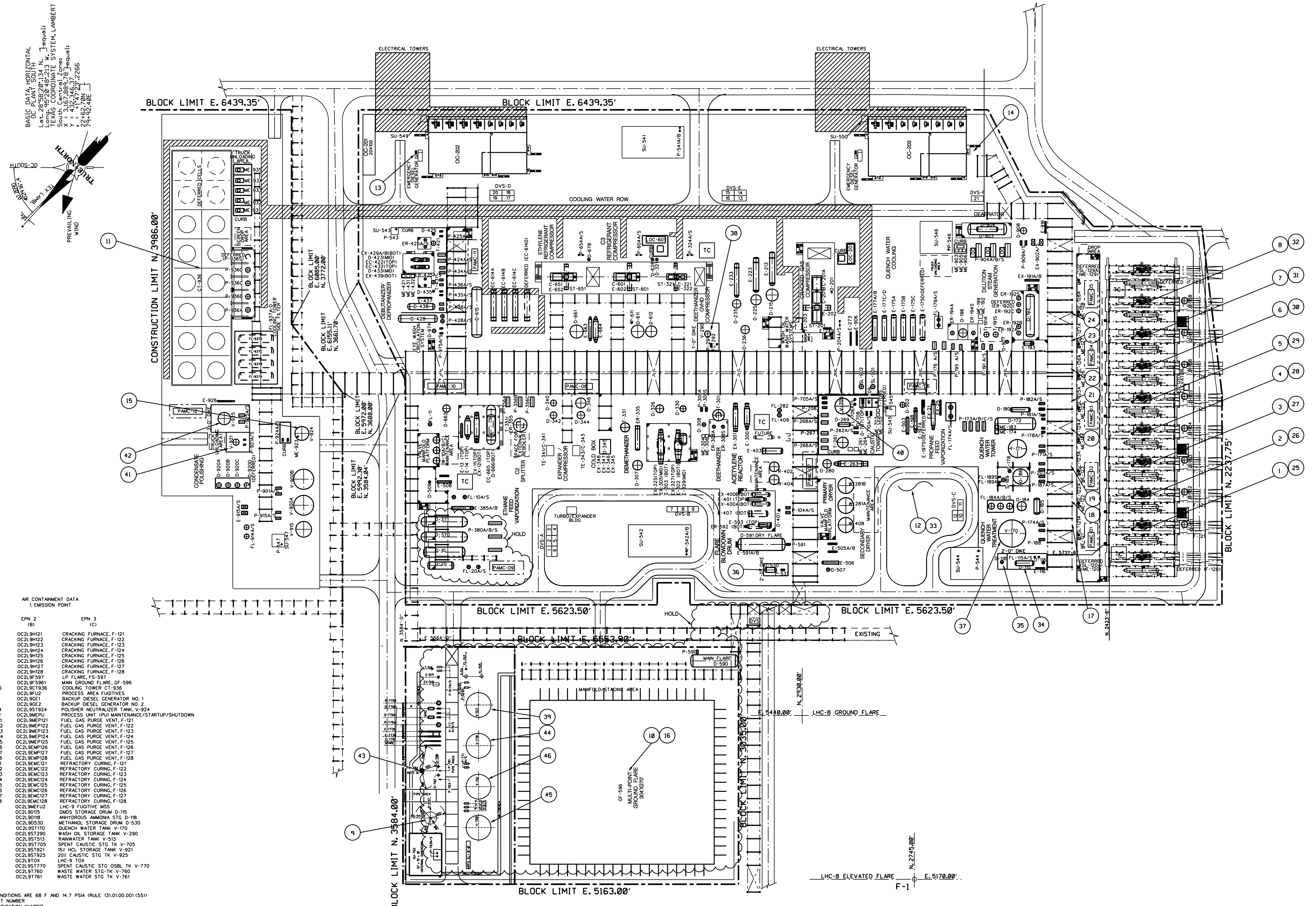
c. Is the nominal production capacity 1.5 mmtpy ethylene or 2.1 mmtpy or some other number?

The nominal plant capacity is 1.5 mmtpy.

d. Should Tables 4-1 and 4-2 also be revised in permit app dated 9/12/13?

Tables 4-1 and 4-2 do not need revision because the design basis was used for the benchmarking analysis.

Jarod D. Davis
The Dow Chemical Company
Operations Regulatory Services
979-238-3190
jdavis5@dow.com



AIR CONTAINMENT DATA

1. EMISSION POINT

PLOT INDEX NO.	EPN 1 (A)	EPN 2 (B)	EPN 3 (C)
1	OC2H121	OC2L9H121	CRACKING FURNACE, F-121
2	OC2H122	OC2L9H122	CRACKING FURNACE, F-122
3	OC2H123	OC2L9H123	CRACKING FURNACE, F-123
4	OC2H124	OC2L9H124	CRACKING FURNACE, F-124
5	OC2H125	OC2L9H125	CRACKING FURNACE, F-125
6	OC2H126	OC2L9H126	CRACKING FURNACE, F-126
7	OC2H127	OC2L9H127	CRACKING FURNACE, F-127
8	OC2H128	OC2L9H128	CRACKING FURNACE, F-128
9	OC2F597	OC2L9F597	LP FLARE, FS-597
10	OC2F5961	OC2L9F5961	MAIN GROUND FLARE, GF-596
11	OC2CT936	OC2L9CT936	COOLING TOWER CT-936
12	OC2FU2	OC2L9FU2	PROCESS AREA FUGITIVES
13	OC2GE1	OC2L9GE1	BACKUP DIESEL GENERATOR NO. 1
14	OC2GE2	OC2L9GE2	BACKUP DIESEL GENERATOR NO. 2
15	OC2ST924	OC2L9ST924	POLISHER NEUTRALIZER TANK, V-924
16	OC2F5962	OC2L9MEPU	PROCESS UNIT (PU) MAINTENANCE/STARTUP/SHUTDOWN
17	OC2MEP121	OC2L9MEP121	FUEL GAS PURGE VENT, F-121
18	OC2MEP122	OC2L9MEP122	FUEL GAS PURGE VENT, F-122
19	OC2MEP123	OC2L9MEP123	FUEL GAS PURGE VENT, F-123
20	OC2MEP124	OC2L9MEP124	FUEL GAS PURGE VENT, F-124
21	OC2MEP125	OC2L9MEP125	FUEL GAS PURGE VENT, F-125
22	OC2EMP126	OC2L9EMP126	FUEL GAS PURGE VENT, F-126
23	OC2EMP127	OC2L9EMP127	FUEL GAS PURGE VENT, F-127
24	OC2EMP128	OC2L9EMP128	FUEL GAS PURGE VENT, F-128
25	OC2EMC121	OC2L9EMC121	REFRACTORY CURING, F-121
26	OC2EMC122	OC2L9EMC122	REFRACTORY CURING, F-122
27	OC2EMC123	OC2L9EMC123	REFRACTORY CURING, F-123
28	OC2EMC124	OC2L9EMC124	REFRACTORY CURING, F-124
29	OC2EMC125	OC2L9EMC125	REFRACTORY CURING, F-125
30	OC2EMC126	OC2L9EMC126	REFRACTORY CURING, F-126
31	OC2EMC127	OC2L9EMC127	REFRACTORY CURING, F-127
32	OC2EMC128	OC2L9EMC128	REFRACTORY CURING, F-128
33	OC2MEFU2	OC2L9MEFU2	LHC-9 FUGITIVE MSS
34	OC2F5961	OC2L9D115	DMDS STORAGE DRUM D-115
35	---------	OC2L9D118	ANHYDROUS AMMONIA STG D-118
36	OC2F5961	OC2L9D530	METHANOL STORAGE DRUM D-530
37	OC2TOX	OC2L9ST170	QUENCH WATER TANK V-170
38	OC2TOX	OC2L9ST290	WASH OIL STORAGE TANK V-290
39	---------	OC2L9ST513	RAINWATER TANK V-513
40	OC2TOX	OC2L9ST705	SPENT CAUSTIC STG TK V-705
41	OC2SV923	OC2L9ST921	15% HCL STORAGE TANK V-921
42	----------	OC2L9ST925	20% CAUSTIC STG TK V-925
43	OC2TOX	OC2L9TOX	LHC-9 TOX
44	OC2TOX	OC2L9ST770	SPENT CAUSTIC STG OSBL TK V-770
45	OC2TOX	OC2L9T760	WASTE WATER STG-TK V-760
46	OC2TOX	OC2L9T761	WASTE WATER STG TK V-761

TACB STANDARD CONDITIONS ARE 68 F AND 14.7 PSIA (RULE 131.01.00.001 (55))
EPN= EMISSION POINT NUMBER
FIN= FACILITY IDENTIFICATION NUMBER

LEGENDS

TC -TOWER CRANE

U/G COOLING WATER RIGHT OF WAY

HPFS. EL. 9'-8" MSL

GRAPHIC SCALE

REV. MARK	REVISION	BY	CHK	APP	DATE
0A	FOR INFORMATION	NR	RC	NK	02/05/14

DRAWING ISSUE RECORD

ISSUE NO.	REV	MATERIAL OR JOB SPEC	BID	FAB	CONST	REF
1	A	FOR INFORMATION				

DATE ISSUED FOR

DESIGNED	NATHAN RAO	02/05/14
DRAWN	NATHAN RAO	02/05/14
CHECKED	RANDY CONDREY	02/05/14
APPROVED	NORM KNEISEL	02/05/14
PROJ. ENGR.		
MFG. REP.		

STATUS: DN
PLANT NO.: LCH9
P.E. SEAL

THE DOW CHEMICAL COMPANY

TEXAS OPERATIONS — FREEPORT, TEXAS

LHC #9

DOW LHC-9 PROJECT
EMISSION POINTS PLAN

CHARGE NUMBER: 100872
SCALE: 1" = 80'-0"
C4-OVL150-100872
REV. 0A
PRINTED
VER.

Table 4-2 compares the thermal efficiency on a LHV basis of the cracking furnaces for the technical alternatives studied and Dow's existing plants. As one of the major energy consumers in the ethylene plant, overall plant performance is dependent on an efficient furnace design. The design selected will achieve the highest practical energy efficiency.

Table 4-3 provides a comparison of furnace flue gas stack temperatures for the technical alternatives studied and Dow's existing plants. As the primary source of unrecovered energy in the cracking furnace, the flue gas temperature is the key indicator of furnace efficiency. The design selected by Dow will have the lowest practical stack temperature resulting in high energy efficiency.

With all the above factors considered, Dow has calculated that the ethylene plant will achieve a 24 hour rolling average GHG emissions per lb or ethylene of 1.1 lb/lb and an annual GHG emission rate of 1.1 lb/lb. See the calculations provided below. For the chosen design, the overall GHG emissions per pound of ethylene produced compare closely to EPA's draft permits for other ethylene plants.

538,343 lb/hr CO_2e ÷ 490,000 lb/hr ethylene maximum = 1.1 lb CO_2e / lb ethylene
2,357,946 tpy CO_2e ÷ 2,102,100 tpy ethylene maximum = 1.1 ton CO_2e / ton ethylene

As the benchmarking data demonstrates and as the support letter from Solomon Associates confirms, the technical alternatives selected by Dow will be a leader in energy efficiency for ethane cracking plants.

Table 3-1 Proposed GHG Emission Limits

Date:	February 4, 2014	Permit No.:	TBD	RN Number:	100225945
Area Name:	LHC-9 Unit			CN Number:	600356976

AIR CONTAMINANT DATA				
1. EMISSION POINT			2. COMPONENT NAME	3. AIR CONTAMINANT EMISSION RATE
EPN (A)	FIN (B)	NAME (C)		TPY
OC2H121	OC2L9H121	Cracking Furnace, F-121	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H122	OC2L9H122	Cracking Furnace, F-122	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H123	OC2L9H123	Cracking Furnace, F-123	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H124	OC2L9H124	Cracking Furnace, F-124	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H125	OC2L9H125	Cracking Furnace, F-125	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H126	OC2L9H126	Cracking Furnace, F-126	CO2	301,855
			CH4	5.63
			N2O	0.56
			CO2e	302,164
OC2H127	OC2L9H127	Cracking Furnace, F-127	CO2	301,855
			CH4	5.63
			N2O	0.56
			CO2e	302,164
OC2H128	OC2L9H128	Cracking Furnace, F-128	CO2	301,855
			CH4	5.63
			N2O	0.56
			CO2e	302,164
OC2F597	OC2L9F597	Low Pressure Flare, FS-597	CO2	14,034
			CH4	0.22
			N2O	0.02
			CO2e	14,046
OC2F5961	OC2L9F596	Pressure-Assisted Flare, GF-596	CO2	43,910
			CH4	2.13
			N2O	0.42
			CO2e	44,089
OC2FU2	OC2L9FU2	Process Area Fugitives	CO2	0.02
			CH4	3.82
			CO2e	80.31
OC2GE1	OC2L9GE1	Backup Diesel Generator No. 1	CO2	16.04
			CH4	0.001
			N2O	0.0001
			CO2e	16.10
OC2GE2	OC2L9GE2	Backup Diesel Generator No. 2	CO2	16.04
			CH4	0.001
			N2O	0.0001
			CO2e	16.10
OC2TOX	OC2L9TOX	LHC-9 TOX	CO2	3,320.21
			CH4	0.06
			N2O	0.007
			CO2e	3,323.92

Total GHG Emissions

Component	TPY
CO2	2,355,327
CH4	49.00
N2O	4.73
CO2e	2,357,946

Table 4-11 GHG Emissions Summary
Annual Facility Emission Limits and BACT Selection
Permit Application for a New Facility - LHC-9 Unit

EPN	FIN	Description	GHG Mass Basis Emission Rates		CO_2e	BACT
			Pollutant	Ton per Year	Ton per Year	Selection
OC2H121	OC2L9H121	Cracking Furnace, F-121	CO2	278,357	278,641	Flue Gas Exit Temperature ≤ 330° F. Fuel for the furnace will have ≤ 0.74 lbs carbon per lb fuel (CC). Fuel rate not to exceed 598 MMBtu/hr. Annual output based limit of 1.1 lbs GHG/lbs of ethylene.
			CH4	5.19		
			N2O	0.52		
OC2H122	OC2L9H122	Cracking Furnace, F-122	CO2	278,357	278,641	
			CH4	5.19		
			N2O	0.52		
OC2H123	OC2L9H123	Cracking Furnace, F-123	CO2	278,357	278,641	
			CH4	5.19		
			N2O	0.52		
OC2H124	OC2L9H124	Cracking Furnace, F-124	CO2	278,357	278,641	
			CH4	5.19		
			N2O	0.52		
OC2H125	OC2L9H125	Cracking Furnace, F-125	CO2	278,357	278,641	
			CH4	5.19		
			N2O	0.52		
OC2H126	OC2L9H126	Cracking Furnace, F-126	CO2	301,855	302,164	Flue Gas Exit Temperature ≤ 330° F. Fuel for the furnace will have ≤ 0.74 lbs carbon per lb fuel (CC). Fuel rate not to exceed 599 MMBtu/hr. Annual output based limit of 1.1 lbs GHG/lbs of ethylene.
			CH4	5.63		
			N2O	0.56		
OC2H127	OC2L9H127	Cracking Furnace, F-127	CO2	301,855	302,164	
			CH4	5.63		
			N2O	0.56		
OC2H128	OC2L9H128	Cracking Furnace, F-128	CO2	301,855	302,164	
			CH4	5.63		
			N2O	0.56		
OC2F597	OC2L9F597	Low Pressure Flare, FS-597	CO2	14,034	14,046	Use of good combustion practices.
			CH4	0.22		
			N2O	0.02		
OC2F5961	OC2L9F596	Pressure-Assisted Flare, GF-596	CO2	43,910	44,089	Use of good combustion practices.
			CH4	2.13		
			N2O	0.42		
OC2FU2	OC2L9FU2	Process Area Fugitives	CO2	0.02	80.31	Use of 28VHP LDAR TCEQ program
			CH4	3.82		
OC2GE1	OC2L9GE1	Backup Diesel Generator No. 1	CO2	16.04	16.10	Use of good combustion practices.
			CH4	0.001		
			N2O	0.0001		
OC2GE2	OC2L9GE2	Backup Diesel Generator No. 2	CO2	16.04	16.10	
			CH4	0.001		
			N2O	0.0001		
OC2TOX	OC2L9TOX	LHC-9 TOX	CO2	3,320	3,324	Use of good combustion practices.
			CH4	0.06		
			N2O	0.007		

Total GHG Emissions

Component	TPY
CO2	2,355,327
CH4	49.00
N2O	4.73
CO2e	2,357,946

TABLE 1F
AIR QUALITY APPLICATION SUPPLEMENT

Permit No.:	**107153**	Application Submittal Date:	**November 29, 2012: revised 9/12/13, 12/19/13**
Company:	**The Dow Chemical Company - Freeport Operations (TXO)**		
RN:	**RN100225945**	Facility Location:	**Dow Texas Operations**
City:	**Freeport**	County:	**Brazoria**
Permit Unit I.D.:	**LHC-9**	Permit Name:	**Ethylene Production Facility**
Permit Activity:	☐ New Source ☑ Modification		

Complete for all Pollutants with a Project Emission Increase.	**POLLUTANTS**								
	Ozone								
	VOC	**NO_X**	**CO**	**NO_X**	**PM**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**CO_2e**
Nonattainment?	YES	YES	NO	NO	NO	NO	NO	NO	NO
PSD?	YES	YES	YES	YES	YES	YES	YES	YES	YES
Existing site PTE (tpy)?	> 25	> 25	> 100	> 40	> 25	> 15	> 10	> 40	> 100
Proposed project emission increases (tpy from 2F[1])?	98.38	219.76	417.61	219.76	69.41	67.51	65.28	11.15	2,357,946
Is the existing site a major source?	YES	YES	YES	YES	YES	YES	YES	YES	YES
If not, is the project a major source by itself?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
If site is major source, is project increase	YES	YES	YES	YES	YES	YES	YES	NO	YES
If netting required, estimated start of construction:	Jan-14								
5 years prior to start of construction	Dec-08		contemporaneous						
Estimated start of operation	Jan-17		period						
Net contemporaneous change, including proposed project, from Table 3F. (tpy)	-19.73	-1,876.55	538.62	-1,876.55	-15.84	-1.36	-6.84	13.16	2,760,991
Major NSR Applicable?	NO	NO	YES	NO	NO	NO	NO	NO	YES
Cheryl Steves		Environmental Manager				2-4-14			
Signature		***Title***				***Date***			

[1] Sum of proposed emissions minus baseline emissions, increases only.

The representations made above and on the accompanying tables are true and correct to the best of my knowledge.

TCEQ - 10154 (Revised 04/12) Table 1F
These forms are for use by facilities subject to air quality permit requirements and may

TCEQ

TABLE 2F
PROJECT EMISSION INCREASE

Pollutant[1]:	**CO_2e**	**Permit:**	**107153**
Baseline Period:	**Dec-08 - Jan-14**		

	Affected or Modified Facilities[2]				A	B				
	FIN	**EPN**	**Permit No.**	**Actual Emissions[3]**	**Baseline Emissions[4]**	**Proposed Emissions[5]**	**Projected Actual Emissions**	**Difference (B-A)[6]**	**Correction[7]**	**Project Increase[8]**
1	OC2L9H121 OC2L9H122 OC2L9H123 OC2L9H124 OC2L9H125 OC2L9H126 OC2L9H127 OC2L9H128	OC2H121 OC2H122 OC2H123 OC2H124 OC2H125 OC2H126 OC2H127 OC2H128	107153	-	-	2,299,698		2,299,698		2,299,698
2	OC2L9F596 OC2L9F597 OC2L9TOX	OC2F5961 OC2F597 OC2TOX	107153	-	-	58,135		58,135		58,135
3	OC2L9CT936	OC2CT936	107153	-	-	-		-		-
4	OC2L9FU2	OC2FU2	107153	-	-	80		80		80
5	OC2L9GE1	OC2GE1	107153	-	-	16		16		16
6	OC2L9GE2	OC2GE2	107153	-	-	16		16		16
									Page Subtotal[9] =	2,357,946
									Table Total =	2,357,946

[1] Individual Table 2Fs should be used to summarize the project emission increase for each criteria pollutant.
[2] Emission Point Number as designated in NSR Permit or Emissions Inventory.
[3] All records and calculations for these values must be available upon request.
[4] Correct actual emissions for currently applicable rule or permit requirements, and periods of non-compliance. These corrections, as well as any MSS previously demonstrated
[5] If projected actual emission is used it must be noted in the next column and the basis for the projection identified in the Table 2F supplement.
[6] Proposed Emissions (column B) minus Baseline Emissions (column A).
[7] Correction made to emission increase for what portion could have been accommodated during the baseline period. The justification and basis for this estimate must be
[8] Obtained by subtracting the correction from the difference. Must be a positive number.
[9] Sum all values for this page.

TCEQ - 20470(Revised 03/12) Table 2F
These forms are for use by facilities subject to air quality permit requirements and may be revised periodically. (APDG 5915v2)

TABLE 3F

PROJECT CONTEMPORANEOUS CHANGES[1]

Company:	The Dow Chemical Company		
Permit Application Number:	107153	Criteria Pollutant: CO_2e	

	Project Date[2]	Project Number	Facility at Which Emission Change Occurred[3] FIN	EPN	Permit No.	Project Name or Activity	Baseline Period (years)	Proposed Emissions (tons/year)4 A	Baseline Emissions (tons/year)5 B	Difference (A-B)6	Creditable Decrease or Increase7
1	6/29/2009	148288	B47C4F1	B47F1	89262	AUTHORIZATION TO SEND PDC HYDROGEN STREAM TO B47FI HYDROGEN FLARE	N/A	97	-	97	97.35
2	8/17/2009	143178	B78APF1	B78F1	8567	FLARE EMISSIONS	07-08	3,842	2,765	1,078	1,077.67
3	9/3/2009	0	B20LTXFU10 B20LXCT1 B20LXTX101 B20LXLR1 B20LXLR1 B20LXRX1 B20LXFU2 B20LXFU3 B20LXST1 B20LXST11A B20LXST11B B20LXST28 B20LXST31 B20LXSTD12 B20LXST765	B20FU10 B20CT1 B20TX101 B20LR1 B20TX101 B20TX101 B20FU2 B20FU3 B20ST1 B20ST11A B20ST11B B20ST28 B20ST31 B20STD12 B20ST765	3320	Latex Shutdown	N/A	-	2,200	(2,200)	(2,199.83)
4	12/23/2009	139749	A32CSTO500/ A32CSSTO560	A32STHROX/ A32TO560	770	PYRIDINE DERIVATIVES FACILITY	07-08	9,916	8,552	1,364	1,364.45
5	1/5/2010	152689	A30MRML801	A40F100	91437	MARINE LOGISTICS	N/A	0.08	-	0.08	0.08
6	2/2/2010	145810	A153PGT32	A15S10	9045	POWER 3 GAS TURBINES	N/A	-	488,767	(488,767)	(488,766.98)
7	3/12/2010	138177	A36MDTO520	A36S531	46431	PMDI PLANT	06-07	11,272	8,097	3,175	3,175.14
8	3/12/2010	138177	A36MDF621	A36S621	46431	PMDI PLANT	06-07	94,775	45,900	48,875	48,875.07
9	3/12/2010	138177	A36MDF532	A36F532	46431	PMDI PLANT	06-07	1,936	1,444	492	492.14
10	4/29/2010	145800	B246PGT62	B24S2	9044	THREE GENERAL ELECTRIC GAS TURBINES	N/A	-	310,303	(310,303)	(310,303.17)
11	6/29/2010	0	B25P2CT100 B25P2D750 B25P2D750A B25P2LDL101 B25P2LDL103 B25P2DL50A B25P2FU1 B25P2FU2 B25P2FU3 B25P2LR03B B25P2LR109 B25P2PU1 B25P2RX101 B25P2RX101 B25P2RX101 B25P2RX101 B25P2RX101 B25P2RX101 B25P2RX102 B25P2RX102 B25P2RX102 B25P2RX102 B25P2RX102 B25P2RX102 B25P2RX102 B25P2RX102 B25P2RX102 B25P2RX102 B25P2RX102 B25P2RX102	B25CT100 B25ST750 B25ST750A B25DL101 B25DLBD103 B25DL750A B25FU1 B25FU2 B25FU3 B25LR03B B25LR109 B27F2 B25RL101 B25RLR101 B25RLS101 B25RLS111 B25VF01 B25VF60 B25RL201 B25RLR102 B25RLS102 B25RLS112 B25RX102 B25SB201 B25SB202 B25SB203 B25SBRB103 B25SBRB104 B25SP102 B25V102	19519 48813	Polyethylene 2 Shutdown	N/A	-	4,034	(4,034)	(4,033.78)
12	8/6/2010	158743	B42SDTO35	B42TO35	92938	SPC PLANT STYRENE TANK PROJECT	N/A	2,323	-	2,323	2,322.69
13	8/11/2010	135804	BL7FT01	BL7FT01	83841	MSS	N/A	62	-	62	62.40
14	10/12/2010	160288	BSRSROE1 or BSRSRMW	BSRFT02 or BSRMW1	93604	SALT DOME OPERATIONS FACILITY	N/A	1,201	-	1,201	1,201.47
15	11/1/2010	161190	B78APF1	B78F1	8567	AMENDMENT AND RENEWAL	07-08	4,113	2,765	1,348	1,347.86
16	1/6/2011	161642	B45P4F1	B45F1	94180	POLYETHYLENE 4 PLANT REFURBISH PROJECT	06-07	15,227	4,755	10,472	10,471.92
17	2/7/2011	0	OC1CT73 OC1ST64 OC1U1CT300 OC1U1FU1 OC1U1FU2 OC1U1GE12 OC1U1GE500 OC1U1H201 OC1U1H202 OC1U1H203 OC1U1H204 OC1U1H205 OC1U1RX1 OC1U1RX1 OC1U1RX1 OC1U1RX1 OC1U1RX1 OC1U1TL1 OC1U1TL140	OC1CT73 OC1ST64 OC1CT300 OC1FU1 OC1FU2 OC1GE12 OC1GE500 OC1S201 OC1S202 OC1S203 OC1S204 OC1S205 OC1SV151 OC1SV33 OC1SV400 OC5SV403 OC5SV404 OC1TL1 OC1TL140	941	EDC VINYL UNIT 1 Shutdown	N/A	-	58,839	(58,839)	(58,838.59)
18	4/11/2011	160920	OC3DOT01	OC3T01	28363	CHEMICAL MANUFACTURING PLANT	08-09	1,599	905	694	693.87
19	4/11/2011	160920	OCDO3H61	OC3H61	28363	CHEMICAL MANUFACTURING PLANT	08-09	3,330	2,449	881	881.31
20	5/27/2011	164836	BSRRXF01	BSRF401	95672	REGISTRATION FOR ETHYLENE COMPRESSOR C-	N/A	626	-	626	626.16
21	8/17/2011	135607	--	OC3T01	83795	DIPHENYL OXIDE PLANT	N/A	13,618	-	13,618	13,618.05
22	8/25/2011	169369	B46FT850	B46USFT850 (MSS Only)	46429	SPECIALTY POLYURETHANE COPOLYMER PLANT	N/A	1,678	-	1,678	1,678.08

Company:		The Dow Chemical Company									
Permit Application Number:				107153		Criteria Pollutant: CO_2e					
	Project Date[2]	Project Number	Facility at Which Emission Change Occurred[3] FIN	EPN	Permit No.	Project Name or Activity	Baseline Period (years)	Proposed Emissions (tons/year)4 A	Baseline Emissions (tons/year)5 B	Difference (A-B)6	Creditable Decrease or Increase7
23	8/25/2011	169369	B42SDTO35	B42TO35	46429	SPECIALTY POLYURETHANE COPOLYMER PLANT	N/A	4,345	-	4,345	4,345.00
24	9/22/2011	169077	B68RXX2	B70F801	98110	MOLECULAR SIEVE SYSTEM	N/A	212	-	212	212.22
25	10/12/2011	169469	B3814RX1	B3808F1	83031	REACTOR R-600 PROJECT	02-03	3,060	98	2,962	2,962.08
26	10/28/2011	170066	OCDO3H61	OC3H61	98680	DIPHENYL OXIDE PLANT	08-09	4,939	2,449	2,490	2,490.12
27	10/28/2011	170066	OCDO3H62	OC3H62	98680	DIPHENYL OXIDE PLANT	08-09	4,939	1,985	2,954	2,954.17
28	3/1/2012	Internal	B31S1F1 B31S1HMOD B31S1RX1 B31S1FU1 B31S1FU2 B31S1CT100 B42S1FU23 B42S1ST21A	B31F1 B31HMOD B31HMOD B31FU1 B31FU2 B31CT100 B42FU1 B42ST21A	20432	TXO STYRENE 1 OPS Shutdown	N/A	-	65,221	(65,221)	(65,221.30)
29	3/1/2012	Internal	A40SDFSTV A40SDCO8 A40SDFU1 A40SDFU2 A40SDST1 A40SDST2 A40SDST8 A40SDST9 B42SDFU1 B42SDLRN B42SDLRS B42SDLRTT B42SDONS B42SDOSS B42SDST22 B42SDST24 B42SDST25 B42SDST31	A40FSTV A40TO8 A40FU1 A40FU1 A40FSTV A40FSTV A40TO8 A40FSTV B42FU1 B42EOLRN B42EOLRS B42LRTT B42NS B42SS B42ST22 B42ST24 B42ST25 B42ST31	20432	TXO STYRENE DISTRIBUTION OPS Shutdown	N/A	-	4,935	(4,935)	(4,935.12)
30	3/1/2012	Internal	B71S2F2 B71S2RX1 B71S2B1 B71S2SP4 B71S2H111 B71S2H112 B71S2H121 B71S2F1 B71S2VJ1 B71S2FU1 B71S2SV14 B71S2FU2 B71S2CT100 B71S20S1 B71S2ST11 B71S2ST12 B71S2ST1 B71S2ST2 B71S2ST3 B71S2ST4 B71S2ST5 B71S2ST6	B71F2 B60F3 B71B1 B71B1 B71S123 B71S123 B71S123 B71F1 B71F2 B71FU1 B71SV14 B71FU2 B71CT100 B71OS1 B71F1 B71F1 B71ST1 B71F1 B71F1 B71F1 B71F1 B71F1	20432	TXO STYRENE 2 OPS Shutdown	N/A	-	156,097	(156,097)	(156,097.50)
31	3/7/2012	Internal	A17EAF11 A17EAH551 A17EAH555 A17EAF10 A17EARX1 A17EAFU2 A15EAFU3 A15EALRELR A15EALRWLR A15EAST3 A17EACT1 A17EAST145 A17EAST155 A17EAST18 A17EAST19 A17EAST20 A17EAST20X A17EAST28 A17EAST44A A17EAST44B A28EAFUST A28EAST28 A40EAFU1	A17F11 A17S551 A17S555 A17F10 A17F10 A17FU2 A15FU3 A15LRELR A15LRWLR A15ST3 A17CT1 A17ST145 A17ST155 A17F10 A17F10 A17ST20 A17F10 A17ST28 A17ST44A A17ST44B A28FUST A28ST28 A40FU1	21596	TXO ETHYLBENZENE A OPS Shutdown	N/A	-	61,716	(61,716)	(61,716.46)
32	4/14/2012	Internal	OCU3D3FU	OCD3FU	3434	MRU Replacement	10 - 11	3,536	-	3,536	3,536.00

Company:			The Dow Chemical Company								
Permit Application Number:					107153	Criteria Pollutant: CO_2e					
	Project Date[2]	Project Number	Facility at Which Emission Change Occurred[3] FIN	EPN	Permit No.	Project Name or Activity	Baseline Period (years)	Proposed Emissions (tons/year)4 A	Baseline Emissions (tons/year)5 B	Difference (A-B)6	Creditable Decrease or Increase7
33	12/3/2013	0	A32CSF1 A32CSH301 A32CSH200 A32CSFU1 A38CSRX1 A32CSCT200 A32CSPU301 A32CSFU3 A32CSSP214 A32CSST05A A32CSST05B A32CSST1A A32CSST1C A32CSST280 A32CSST284 A32CSCLSYM A32CSPUDIL A32CSRX600 A32CSST331 A32CSRL1 A32CSST25 A32CSTL284 A32CSTL220 A32CSTL229 A32CSTL31G A32CSST13 A32CSFU4	A32F-1 A32H-DTU A32H-NIT A32FU1 A32STHROX A32CT200 A32F-1 A32FU3 A32F-1 A32F-1 A32F-1 A32F-1 A32F-1 A32F-1 A32F-1 A32LR1 A32STHROX A32STHROX A32ST331 A32RL1 A32ST-D25 A32F-1 A32STHROX A32STHROX A32STHROX A32STHROX A32FU1	770	TXO CHLOR-PYRIDINE: SYM-TET OPS Shutdown	N/A	-	12,671	(12,671)	(12,671.23)
34	1/1/2013	173900	OC4PHH310 OC4PHH320 OC4PHH330 OC4PHH340	OC4H310 OC4H320 OC4H330 OC4H340	100787	PROPANE DEHYDROGENATION UNIT	N/A	356,070	-	356,070	356,070.47
35	1/1/2013	173900	OC4PHF955	OC4F955	100787	PROPANE DEHYDROGENATION UNIT	N/A	35,291	-	35,291	35,291.05
36	1/1/2013	173900	OC4PHF956	OC4F956	100787	PROPANE DEHYDROGENATION UNIT	N/A	405	-	405	404.77
37	1/1/2013	173900	OC4PHF957	OC4F957	100787	PROPANE DEHYDROGENATION UNIT	N/A	504	-	504	503.58
38	1/1/2013	173900	OC4PHFU2	OC4FU2	100787	PROPANE DEHYDROGENATION UNIT	N/A	37	-	37	36.98
39	1/1/2013	173900	OC4PHSV485	OC4SV485	100787	PROPANE DEHYDROGENATION UNIT	N/A	3,477	-	3,477	3,476.76
40	1/1/2013	173900	OC4PHGE860	OC4GE860	100787	PROPANE DEHYDROGENATION UNIT	N/A	10	-	10	10.41
41	1/1/2013	173900	OC4PHMEFU2	OC4MEFU2	100787	PROPANE DEHYDROGENATION UNIT	N/A	1	-	1	0.62
42	1/1/2013	173900	OC4PHMEPU	OC4F955	100787	PROPANE DEHYDROGENATION UNIT	N/A	27,074	-	27,074	27,073.61
43	9/25/2012	180758	OC3DOT01	OC3T01	104727	3RD REACTOR TRAIN	10-11	1,803	1,242	561	560.61
44	9/25/2012	180758	OCDO3H63	OC3H63	104727	3RD REACTOR TRAIN	10-11	6,500	-	6,500	6,500.00
45	8/30/2012	INTERNAL	B255TODCR	B255TODCR	NONE	R&D B255 DCR PP	N/A	10	-	10	9.88
46	10/11/2013	185272	B34VMTO121	B34S1400	46428	PLANT B VENT MANAGEMENT UNIT	06-07	1,124,631	95,300	1,029,331	1,029,331.00
47	2/19/2014	189312	B35EWS201	B35EWS201	83792	INCLUDE MSS ACTIVITIES NOT CURRENTLY AUTHORIZED	N/A	4,074	-	4,074	4,074.21
										Page Subtotal8:	403,045.30
										Table Total:	403,045.30
										Project Emission Increase (from Table 2F):	2,357,945.51
Summary of Contemporaneous Changes										Total (Includes Project Increases):	2,760,990.80

[1] Individual Table 3Fs should be used to summarize the project emission increase and net emission increase for each criteria pollutant.
[2] The start of operation date for the modified or new facilities. Attach Table 4F for each project reduction claimed.
[3] Emission Point No. as designated in NSR Permit or Emissions Inventory.
[4] All records and calculations for these values must be available upon request.
[5] All records and calculations for these values must be available upon request.
[6] Proposed (column A) - Baseline (column B).
[7] If portion of the decrease not creditable, enter creditable amount.
[8] Sum all values for this page.

The Dow Chemical Company
2301 Brazosport Blvd.
Freeport, TX 77541-3257
U.S.A.

January 24, 2014

Certified Mail 7013 2250 0001 2961 5482
Return Receipt Requested

Mr. Brad Toups
Chief, Air Permits Section
U.S. EPA Region 6, 6PD
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: The Dow Chemical Company
PSD Greenhouse Gas (GHG) Permit Application
Additional Information for the Ethylene Production Facility (LHC-9)

Dear Mr. Toups:

Enclosed please find an updated BACT analysis for the flare system for the proposed Light Hydrocarbon 9 production unit. The attached Section 4.4 is being presented to replace the previously submitted Section 4.4. The updates made are in response to questions received on January 17, 2014 via e-mail.

Should you have any questions regarding this information, I can be contacted at (979) 238-5832 or via e-mail at clsteves@dow.com.

Sincerely,

Cheryl Steves

Cheryl Steves
Environmental Manager, The Dow Chemical Company

Cc via Email:	Ms. Cindy Rodriguez	The Dow Chemical Company
	Ms. Mary Schwartz	The Dow Chemical Company

THE DOW CHEMICAL COMPANY
DOW TEXAS OPERATIONS – FREEPORT

PREVENTION OF SIGNIFICANT DETERIORATION

GREENHOUSE GAS

PERMIT APPLICATION

FOR

ETHYLENE PRODUCTION FACILITY (LHC-9)

January 24, 2014

4.4 BACT FOR FLARE SYSTEM

The flare system associated with the LHC-9 production unit consists of an elevated low pressure flare and a larger, pressure-assisted ground flare. The low pressure flare is designed to control emissions from API storage tanks. There is also a continuous N_2 and natural gas purge to maintain header velocity and heating value. The pressure-assisted ground flare manages routine continuous and intermittent vents. Continuous vents include compressor seals, small leaks from pressure safety valves and pressure vent control valves, and excess off-gas from LHC-9 operations (this is a necessary pressure control mechanism to address changes in off-gas consumption by other consumer plants at the site). Fuel line purging to safely isolate LHC-9 cracking furnaces burners is routinely flared for OC2L9HH1 – OC2L9HH8. Additionally, there is a continuous natural gas purge to the pressure-assisted ground flare to maintain header velocity. The flare's pilots are fueled by low-carbon pipeline natural gas and are in operation 8,760 hours per year. Both flares will be subject to TCEQ HRVOC and Federal 40 CFR 60.18 requirements.

4.4.1 Step 1 – Identify Available Control Technologies

A search of the RBLC database did not identify any GHG control technologies for control devices such as the small elevated or pressure-assisted flares, particularly since the flares themselves are considered add-on control units. However, to expedite this permit issuance process, Dow considered the following technologies as potential GHG control measures for the flares at the LHC-9 facility:

1. Good plant design to minimize flaring
2. Use of low-carbon assist gas
3. Good flare design and operation
4. Carbon Capture and Storage
5. Flare Gas Recovery

4.4.1.1 Good plant design to minimize flaring

The current plant design incorporates minimum-flaring attributes such as recovery of low flow vent streams and off-spec recycle to minimize material that would otherwise be routed to the flare. It is inherent in Dow's plant design to re-use as much of the hydrocarbons as possible within the plant that would otherwise be routed to a flare. The only routine materials that will go to the flare are vent streams that cannot be recycled to the process for safety or other technical reasons. These streams include compressor seal vents and minor leaks from relief valves which are variable and unpredictable in flow and composition

4.4.1.2 Low-Carbon Assist Gas

The use of natural gas as assist gas is the lowest-carbon fuel available for the proposed project. Dow proposes to use natural gas for the flares' pilot gas and as supplemental fuel, if needed, to maintain the appropriate vent stream heating value as required by applicable air quality regulations.

4.4.1.3 Good Flare Design and Operation

Good operating and maintenance practices for flares include appropriate maintenance of equipment (such as periodic flare tip maintenance) and operating within the recommended heating value and flare tip velocity as specified by its design. The use of good operating and maintenance practices results in longer life of the equipment and more efficient operation. Therefore, such practices indirectly reduce GHG emissions by supporting operation as designed by the flare manufacturer. Good flare design includes pilot flame monitoring, flow measurement, and monitoring/control of waste gas heating value.

4.4.1.4 Carbon Capture and Storage

The primary source of GHG emissions from a flare is the result of combustion of the hydrocarbon-containing gas stream in the flare. CCS requires separation of CO_2 from the flare exhaust, compression of the CO_2, and transportation to an injection/storage location.

4.4.1.5 Flare Gas Recovery

Flare gas recovery (FGR) would be sized to recover the continuous expected vent streams to the flare not currently recovered and recycled internally, such as small leakage rates across compressor seals and minor leaks from closed vent control and pressure relief valves. These streams cannot be recycled to the process for safety and technical reasons as follows:

- Process safety concern includes the potential for a relief episode that would disrupt the compositions to the flare gas recovery stream, resulting in a process upset that would subsequently result in increased flaring to manage the event. A relief episode has unpredictable flow and composition.
- Technical concerns associated with the periodic maintenance activities that require purging of nitrogen through equipment to clear it – this surge in nitrogen would have significant impact to the flare gas recovery system by adding significant amounts of nitrogen and changing the composition and overall heat value of the recovered flare gas stream, rendering this type of stream unsuitable for FGR. This abrupt change could also trigger a plant upset, resulting in significant flaring to manage the event.

4.4.2 Step 2 – Eliminate Technically Infeasible Options

4.4.2.1 Good Plant Design to Minimize Flaring

Good plant design that recovers and recycles materials to minimize flaring is considered technically feasible.

4.4.2.2 Low-Carbon Assist Gas

Use of low-carbon assist gas is considered technically feasible.

4.4.2.3 Good Flare Design and Operation

Use of good flare design and operation is considered technically feasible.

4.4.2.4 Carbon Capture and Storage

The primary source of GHG emissions from a flare is the result of combustion of the hydrocarbon-containing gas stream in the flare. Flare exhaust cannot be captured for CO_2 separation unless the flare device is enclosed, which poses a safety hazard for a flare system designed for an ethylene production facility. Post-combustion capture is not a feasible control technique for flare exhaust, therefore CCS is considered a technically infeasible option and is not considered further in this BACT analysis.

4.4.2.5 Flare Gas Recovery

FGR is used in refineries; it is not commonly used in olefins production. There is a significant process risk associated with recovering and recycling the vents from compressor seals, emergency pressure relief valves, pressure vent control valves, and purge nitrogen in that these systems are in place to manage maintenance and episodic events safely. Waste gases routed to the flare from these sources are not suited for recovery into a fuel gas system because they can contain maintenance, startup, shutdown, and emergency relief streams that vary greatly in composition and flow. Routing these streams to the fuel system can impact the overall stability of the entire process unit. Operation of these cracking furnaces is significantly more sensitive to changes in fuel quality than some processes like boilers or heat recovery units. Dow believes installing an FGR system for these vents is technically infeasible, however because FGR systems are existing technology and have been installed in certain petrochemical applications this technology will be included for further evaluation.

4.4.3 Step 3 – Rank According to Effectiveness

Use of good plant design to minimize flaring, low-carbon assist gas, good flare design and operation, and flare gas recovery are being proposed for this project. These techniques are ranked as follows:

1. Good plant design to minimize flaring is ranked first. This technique is a source reduction approach as various routine, stable vent streams are collected and routed back to the process for recovery. This the most effective manner in which to inherently recover valuable product from the plant vent system as well as minimize the vents that are flared. Implementation of this minimum-flaring attribute significantly reduces the quantity of materials that are flared on a routine basis.
2. Low-carbon assist gas is ranked next – the low carbon assist gas is natural gas, which is primarily methane.
3. Good flare design and operation is ranked third. This attribute does not involve extensive capital cost or annual operating costs; examples of good flare design and operation include pilot flare monitoring, control of flare exit velocity, and maintaining a minimum heating value for the flared waste stream.
4. FGR is ranked last as it will require significant capital investment, has a relatively high emission control cost, has a high process risk element, and will have minimal impact on overall GHG emissions from the project.

4.4.4 Step 4 – Evaluate the Most Effective Controls

Use of good plant design to minimize flaring, low-carbon assist gas, and good flare design and operation are being incorporated as control measures therefore an evaluation of the energy, environmental, and economic impacts of the proposed measures is not necessary for this application.

An economic feasibility analysis was completed for a FGR system. Dow has developed an estimate based on design criteria for the proposed LHC-9 project as actual vent flows and compositions are not available. The FGR cost estimate is based on a potential reduction of 8,812 tons/yr of CO_2 (less than 1% of the total GHG emissions from the plant) that would be generated when flaring the material in lieu of recovering and using as a furnace fuel. The estimated cost per ton of CO_2e reduced is $117/ton making an FGR economically infeasible.

Due to the plant design to minimize flaring and the variability in the composition and flow to the FGR system, Dow has determined that an FGR system is not technically feasible.

Figure 4.4.4 Flare Gas Recovery Unit Cost Analysis

Source Name: GF-596
Pollutant: CO2
Control Option: Flare Gas Recovery Unit

I.	DIRECT COSTS (DC)	COST $	COST BASIS
A.	Primary control device & ancilliary equipment cost (A)	$3,871,000	Estimated Cost = A
	Instrumentation	$193,550	0.05 A
	Sales Tax	$270,970	0.07 A
	Freight	$193,550	0.05 A
	Subtotal Purchased Equipment Cost (B)	$4,529,070	Estimated A*1.17 = B
B.	Direct Installation Costs		Cost Factors from *Aspen ICARUS*
	Foundation & Support	$181,163	4% TDC
	Handling & Erection	$45,291	1% TDC
	Electrical	$90,581	2% TDC
	Piping	$905,814	20% TDC
	Insulation	$45,291	1% TDC
	Painting	$158,517	3.5% TDC
	Total Direct Installation Costs	$1,426,657	
C.	Site Prepration	$50,000	
D.	Buildings	$0	
E.	TOTAL	**$6,005,727**	
II.	**INDIRECT COSTS(Installation, IC)**		
A.	Final engineering design	$997,000	10% TCI
B.	Construction expense, including permits, insurance, temporary facilities, and clean-up	$452,907	10% Purchased Equipment
C.	Contractor's fee and overhead	$452,907	10% Purchased Equipment
D.	Startup	$45,291	1% Purchased Equipment
E.	Performance Tests	$45,291	1% Purchased Equipment
F.	Contingency	$1,996,000	20% TCI
G.	TOTAL INDIRECT COSTS	**$3,989,395**	
III.	**TOTAL CAPITAL INVESTMENT (TCI=DC+IC)**		
A.	Sum of Total Direct and Indirect Costs	$9,995,122	
B.	Retrofit Factor (Dependant upon system complexity)	0%	2% to 50% for retrofits on existing sources
C.	ADJUSTED TOTAL CAPITAL INVESTMENT	**$9,995,122**	

ANNUAL OPERATING COSTS (AOC)			
I.	**DIRECT ANNUAL COSTS (DAC)**		
A.	Labor		
	Operator (1 hr/shift)	$29,751	$27.17
	Supervisory	$4,463	15% of Operator Cost
	Maintenance (1.5% of purchased equipment)	$67,936	$27.97
B.	Maintenance Materials(set to zero, normally = mtc labor)		
C.	Operational Materials		
	Chemicals	0	
	Other (Carbon, Catalyst etc)		
	Value of any recovered material for sale or credit		
D.	Utilities		
	Natural Gas	-$882,701	-28.79 MMBtu/hr @ $5/MMBtu, 70% on-stream factor
	Other Fuel		
	Electricity	$173,448	330 kw @ $0.06/kwh
	Other	$0	
E.	TOTAL DIRECT ANNUAL COSTS	-$607,104	
II.	**INDIRECT ANNUAL COSTS (IAC)**		
A.	Capital Recovery (CR=CRF*TCI)	$1,174,023	Annual Cost to Recover TCI
	Capital Recovery Factor	0.1175	Based on APR & Term below
	Annual Interest Rate	0.100	
	Investment Term (yr)	20	
B.	Labor Overhead	$61,290	60% of Total Labor & Mtc
C.	Administration, Taxes & Insurance	$399,805	4% of TCI
E.	TOTAL INDIRECT ANNUAL COSTS	$1,635,138	
III.	**TOTAL ANNUAL OPERATING COSTS (AOC=DAC+IAC)**	**$1,028,035**	
IV.	**POLLUTANT CONTROL EFFECTIVENESS**		
A.	Typical Emission Rate W/O FGRU	44,097	Tons/yr; This is the total CO2e emissions from the pressure-assisted ground flare
B.	Emission Rate with FGRU	35,285	Tons/yr; This includes emissions from MSS, intermittent streams, flare pilots, and 30% of the streams intended for FGR
C.	Total Emission Reduction	8,812	Tons/yr. Difference between IV.A. and IV.B
V.	**EMISSION CONTROL COST EFFECTIVENESS**		
	Overall Cost Effectiveness ($/Ton)	$117	

4.4.5 Step 5 – Select BACT

Dow proposes to incorporate low-carbon assist gas and good flare design and operation discussed in Section 4.4.1 as BACT for controlling CO_2 emissions from the flares.

Table 4-7: Proposed Practices and MRR for Flare System

Practices	Monitoring*	Recordkeeping*	Reporting
Good flare design and operation	Continuous monitoring of waste gas heating value and flow rate	Continuous recording of waste gas heating value and flow rate	None
	Continuous monitoring of flare pilot flame	Continuous recording of pilot flame monitoring	None

* Continuous monitoring, continuous record and continuous recorder shall have the same definitions as in the Hazardous Organic NESHAP, 40 CFR 63.152(f) and 63.152(g).

The Dow Chemical Company
2301 Brazosport Blvd.
Freeport, TX 77541-3257
U.S.A.

January 24, 2014

Electronic submittal

Mr. Brad Toups
Chief, Air Permits Section
U.S. EPA Region 6, 6PD
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: The Dow Chemical Company
PSD Greenhouse Gas (GHG) Permit Application
Response to January 17, 2014 Questions

Dear Mr. Toups:

Enclosed please find responses to the January 17, 2014 e-mail in which additional information on the flare gas recovery analysis was requested. Additionally, we are submitting an updated BACT analysis for the flare system for the proposed Light Hydrocarbon 9 production unit that reflects revisions made as part of this response. The original questions are presented in bold font, and Dow's response follows each question.

Should you have any questions regarding this information, I can be contacted at (979) 238-5832 or via e-mail at clsteves@dow.com.

Sincerely,

Cheryl Steves

Cheryl Steves
Environmental Manager, The Dow Chemical Company

Enclosures/cls

Cc:

Mary Schwartz, Dow Chemical (email)
Cindy Rodriguez, Dow Chemical (email)

Responses to Questions

1) What are the recovered volume by stream, specifically, that Dow used in its analysis? If the speciated composition of the streams relied upon has not already been provided to us previously, please do so.

For the Flare Gas Recovery (FGR) BACT analysis, Dow initially used a portion of the routine vents plus the flare header purge represented in the permit application for the pressure-assisted ground flare, GF-596. For the routine vents, only the portion of the vent stream that occurs more or less continuously was included. There are other specific streams included in the routine vents that occur infrequently (weekly or less) and these were not considered. The continuous portion of the routine vents plus the flare header purges make up the 26.1 MMBtu/hr (LHV) that was used in the BACT Tier 3 analysis.

Additionally, Dow applied an on-stream factor of 70% for the FGR. This factor is used because the FGR system cannot be used while preparing equipment for maintenance by purging to flare with nitrogen. See additional discussion on this topic on page 6. The final value of fuel recovered for continuous vents is estimated to be 28.79 MMBtu/hr (LHV).

The 34.31 MMBtu/hr reflected in the permit application for routine vents includes infrequent vent streams and worst case scenarios in order to ensure the higher hourly emissions were appropriately permitted, but were not appropriate for the BACT Tier 3 analysis on an annual basis.

The volume and composition of the continuous routine vent stream to the Pressure-Assisted Flare is shown below:

Volume:

Hourly Flows to Flare		LHV	Heat in
Compound	**SCFM**	**Btu/scf**	**MMBtu/hr**
Waste Gas - continuous vents	429.4	901	23.21
Waste Gas - intermittent vents	187.2	928	10.42
Natural Gas - Purge	91.2	1020	5.58
Natural Gas - Pilot	25.5	1020	1.56
		Annual @ 8760 hrs/yr	**40.77**

Composition (continuous routine vents):

Component		Wt %
Hydrogen	H_2	1.15
Nitrogen	N_2	27.26
Methane	CH_4	40.72
Ethylene	C_2H_4	13.42
Ethanol	C_2H_6	4.60
Carbon Dioxide	CO_2	1.43
Propylene	C_3H_6	3.21
Propane	C_3H_8	1.49
Isobutane	C_4H_{10}	0.08
Isobutene	C_4H_8	0.23
N-Butene	C_4H_8	0.32
1,3-Butadiene	C_4H_6	1.21
N-Butane	C_4H_{10}	0.25
N-Pentene	C_5H_{10}	1.75
Methanol	CH_4O	1.75
Methyl -Cyclopentane	C_6H_{12}	0.78
Water	H_2O	0.35
		100.00

The continuous vents to the Low Pressure Flare, FS-597 were not included because this flare header system is completely separate from the pressure-assisted ground flare. The systems cannot be tied together due to the inherent high-pressure operation of the pressure-assisted flare. Equipment connected to the low pressure flare (e.g. API storage tanks) is not designed for connection to the pressure assisted flare.

Additionally, the normal composition of flows to the low pressure flare are much higher in nitrogen due to operations such as breathing losses from nitrogen padded API tanks, making this stream unsuitable for FGR.

2) With regards to the FGRS compressor: a) what is the size upon which Dow's analysis was made, b) why was the service life of 10 years selected for the equipment? and c) why was the 5.7% interest rate used by Dow?

a) Dow's capital estimate was based on an FGR system comprised of 2 compressors, each sized for 1 mmscfd (42 mscfh). One operating and one spare.

b) the service life has been revised to reflect 20 years which is typical for capital expenditures.

c) the interest rate has been updated to reflect Dow's minimum internal project hurdle rate.

3) What is the anticipated relative concurrency of any of the streams being part of the flare gas? Please describe how you anticipate the timing of the various streams being sent to the flare. Are they all expected to be flowed concurrently? Please explain your expected worst case conditions, particularly any combination of conditions that would result in a fuel gas that would not permit stable operations of the furnaces when introduced into the fuel gas header.

The flare gas generally consists of five types of flows to flare. Each is described below:

<u>Continuous Routine Vents</u>

Continuous routine vents include the natural gas flare header purges, compressor seals, plus the accumulation of small leaks from hundreds of closed Pressure Safety Valves (PSV's) and vent control valves. These small leaks are minimized through routine maintenance of these devices, but the small leaks are inherent in the design of these devices which is why they are routed to a control device i.e. the flare. Unless the plant is completely shut down and de-inventoried, these continuous vents would be concurrent with the other types of vents described below.

<u>Intermittent Routine Vents</u>

Intermittent routine vents are generated from routine activities that occur infrequently for short durations of time, but that are part of normal operation of the plant. One example is the depressurization to flare of the natural gas pad on the DMDS storage drum to allow for refilling of the drum from a tank truck (weekly activity). These vents are concurrent with the Continuous Routine Vents.

<u>Maintenance Vents</u>

Maintenance vents are generated from draining, depressurization, and/or purging of equipment for maintenance. All the equipment in LHC-9 is connected to a closed-drain system to ensure no VOC's are vented to atmosphere. Initially these vents would be primarily hydrocarbons, but would soon transition to be essentially 100% nitrogen as equipment preparation progresses. As such, these vents are not suitable for recovery and also would require shutdown of the Flare Gas Recovery System in order to avoid significant fuel disturbances to the Cracking Furnaces.

These vents would typically be concurrent with continuous routine vents and potentially with the intermittent routine vents. While each piece of equipment would be maintained infrequently, with hundreds of pieces of equipment in the plant, it is normal for equipment preparation with nitrogen to be occurring on an on-going basis. This is the reason the FGR was credited with a reduced 70% on-stream factor.

Start-up and Shutdown Vents

These vents occur as part of a controlled start-up and shutdown. The peak vent flows are typically much larger vent flows (100 times larger than the continuous vents) than those described above, but occur on a very infrequent basis (typically less than one event per year). While these vents have a composition that would be suitable for recovery, the flow rates are very large such that only a very small portion of this vent could be recovered on top of the continuous routine vents already being recovered. The capacity of the FGR system is matched to the continuous routine vent flows. It is not economically feasible to design for large events (100 times larger than routine vents) of short duration (4 to 8 hours) that occur infrequently (less than one time per year). Additionally, there is no outlet for this large recovered stream so it would be technical infeasible to do so because the equivalent heat value is much larger than the demands of the process.

Additionally, there is no outlet for this large recovered stream because the equivalent heat value of it is much larger than the demands of the process during these events so it would be technically infeasible to recover it.

Episodic Events

These vents occur as part of un-planned trips or off-spec incidents. These vent flows are typically much larger vent flows (up to 1,000 times larger than the continuous vent stream) than any of the vent streams described above (i.e. they set the sizing basis of the pressure-assisted flare system) and occur on a very infrequent basis. These types of events are not permitted events. In all other factors, these types of vents have a similar impact and consideration as the start-up and shutdown vents.

4) Why would it not be possible to accommodate for these various streams to be captured while still allowing protection against catastrophic flows?

As noted above, all of the typical vent streams listed above flow together in the same flare header system to the Pressure-Assisted Flare, GF-596. It is on this common system near the inlet to the pressure assisted flare that the FGR would be placed. In this sense, all the streams are brought to one location. The reason they are not economically or technically considered for recovery in the BACT Analysis is based on the factors mentioned above and further discussed below.

For the large start-up, shutdown and episodic events, it is simply a matter of capacity and frequency of occurrence of these vents. There would only be a small incremental recovery on a very infrequent basis.

Another technical issue is the nitrogen associated with the Maintenance Vents that limits the duration that the FGR is credited as on-stream. Nitrogen is not suitable for recovery into the process or the fuel system. When it is recovered into the process, it would go with the offgas from the process (hydrogen and methane) and end up in the fuel system. When it enters the fuel system, either directly or indirectly via the process, it will create a disturbance to the furnace temperature control. Such disturbances have caused documented plant upsets in another Dow plant (non-US based) that has the same process flowsheet as LHC-9. Such an episodic event would result in GHG emissions that would potentially offset a whole year's benefit of an FGR system. It would also cause similar increases of VOC and NOx emissions associated with flaring necessary to stabilize the plant. For example, one off spec event typically results in 5,000 tons of CO_2 emissions. With on-going maintenance operations as described in #3, the risk to have an episodic event increases.

Therefore, whenever equipment is being purged with nitrogen to the flare system, the FGR would have to be turned off. The necessity of having the purge system connected to the main flare is discussed further below.

5) If one or more waste stream composition would preclude stable operation of the furnaces when used as fuel gas, or could not be reintroduced into the process as raw material, please provide an explanation of why those streams would result in such problems and why it would not be possible to segregate those streams to either the flare or to the TOX?

As mentioned above, the primary concern is the variable nitrogen composition of the combined flare gas stream to the Pressure-Assisted Flare, GF-596. Each piece of equipment containing hydrocarbons in LHC-9 is connected to a flare system to allow safe and environmentally sound methods of clearing equipment for maintenance. The flare system collects vents, PSV’s, and drains from each piece of equipment. The flare system consists of a warm flare header and a cryogenic flare header.

The cryogenic flare header is designed for receiving very cold liquid hydrocarbons that can flash as cold as -250°F and is constructed of low temperature stainless steel and includes a vaporizer to ensure the material is vaporized and warmed before being sent to the flare.

The warm flare header is designed for receiving warm liquids that do not flash or warm vapor, but is connected to systems that operate at large volumes and high pressures. These two header systems are very extensive and exist throughout the entire plant, one of which connects to almost every piece of equipment. The two headers come together only at the inlet to the Pressure-Assisted Flare after the cryogenic header has been warmed.

When preparing a piece of equipment to either of the respective header systems, the equipment is first minimized of inventory while still in service, then drained, depressurized, and then purged to flare with nitrogen. The transition from process (hydrocarbons) to nitrogen occurs over a period of time during the purge step. It would be difficult to manage the transition reliably so that the hydrocarbons went to flare while the nitrogen went to a separate header system connected to a TOX.

More technically challenging, neither of these systems would be suitable for inadvertent connection to a separate header system routed to a TOX. The high pressure warm gas systems, the cryogenic liquids from the cold systems, or the significant liquid volume from either would overwhelm a TOX system.

In order to connect all equipment to a separate header system for nitrogen purging to a TOX, the header would need to be protected against unintended flow from the plant equipment. Safety Instrumented Systems (SIS) would have to be installed at the connection to every piece of equipment to protect the purge header from unintended cryogenic, high pressure, or liquid streams in order to prevent a catastrophic event at the TOX. These factors add a high degree of complexity to operating the plant and increase the risk of having a process safety event compared to the small amount of GHG emissions that would be reduced. The installed cost of another header system and all of the associated safety systems outweighs the benefit of trying to capture the remaining 30% of the continuous vent stream.

Flare Gas Recovery
Summary of Impacts to Permit Representations

Emissions Adjustment

The Flare Gas Recovery Unit (FGRU) design is based on the recovery of natural gas flare header purge and continuous vents to the multipoint ground flare. Vents to the elevated low pressure flare and intermittent vents to the multipoint ground flare are not candidates for FGR as discussed in the general response. It was necessary to make a few adjustments to the emission calculations in the permit in order to segregate these streams to demonstrate the potential emission reduction associated with FGRU. The original permit calculations combined the continuous vents and intermittent vents as a single stream.

While the revised BACT Tier 3 Analysis for the flare system reflects these changes, the permit application will not be updated because the overall change in emission rate is insignificant. The emissions tables provided in this summary are solely for supporting documentation for the Tier 3 analysis. Additionally, this summary provides the background on the emissions data used for the cost estimate in the Tier 3 analysis.

The first minor change is relative to the annual average heat input of the routine vent stream. While the annual average fuel flow does not change, the annual average heat input is slightly lower when the streams are separated. This is because the overall average heat input for the continuous streams is 901 Btu/scf while the average heat input for the intermittent stream is 928 Btu/scf. The impact of this difference is shown in Table 1. Attachment 1 is the original calculation and Attachment 2 is the revised calculation separating the continuous and intermittent streams.

Table 1. Summary of Changes to Average Heat Input

Source	Stream	Flow (scfm)	Heat content (Btu/scf)	Hourly Heat input (MMBtu/hr)[1]	Average Heat Input (MMBtu/yr)[2]	Average Fuel Gas Flow (MMscf/yr)[3]
Att. 1	Routine vents	616.6	928	34.32	300,603	324.09
Att. 2	Routine vents - continuous	429.4	901	23.21	203,299	225.67
	Routine vents – intermittent	187.2	928	10.42	91,284	98.42
Total (continuous + intermittent)		616.6	n/a	33.63	294,583	324.09

[1] Hourly heat input calculation: flow (scfm) x heat content (btu/scf) x 60 min/hr x 1 MM/10^6
616.6 scfm x 928 Btu/scf x 60 min/hr x 1 MM/1,000,000 = 34.32 MMBtu/hr
[2] Average Heat Input: hourly heat input (MMBtu/hr) x 8760
34.32 MMBtu/hr x 8760 hours/year = 300,643 MMBtu/yr
3 Average Fuel Gas Flow: flow (scfm) x 60 min/hr x 8760 hrs/year x 1 MM/10^6
616.6 scfm x 60 min/hr x 8760 hours/yr x 1/1,000,000 = 324.09 MMscf/yr

The second minor change involves the stream compositions. The compositions for routine vents change slightly when continuous vents are segregated from intermittent vents, resulting in different carbon content and average molecular weight. These changes are summarized in Table 2 on the following page. Attachment 3 contains the detailed stream speciation used to generate the stream carbon content and average molecular weight.

Table 2. Summary of Changes to Fuel Carbon Content and MW

Source	Stream	Fuel Carbon Content (kg C/kg Gas)	Fuel MW (kg/kg-mol)
Att. 3	Routine vents	0.59	19.2
Att. 3	Routine vents - continuous	0.55	20.0
	Routine vents – intermittent	0.71	17.5

Finally, these changes impact the calculated GHG emissions for the routine vent stream as shown in Table 3. Because the overall emissions change is insignificant (0.045 percent of the total CO_2e emission rate), updated calculations are not necessary for the permit, and are only used for the cost estimate in the BACT analysis. Attachment 4 is the original calculation and Attachment 5 is the revised calculation separating the continuous and intermittent streams.

Table 3. Summary of Changes to the Calculated GHG Emissions

Source	Stream	CO_2	CH_4	N_2O	CO_2e
Att. 4	Routine vents	17,554	0.99	0.20	17,639
Att. 5	Routine vents - continuous	11,734	0.67	0.13	11,791
	Routine vents – intermittent	5,831	0.30	0.06	5,856
	Total (continuous + intermittent)	17,565	0.97	0.19	17,647
				% change	=(17,647 – 17,639)/17,639 = 0.00045

BACT Tier 3 Cost Analysis Details

Direct Annual Costs, Utilities: Natural Gas

The hourly average heat content of the natural gas flare header purge (5.58 MMBtu/hr) and the continuous vents (23.21 MMBtu/hr) totals to 28.79 MMBtu/hr. See Attachment 2.

We assumed a 70% operational rate to accommodate for periods of time when other vents from maintenance activities containing nitrogen would be introduced into the flare header making recovery infeasible.

The average cost of natural gas was estimated to be $5/MMBtu.

The calculated cost savings associated with recovering the natural gas flare header purge and continuous vent stream:

28.79 MMBtu/hr x 8760 hours/year x 70% recovery x $5/MMBtu = $-882,701.

Pollution Control Effectiveness

1) Emission Rate w/o FGRU

The emission rate used in the Tier 3 cost analysis reflects emissions from the multipoint ground flare only and includes emissions from all streams (flare pilots, natural gas flare header purge, continuous vents, and intermittent vents, as well as maintenance, startup, and shutdown streams). We limited the emissions to this source because the recovered flare gas will only offset other fuels used in the furnaces resulting in insignificant changes to GHG emissions from the furnaces. No other sources in the permit have the potential to be impacted. This total emission rate from the multipoint ground flare is 44,097 tons of CO_2e. See Attachment 5.

2) Emission rate with FGRU

Flare pilots, intermittent, maintenance, startup, and shutdown streams will not be impacted by the FGRU system. The total emissions from these streams is 31,509 tons CO_2e. See Attachment 5.

Additionally, because the FGRU is anticipated to recover 70% of the continuous and natural gas flare header purge streams, 30% of the emissions associated with those streams will also remain: (797 tons + 11,791 tons) x 30% = 3,776 tons CO_2e.

Total emissions remaining at the flare: 31,509 + 3,776 = 35,285 tons CO_2e

3) Total Emission Reduction

The total emission reduction is the difference between the Emission Rate w/o FGRU and the Emission Rate w/FGRU.

Emission rate w/o FGR:	44,097	Tons CO_2e
Emission rate with FGR:	35,285	Tons CO_2e
Emission Reduction	8,812	Tons CO_2e

Attachment 1

OC2F5961 emission calculations

(from current permit application representations)

FIN: OC2L9F596
EPN: OC2F5961
Pressure-Assisted Flare, GF-596

Basis:

1. There is a continuous natural gas purge to flare to maintain flare header velocity and heating value
2. This flare primarily combusts fugitive emission from vents and compressor seals as listed below.
3. Emission factors for VOC's from Table 1.4-2. AP-42 Fifth Edition, 7/98.
4. Emission factors for CO, and NOx from TNRCC Guidance Document, "Flares and Vapor Oxidizers, June 1998" for the appropriate heat content, steam-assisted flare.
5. 99.5% Destruction efficiency for compounds containing no more than 3 carbons that contain no elements other than carbon and hydrogen; all others 98%.
6. There are no PM emissions from this flare since it is required to be smokeless.
7. Flows to GF-596 are as follows

	C-201B	C-321	C-651	C-601	D115 Depad	HC Vents	HP Flare Header Purge	Totals for Waste Gas Flow (Excluding Header Purge)	
Process flow rate, SCFM	11.01	11.01	10.93	10.94	187.25	385.47	91.19	616.61	Total SCFM
Process Avg MW	27.19	27.19	28.02	29.29	17.51	19.55	17.24		
Process Flow, lb/hr	47.58	47.58	48.67	50.90	520.75	1197.22	249.75	1912.69	Total lb/hr
Process LHV, Btu/lb	1482.30	1482.30	1831.78	2565.49	20010.62	17402.70	20282.85		
Pressure, psig	0.50	0.50	0.50	0.50	0.50	0.50	0.50		
Temperature, F	75.00	75.00	75.00	75.00	75.00	75.00	75.00		
Btu/scf for each vent and compressor	107	107	136	199	928	901	926		

Process Flow (lb/hr) = Process Flow Rate (SCFM) / Universal Gas Constant (psi-ft^3/lbmol-R) / (Temp (F) + 460) * (Pressure (psig) + 14.7 psia) * Process Avg MW (lb/lb-mol) * (60 min/hr)
lb/hr = 11.01 SCFM / 10.73 psi-ft3/lbmol-R / (75 + 460) * (0.50 psig + 14.7 psia) * 27.19 lb/lbmol * 60 min/hr
lb/hr = 47.58
Heating Value per Compressor (Btu/scf) = (Process Flow (lb/hr) * Process LHV (Btu/lb)) / (Process flow rate (SCFM) * 60 min/hr)
(Btu/scf) = (47.58 lb/hr * 1482.295 Btu/lb) / (11.01 SCFM * 60 min/hr)
(Btu/scf) = 107

Emission Factors

Flare Emissions Factors - 99.5% DRE - Steam Assisted		
CO	0.2600	lb/MMBtu
NOx	0.0500	lb/MMBtu
PM	0.0000	lb/MMscf

Emission Factors

Flare Emissions Factors - AP-42		
VOC	5.5	lb/MMscf fuel

Flare DRE - Steam Assisted		
DRE for VOCs (except C2-3)	98	Percent
DRE for VOCs (C2 or C3)	99.5	Percent

Sulfur Content		
Maximum Sulfur Content in Fuel =	5	gr/100scf
Average Sulfur Content in Fuel =	0.2	gr/100scf

EPN: OC2F5961

Pressure-Assisted Flare, GF-596, Continued

Table 1 Hourly Calculations

Maximum Hourly Flows to Flare			LHV	LHV	Heat in	CO		NOx		SO_2			PM		VOC	
						Factor	Emission	Factor	Emission	Factor	Factor	Emission	Factor	Emission	Factor	Emission
Compound	SCFM	lb/hr	Btu/lb	Btu/scf	MMBtu/hr	lb/MMBtu	lb/hr	lb/MMBtu	lb/hr	gr/100scf	ppm,wt	lb/hr	lb/MMscf	lb/hr	lb/MMscf	lb/hr
Waste Gas	616.6	1912.7		928	34.32	0.2600	8.92	0.0500	1.72		-	0.00	0.000	0.000		3.41
Natural Gas - Purge	91.2			1020	5.58	0.2600	1.45	0.0500	0.28	5.00		0.08	0.000	0.000	5.500	0.03
Natural Gas - Pilot	25.5			1020	1.56	0.2600	0.41	0.0500	0.08	5.00		0.02	0.000	0.000	5.500	0.01
Total					**41.46**		**10.78**		**2.07**			**0.10**		**0.000**		**3.45**

Basis:

SCFM = Waste Gas Flow based on normal flows of vents and compressor seals shown above
Natural Gas Purge flow rate = 91.2 scfm
Pilot gas flow based on plant design 1.06 scfm/pilot 24 pilots 25.49 scfm
Heat Input (MMBtu/hr) = Max Flow (SCFM) * LHV (Btu/scf) * 60 (min/hr) / 1,000,000
CO Emissions (lb/hr) = Heat Input (MMBtu/hr) * CO Emission Factor (lb/MMBtu)
Nox Emissions (lb/hr) = Heat Input (MMBtu/hr) * NOx Emission Factor (lb/MMBtu)
SO2 Emissions - Waste Gas (lb/hr) = Sum of Sulfur Containing Flow Streams (lb/hr) * SO2 Emission Factor (ppm) / 1,000,000 * (2 lb SO2/lb S)
SO2 Emissions - Fuel Gas (lb/hr) = Max Flow (SCFM) * 60 (min/hr) * SO2 Emission Factor (gr/100 scf) * 0.0001429 (lb/gr) * (2lb SO2/lb S)
PM Emissions (lb/hr) = Max Flow (SCFM) * 60 (min/hr) * PM Emission Factor (lb/MMscf) / 1,000,000
VOC Emissions - Waste Gas (lb/hr) = Sum of Max VOC Flow from Vent/Compressor Fugitives
VOC Emissions - Fuel Gas (lb/hr) = Max Flow (SCFM) * 60 (min/hr) * VOC Emission Factor (lb/MMscf) / 1,000,000

Table 2 Annual Calculations

Average Hourly Flows to Flare			LHV	LHV	Heat in	CO		NOx		SO_2			PM		VOC	
						Factor	Emission	Factor	Emission	Factor	Factor	Emission	Factor	Emission	Factor	Emission
Compound	SCFM	lb/hr	Btu/lb	Btu/scf	MMBtu/hr	lb/MMBtu	tpy	lb/MMBtu	tpy	gr/100scf	ppm,wt	tpy	lb/MMscf	tpy	lb/MMscf	tpy
Waste Gas - continuous vents	616.6	1912.7		928	34.32	0.2600	39.08	0.0500	7.52		-	0.000	0.000	0.000		13.29
Natural Gas - Purge	91.2			1020	5.58	0.2600	6.36	0.0500	1.22	0.20		0.014	0.000	0.000	5.500	0.13
Natural Gas - Pilot	25.5			1020	1.56	0.2600	1.78	0.0500	0.34	0.20		0.004	0.000	0.000	5.500	0.04
Annual TPY @ 8760 hrs/yr					**41.46**		**47.21**		**9.08**			**0.02**		**0.000**		**13.46**

Basis:

SCFM = Waste Gas Flow based on normal flows of vents and compressor seals shown above
Natural Gas Purge flow rate = 91.2 scfm
Pilot gas flow based on plant design 1.06 scfm/pilot 24 pilots 25.49 scfm
Heat Input (MMBtu/hr) = Max Flow (SCFM) * LHV (Btu/scf) * 60 (min/hr) / 1,000,000
CO Emissions (tpy) = Heat Input (MMBtu/hr) * CO Emission Factor (lb/MMBtu) * 8760 (hrs/yr) / 2000 (lbs/ton)
Nox Emissions (tpy) = Heat Input (MMBtu/hr) * NOx Emission Factor (lb/MMBtu) * 8760 (hrs/yr) / 2000 (lbs/ton)
SO2 Emissions - Waste Gas (tpy) = Sum of Sulfur Containing Flow Streams (lb/hr) * SO2 Emission Factor (ppm) / 1,000,000 * (2 lb SO2/lb S) * 8760 (hrs/yr) / 2000 (lbs/ton)
SO2 Emissions - Fuel Gas (tpy) = Max Flow (SCFM) * 60 (min/hr) * SO2 Emission Factor (gr/100 scf) * 0.0001429 (lb/gr) * (2lb SO2/lb S) * 8760 (hrs/yr) / 2000 (lbs/ton)
PM Emissions (tpy) = Max Flow (SCFM) * 60 (min/hr) * PM Emission Factor (lb/MMscf) / 1,000,000 * 8760 (hrs/yr) / 2000 (lbs/ton)
VOC Emissions - Waste Gas (tpy) = Sum of Max VOC Flow from Vent/Compressor Fugitives
VOC Emissions - Fuel Gas (tpy) = Max Flow (SCFM) * 60 (min/hr) * VOC Emission Factor (lb/MMscf) / 1,000,000 * 8760 (hrs/yr) / 2000 (lbs/ton)

EPN: OC2F5961
Pressure-Assisted Flare, GF-596, Continued

Speciated Emissions - Vent/Compressor Seal Emissions

Maximum Hourly, lb/hr	**VOC DRE**	**C-201B**		**C-321**		**C-651**		**C-601**		**D115 Depad**		**HC Vents**		**Total**	**Total VOC**
	(%)	**wt%**	**lb/hr**	**wt%**	**lb/hr**	**wt%**	**lb/hr**	**wt%**	**lb/hr**	**wt%**	**lb/hr**	**wt%**	**lb/hr**	**lb/hr**	**lb/hr**
Maximum Waste Gas Load, lb/hr			47.58		47.58		48.67		50.90		520.75		1197.22		
Hydrogen	99.5	0.21%	0.00	0.21%	0.00	0.00%	-	0.00%	-	0.00%	-	1.32%	0.08	0.08	
Nitrogen	-	93.07%	44.28	93.07%	44.28	90.97%	44.28	87.00%	44.28	1.10%	5.73	16.89%	202.21	385.05	
Methane	99.5	0.63%	0.00	0.63%	0.00	0.00%	-	0.00%	-	86.30%	2.25	47.29%	2.83	5.08	
Ethylene	99.5	3.78%	0.01	3.78%	0.01	9.03%	0.02	0.00%	-	0.00%	-	14.94%	0.89	0.93	0.93
Ethanol	99.5	2.31%	0.01	2.31%	0.01	0.00%	-	0.00%	-	4.20%	0.11	5.17%	0.31	0.43	
Carbon Dioxide	-	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	3.90%	20.31	1.66%	19.87	40.18	
Propylene	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	13.00%	0.03	0.00%	-	3.18%	0.19	0.22	0.22
Propane	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	1.20%	0.03	1.73%	0.10	0.13	0.13
Isobutane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.09%	0.02	0.02	0.02
Isobutene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.27%	0.06	0.06	0.06
N-Butene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.37%	0.09	0.09	0.09
1,3-Butadiene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	1.41%	0.34	0.34	0.34
N-Butane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.50%	0.05	0.29%	0.07	0.12	0.12
N-Pentene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	2.03%	0.49	0.49	0.49
Methanol	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	2.03%	0.49	0.49	0.49
Methyl -Cyclopentane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.91%	0.22	0.22	0.22
Water	-	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.41%	4.91	4.91	
Dimethyl Disulfide	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	2.80%	0.29	0.00%	-	0.29	0.29
Total														439.14	3.41

Max Annual, tpy	**VOC DRE**	**C-201B**		**C-321**		**C-651**		**C-601**		**D115 Depad**		**HC Vents**		**Total**	**Total VOC (continuous**
	(%)	**wt%**	**tpy**	**wt%**	**tpy**	**wt%**	**tpy**	**wt%**	**tpy**	**wt%**	**tpy**	**wt%**	**tpy**	**tpy**	**tpy**
Maximum Waste Gas Load, lb/hr			47.58		47.58		48.67		50.90		520.75		1197.22		
Hours/yr		8760		8760		8760		8760		23		8760			
Hydrogen	99.5	0.21%	0.00	0.21%	0.00	0.00%	-	0.00%	-	0.00%	-	1.32%	0.35	0.35	
Nitrogen	-	93.07%	193.94	93.07%	193.94	90.97%	193.93	87.00%	193.95	1.10%	0.07	16.89%	885.68	1661.50	
Methane	99.5	0.63%	0.01	0.63%	0.01	0.00%	-	0.00%	-	86.30%	0.03	47.29%	12.40	12.44	
Ethylene	99.5	3.78%	0.04	3.78%	0.04	9.03%	0.10	0.00%	-	0.00%	-	14.94%	3.92	4.09	4.09
Ethanol	99.5	2.31%	0.02	2.31%	0.02	0.00%	-	0.00%	-	4.20%	0.00	5.17%	1.36	1.40	
Carbon Dioxide	-	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	3.90%	0.23	1.66%	87.05	87.28	
Propylene	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	13.00%	0.14	0.00%	-	3.18%	0.83	0.98	0.98
Propane	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	1.20%	0.000359	1.73%	0.45	0.45	0.45
Isobutane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.09%	0.09	0.09	0.09
Isobutene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.27%	0.28	0.28	0.28
N-Butene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.37%	0.39	0.39	0.39
1,3-Butadiene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	1.41%	1.48	1.48	1.48
N-Butane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.50%	0.000599	0.29%	0.30	0.30	0.30
N-Pentene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	2.03%	2.13	2.13	2.13
Methanol	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	2.03%	2.13	2.13	2.13
Methyl -Cyclopentane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.91%	0.95	0.95	0.95
Water	-	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.41%	21.50	21.50	
Dimethyl Disulfide	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	2.80%	0.00	0.00%	-	0.00	0.00
Total														1797.77	13.29

EPN: OC2F5961
Pressure-Assisted Flare, GF-596, Continued

Example Calculations:

Speciated Emissions (lbs/hr) = Stream Weight % * Flowrate (lb/hr) * DRE (%)
lbs/hr (Ethylene) = 3.78% * 47.58 lb/hr * (1 - 99.5%)
lbs/hr (Ethylene) = 0.01
Speciated Emissions (tpy) = Stream Weight % * Flowrate (lb/hr) * DRE (%) * 8760 hrs/yr / 2000 lb/ton
tpy (Ethylene) = 3.78% * 47.58 lb/hr * (1 - 99.5%) * 8760 hrs / 2000 lb/ton
tpy (Ethylene) = 0.04

Emissions Summary:

	Emissions	
Component	**(lb/hr)**	**(tpy)**
CO	10.78	47.21
NOx	2.07	9.08
SO2	0.10	0.02
PM	0.00	0.00
VOC	3.45	13.46

Attachment 2

OC2F5961 emission calculations for FGR analysis only

Note – these calculations reflect separation of the routine vent stream into continuous and intermittent streams.

FIN: OC2L9F596
EPN: OC2F5961
Pressure-Assisted Flare, GF-596

Basis:

1. There is a continuous natural gas purge to flare to maintain flare header velocity and heating value
2. This flare primarily combusts fugitive emission from vents and compressor seals as listed below.
3. Emission factors for VOC's from Table 1.4-2. AP-42 Fifth Edition, 7/98.
4. Emission factors for CO, and NOx from TNRCC Guidance Document, "Flares and Vapor Oxidizers, June 1998" for the appropriate heat content, steam-assisted flare.
5. 99.5% Destruction efficiency for compounds containing no more than 3 carbons that contain no elements other than carbon and hydrogen; all others 98%.
6. There are no PM emissions from this flare since it is required to be smokeless.
7. Flows to GF-596 are as follows

	C-201B	C-321	C-651	C-601	D115 Depad	HC Vents	HP Flare Header Purge	Totals for Waste Gas Flow (Excluding Header Purge)	
Process flow rate, SCFM	11.01	11.01	10.93	10.94	187.25	385.47	91.19	616.61	Total SCFM
Process Avg MW	27.19	27.19	28.02	29.29	17.51	19.55	17.24		
Process Flow, lb/hr	47.58	47.58	48.67	50.90	520.75	1197.22	249.75	1912.69	Total lb/hr
Process LHV, Btu/lb	1482.30	1482.30	1831.78	2565.49	20010.62	17402.70	20282.85		
Pressure, psig	0.50	0.50	0.50	0.50	0.50	0.50	0.50		
Temperature, F	75.00	75.00	75.00	75.00	75.00	75.00	75.00		
Btu/scf for each vent and compressor	107	107	136	199	928	901	926		

Process Flow (lb/hr) = Process Flow Rate (SCFM) / Universal Gas Constant (psi-ft^3/lbmol-R) / (Temp (F) + 460) * (Pressure (psig) + 14.7 psia) * Process Avg MW (lb/lb-mol) * (60 min/hr)
lb/hr = 11.01 SCFM / 10.73 psi-ft3/lbmol-R / (75 + 460) * (0.50 psig + 14.7 psia) * 27.19 lb/lbmol * 60 min/hr
lb/hr = 47.58
Heating Value per Compressor (Btu/scf) = (Process Flow (lb/hr) * Process LHV (Btu/lb)) / (Process flow rate (SCFM) * 60 min/hr)
(Btu/scf) = (47.58 lb/hr * 1482.295 Btu/lb) / (11.01 SCFM * 60 min/hr)
(Btu/scf) = 107

Emission Factors

Flare Emissions Factors - 99.5% DRE - Steam Assisted		
CO	0.2600	lb/MMBtu
NOx	0.0500	lb/MMBtu
PM	0.0000	lb/MMscf

Emission Factors

Flare Emissions Factors - AP-42		
VOC	5.5	lb/MMscf fuel

Flare DRE - Steam Assisted		
DRE for VOCs (except C2-3)	98	Percent
DRE for VOCs (C2 or C3)	99.5	Percent

Sulfur Content		
Maximum Sulfur Content in Fuel =	5	gr/100scf
Average Sulfur Content in Fuel =	0.2	gr/100scf

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Pressure-Assisted Flare, GF-596, Continued

Table 1 Hourly Calculations

						CO		NOx		SO_2			PM		VOC	
Maximum Hourly Flows to Flare			**LHV**	**LHV**	**Heat in**	**Factor**	**Emission**	**Factor**	**Emission**	**Factor**	**Factor**	**Emission**	**Factor**	**Emission**	**Factor**	**Emission**
Compound	**SCFM**	**lb/hr**	**Btu/lb**	**Btu/scf**	**MMBtu/hr**	**lb/MMBtu**	**lb/hr**	**lb/MMBtu**	**lb/hr**	**gr/100scf**	**ppm,wt**	**lb/hr**	**lb/MMscf**	**lb/hr**	**lb/MMscf**	**lb/hr**
Waste Gas - continuous vents	429.4	1391.9		901	23.21	0.2600	6.03	0.0500	1.16		-	0.00	0.000	0.000		3.03
Waste Gas - intermittent vents	187.2	520.8		928	10.42	0.2600	2.71	0.0500	0.52		-	0.00	0.000	0.000		0.37
Natural Gas - Purge	91.2			1020	5.58	0.2600	1.45	0.0500	0.28	5.00		0.08	0.000	0.000	5.500	0.03
Natural Gas - Pilot	25.5			1020	1.56	0.2600	0.41	0.0500	0.08	5.00		0.02	0.000	0.000	5.500	0.01
Total					**40.77**		**10.60**		**2.04**			**0.10**		**0.000**		**3.45**

Basis:

SCFM = Waste Gas Flow based on normal flows of vents and compressor seals shown above
Natural Gas Purge flow rate = 91.2 scfm
Pilot gas flow based on plant design 1.06 scfm/pilot 24 pilots 25.49 scfm
Heat Input (MMBtu/hr) = Max Flow (SCFM) * LHV (Btu/scf) * 60 (min/hr) / 1,000,000
CO Emissions (lb/hr) = Heat Input (MMBtu/hr) * CO Emission Factor (lb/MMBtu)
Nox Emissions (lb/hr) = Heat Input (MMBtu/hr) * NOx Emission Factor (lb/MMBtu)
SO2 Emissions - Waste Gas (lb/hr) = Sum of Sulfur Containing Flow Streams (lb/hr) * SO2 Emission Factor (ppm) / 1,000,000 * (2 lb SO2/lb S)
SO2 Emissions - Fuel Gas (lb/hr) = Max Flow (SCFM) * 60 (min/hr) * SO2 Emission Factor (gr/100 scf) * 0.0001429 (lb/gr) * (2lb SO2/lb S)
PM Emissions (lb/hr) = Max Flow (SCFM) * 60 (min/hr) * PM Emission Factor (lb/MMscf) / 1,000,000
VOC Emissions - Waste Gas (lb/hr) = Sum of Max VOC Flow from Vent/Compressor Fugitives
VOC Emissions - Fuel Gas (lb/hr) = Max Flow (SCFM) * 60 (min/hr) * VOC Emission Factor (lb/MMscf) / 1,000,000

Table 2 Annual Calculations

						CO		NOx		SO_2			PM		VOC	
Average Hourly Flows to Flare			**LHV**	**LHV**	**Heat in**	**Factor**	**Emission**	**Factor**	**Emission**	**Factor**	**Factor**	**Emission**	**Factor**	**Emission**	**Factor**	**Emission**
Compound	**SCFM**	**lb/hr**	**Btu/lb**	**Btu/scf**	**MMBtu/hr**	**lb/MMBtu**	**tpy**	**lb/MMBtu**	**tpy**	**gr/100scf**	**ppm,wt**	**tpy**	**lb/MMscf**	**tpy**	**lb/MMscf**	**tpy**
Waste Gas - continuous vents	429.4	1391.9		901	23.21	0.2600	26.43	0.0500	5.08		-	0.000	0.000	0.000		13.29
Waste Gas - intermittent vents	187.2	520.8		928	10.42	0.2600	11.87	0.0500	2.28			0.000	0.000	0.000		0.01
Natural Gas - Purge	91.2			1020	5.58	0.2600	6.36	0.0500	1.22	0.20		0.014	0.000	0.000	5.500	0.13
Natural Gas - Pilot	25.5			1020	1.56	0.2600	1.78	0.0500	0.34	0.20		0.004	0.000	0.000	5.500	0.04
Annual TPY @ 8760 hrs/yr					**40.77**		**46.43**		**8.93**			**0.02**		**0.000**		**13.46**

Basis:

SCFM = Waste Gas Flow based on normal flows of vents and compressor seals shown above
Natural Gas Purge flow rate = 91.2 scfm
Pilot gas flow based on plant design 1.06 scfm/pilot 24 pilots 25.49 scfm
Heat Input (MMBtu/hr) = Max Flow (SCFM) * LHV (Btu/scf) * 60 (min/hr) / 1,000,000
CO Emissions (tpy) = Heat Input (MMBtu/hr) * CO Emission Factor (lb/MMBtu) * 8760 (hrs/yr) / 2000 (lbs/ton)
Nox Emissions (tpy) = Heat Input (MMBtu/hr) * NOx Emission Factor (lb/MMBtu) * 8760 (hrs/yr) / 2000 (lbs/ton)
SO2 Emissions - Waste Gas (tpy) = Sum of Sulfur Containing Flow Streams (lb/hr) * SO2 Emission Factor (ppm) / 1,000,000 * (2 lb SO2/lb S) * 8760 (hrs/yr) / 2000 (lbs/ton)
SO2 Emissions - Fuel Gas (tpy) = Max Flow (SCFM) * 60 (min/hr) * SO2 Emission Factor (gr/100 scf) * 0.0001429 (lb/gr) * (2lb SO2/lb S) * 8760 (hrs/yr) / 2000 (lbs/ton)
PM Emissions (tpy) = Max Flow (SCFM) * 60 (min/hr) * PM Emission Factor (lb/MMscf) / 1,000,000 * 8760 (hrs/yr) / 2000 (lbs/ton)
VOC Emissions - Waste Gas (tpy) = Sum of Max VOC Flow from Vent/Compressor Fugitives
VOC Emissions - Fuel Gas (tpy) = Max Flow (SCFM) * 60 (min/hr) * VOC Emission Factor (lb/MMscf) / 1,000,000 * 8760 (hrs/yr) / 2000 (lbs/ton)

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Pressure-Assisted Flare, GF-596, Continued

Speciated Emissions - Vent/Compressor Seal Emissions

Maximum Hourly, lb/hr	VOC DRE	C-201B		C-321		C-651		C-601		D115 Depad		HC Vents		Total	Total VOC (continuous vents)	Total VOC (intermittent vents)
	(%)	wt%	lb/hr	wt%	lb/hr	wt%	lb/hr	wt%	lb/hr	wt%	lb/hr	wt%	lb/hr	lb/hr	lb/hr	lb/hr
Maximum Waste Gas Load, lb/hr			47.58		47.58		48.67		50.90		520.75		1197.22			
Hydrogen	99.5	0.21%	0.00	0.21%	0.00	0.00%	-	0.00%	-	0.00%	-	1.32%	0.08	0.08		
Nitrogen	-	93.07%	44.28	93.07%	44.28	90.97%	44.28	87.00%	44.28	1.10%	5.73	16.89%	202.21	385.05		
Carbon Monoxide	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00		
Methane	99.5	0.63%	0.00	0.63%	0.00	0.00%	-	0.00%	-	86.30%	2.25	47.29%	2.83	5.08		
Ethylene	99.5	3.78%	0.01	3.78%	0.01	9.03%	0.02	0.00%	-	0.00%	-	14.94%	0.89	0.93	0.93	0.00
Ethanol	99.5	2.31%	0.01	2.31%	0.01	0.00%	-	0.00%	-	4.20%	0.11	5.17%	0.31	0.43		
Carbon Dioxide	-	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	3.90%	20.31	1.66%	19.87	40.18		
Acetylene	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00	0.00	0.00
Hydrogen Sulfide	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00		
Propylene	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	13.00%	0.03	0.00%	-	3.18%	0.19	0.22	0.22	0.00
Propane	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	1.20%	0.03	1.73%	0.10	0.13	0.10	0.03
Isobutane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.09%	0.02	0.02	0.02	0.00
Isobutene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.27%	0.06	0.06	0.06	0.00
N-Butene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.37%	0.09	0.09	0.09	0.00
1,3-Butadiene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	1.41%	0.34	0.34	0.34	0.00
N-Butane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.50%	0.05	0.29%	0.07	0.12	0.07	0.05
Isopentane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00	0.00	0.00
N-Pentene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	2.03%	0.49	0.49	0.49	0.00
Normal Pentane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00	0.00	0.00
Methanol	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	2.03%	0.49	0.49	0.49	0.00
Methyl -Cyclopentane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.91%	0.22	0.22	0.22	0.00
Benzene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00	0.00	0.00
Water	-	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.41%	4.91	4.91		
Dimethyl Disulfide	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	2.80%	0.29	0.00%	-	0.29	0.00	0.29
Total														439.14	3.03	0.37

Max Annual, tpy	VOC DRE	C-201B		C-321		C-651		C-601		D115 Depad		HC Vents		Total	(continuous vents)	(intermittent vents)
	(%)	wt%	tpy	wt%	tpy	wt%	tpy	wt%	tpy	wt%	tpy	wt%	tpy	tpy	tpy	tpy
Maximum Waste Gas Load, lb/hr			47.58		47.58		48.67		50.90		520.75		1197.22			
Hours/yr		8760		8760		8760		8760		23		8760				
Hydrogen	99.5	0.21%	0.00	0.21%	0.00	0.00%	-	0.00%	-	0.00%	-	1.32%	0.35	0.35		
Nitrogen	-	93.07%	193.94	93.07%	193.94	90.97%	193.93	87.00%	193.95	1.10%	0.07	16.89%	885.68	1661.50		
Carbon Monoxide	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00		
Methane	99.5	0.63%	0.01	0.63%	0.01	0.00%	-	0.00%	-	86.30%	0.03	47.29%	12.40	12.44		
Ethylene	99.5	3.78%	0.04	3.78%	0.04	9.03%	0.10	0.00%	-	0.00%	-	14.94%	3.92	4.09	4.09	0.00
Ethanol	99.5	2.31%	0.02	2.31%	0.02	0.00%	-	0.00%	-	4.20%	0.00	5.17%	1.36	1.40		
Carbon Dioxide	-	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	3.90%	0.23	1.66%	87.05	87.28		
Acetylene	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00	0.00	0.00
Hydrogen Sulfide	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00		
Propylene	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	13.00%	0.14	0.00%	-	3.18%	0.83	0.98	0.98	0.00
Propane	99.5	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	1.20%	0.000359	1.73%	0.45	0.45	0.45	0.00
Isobutane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.09%	0.09	0.09	0.09	0.00
Isobutene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.27%	0.28	0.28	0.28	0.00
N-Butene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.37%	0.39	0.39	0.39	0.00
1,3-Butadiene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	1.41%	1.48	1.48	1.48	0.00
N-Butane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.50%	0.000599	0.29%	0.30	0.30	0.30	0.00
Isopentane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00	0.00	0.00
N-Pentene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	2.03%	2.13	2.13	2.13	0.00
Normal Pentane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00	0.00	0.00
Methanol	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	2.03%	2.13	2.13	2.13	0.00
Methyl -Cyclopentane	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.91%	0.95	0.95	0.95	0.00
Benzene	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.00%	-	0.00	0.00	0.00
Water	-	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	0.00%	-	0.41%	21.50	21.50		
Dimethyl Disulfide	98	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	-	2.80%	0.00	0.00%	-	0.00	0.00	0.00
Total														1797.77	13.29	0.01

EPN: OC2F5961
Pressure-Assisted Flare, GF-596, Continued

Example Calculations:

Speciated Emissions (lbs/hr) = Stream Weight % * Flowrate (lb/hr) * DRE (%)
lbs/hr (Ethylene) = 3.78% * 47.58 lb/hr * (1 - 99.5%)
lbs/hr (Ethylene) = 0.01
Speciated Emissions (tpy) = Stream Weight % * Flowrate (lb/hr) * DRE (%) * 8760 hrs/yr / 2000 lb/ton
tpy (Ethylene) = 3.78% * 47.58 lb/hr * (1 - 99.5%) * 8760 hrs / 2000 lb/ton
tpy (Ethylene) = 0.04

Emissions Summary:

	Emissions	
Component	**(lb/hr)**	**(tpy)**
CO	10.60	46.43
NOx	2.04	8.93
SO2	0.10	0.02
PM	0.00	0.00
VOC	3.45	13.46

Attachment 3

LHC-9 Stream Analysis

(updated to show the continuous and intermittent routine vents stream average carbon content and average molecular weight)

Ground Flare Waste Gas (Routine Vents)

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Hydrogen	H_2	0.84	2.02	0.41	7.97	0	0.16	0.00
Nitrogen	N_2	20.13	28.01	0.72	13.84	0	3.88	0.00
Carbon Monoxide	CO	0.00	28.01	0.00	0.00	1	0.00	0.43
Methane	CH_4	53.13	16.04	3.31	63.76	1	10.23	0.75
Ethylene	C_2H_4	9.77	28.05	0.35	6.70	2	1.88	0.86
Ethanol	C_2H_6	4.49	30.07	0.15	2.88	2	0.87	0.80
Carbon Dioxide	CO_2	2.10	44.01	0.05	0.92	1	0.40	0.27
Acetylene	C_2H_2	0.00	26.04	0.00	0.00	2	0.00	0.92
Hydrogen Sulfide	H_2S	0.00	34.08	0.00	0.00	0	0.00	0.00
Propylene	C_3H_6	2.34	42.08	0.06	1.07	3	0.45	0.86
Propane	C_3H_8	1.41	44.10	0.03	0.62	3	0.27	0.82
Isobutane	C_4H_{10}	0.06	58.12	0.00	0.02	4	0.01	0.83
Isobutene	C_4H_8	0.17	56.11	0.00	0.06	4	0.03	0.86
N-Butene	C_4H_8	0.23	56.11	0.00	0.08	4	0.04	0.86
1,3-Butadiene	C_4H_6	0.88	54.09	0.02	0.31	4	0.17	0.89
N-Butane	C_4H_{10}	0.32	58.12	0.01	0.11	4	0.06	0.83
Isopentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
N-Pentene	C_5H_{10}	1.27	70.13	0.02	0.35	5	0.24	0.86
Normal Pentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
Methanol	CH_4O	1.27	32.04	0.04	0.76	1	0.24	0.37
Methyl -Cyclopentane	C_6H_{12}	0.57	84.16	0.01	0.13	6	0.11	0.86
Benzene	C_6H_6	0.00	78.11	0.00	0.00	6	0.00	0.92
Water	H_2O	0.26	18.02	0.01	0.27	0	0.05	0.00
Dimethyl Disulfide	$C_2H_6S_2$	0.76	94.20	0.01	0.16	2	0.15	0.25
		100.00		5.2	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Ground Flare Waste Gas = 19.2
Average Carbon Content of Ground Flare Waste Gas = 0.59

Ground Flare Waste Gas (Continuous Routine Vents)

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Hydrogen	H_2	1.15	2.02	0.57	11.38	0	0.23	0.00
Nitrogen	N_2	27.26	28.01	0.97	19.46	0	5.45	0.00
Carbon Monoxide	CO	0.00	28.01	0.00	0.00	1	0.00	0.43
Methane	CH_4	40.72	16.04	2.54	50.76	1	8.14	0.75
Ethylene	C_2H_4	13.42	28.05	0.48	9.57	2	2.68	0.86
Ethanol	C_2H_6	4.60	30.07	0.15	3.06	2	0.92	0.80
Carbon Dioxide	CO_2	1.43	44.01	0.03	0.65	1	0.29	0.27
Acetylene	C_2H_2	0.00	26.04	0.00	0.00	2	0.00	0.92
Hydrogen Sulfide	H_2S	0.00	34.08	0.00	0.00	0	0.00	0.00
Propylene	C_3H_6	3.21	42.08	0.08	1.53	3	0.64	0.86
Propane	C_3H_8	1.49	44.10	0.03	0.67	3	0.30	0.82
Isobutane	C_4H_{10}	0.08	58.12	0.00	0.03	4	0.02	0.83
Isobutene	C_4H_8	0.23	56.11	0.00	0.08	4	0.05	0.86
N-Butene	C_4H_8	0.32	56.11	0.01	0.11	4	0.06	0.86
1,3-Butadiene	C_4H_6	1.21	54.09	0.02	0.45	4	0.24	0.89
N-Butane	C_4H_{10}	0.25	58.12	0.00	0.09	4	0.05	0.83
Isopentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
N-Pentene	C_5H_{10}	1.75	70.13	0.02	0.50	5	0.35	0.86
Normal Pentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
Methanol	CH_4O	1.75	32.04	0.05	1.09	1	0.35	0.37
Methyl -Cyclopentane	C_6H_{12}	0.78	84.16	0.01	0.19	6	0.16	0.86
Benzene	C_6H_6	0.00	78.11	0.00	0.00	6	0.00	0.92
Water	H_2O	0.35	18.02	0.02	0.39	0	0.07	0.00
Dimethyl Disulfide	$C_2H_6S_2$	0.00	94.20	0.00	0.00	2	0.00	0.25
		100.00		5.0	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Ground Flare Waste Gas = 19.995
Average Carbon Content of Ground Flare Waste Gas = 0.55

Ground Flare Waste Gas Intermittent Routine Vents)

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Hydrogen	H_2	0.00	2.02	0.00	0.00	0	0.00	0.00
Nitrogen	N_2	1.10	28.01	0.04	0.69	0	0.19	0.00
Carbon Monoxide	CO	0.00	28.01	0.00	0.00	1	0.00	0.43
Methane	CH_4	86.30	16.04	5.38	94.17	1	15.10	0.75
Ethylene	C_2H_4	0.00	28.05	0.00	0.00	2	0.00	0.86
Ethanol	C_2H_6	4.20	30.07	0.14	2.44	2	0.74	0.80
Carbon Dioxide	CO_2	3.90	44.01	0.09	1.55	1	0.68	0.27
Acetylene	C_2H_2	0.00	26.04	0.00	0.00	2	0.00	0.92
Hydrogen Sulfide	H_2S	0.00	34.08	0.00	0.00	0	0.00	0.00
Propylene	C_3H_6	0.00	42.08	0.00	0.00	3	0.00	0.86
Propane	C_3H_8	1.20	44.10	0.03	0.48	3	0.21	0.82
Isobutane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
Isobutene	C_4H_8	0.00	56.11	0.00	0.00	4	0.00	0.86
N-Butene	C_4H_8	0.00	56.11	0.00	0.00	4	0.00	0.86
1,3-Butadiene	C_4H_6	0.00	54.09	0.00	0.00	4	0.00	0.89
N-Butane	C_4H_{10}	0.50	58.12	0.01	0.15	4	0.09	0.83
Isopentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
N-Pentene	C_5H_{10}	0.00	70.13	0.00	0.00	5	0.00	0.86
Normal Pentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
Methanol	CH_4O	0.00	32.04	0.00	0.00	1	0.00	0.37
Methyl -Cyclopentane	C_6H_{12}	0.00	84.16	0.00	0.00	6	0.00	0.86
Benzene	C_6H_6	0.00	78.11	0.00	0.00	6	0.00	0.92
Water	H_2O	0.00	18.02	0.00	0.00	0	0.00	0.00
Dimethyl Disulfide	$C_2H_6S_2$	2.80	94.20	0.03	0.52	2	0.49	0.25
		100.00		5.7	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Ground Flare Waste Gas = 17.5

Average Carbon Content of Ground Flare Waste Gas = 0.71

Example Calculation (Carbon Dioxide Component):

Carbon Content = (Component MW (lb/lbmol) * Atoms Carbon) / MW Carbon (lb/lbmol)
Carbon Content = (126.24 (lb/lbmol) * 9 (Atoms C)) / 12.01 (lb/lbmol)
Carbon Content = 0.86

Attachment 4

GHG Calculations for multipoint ground flare
(current permit representations)

EPN: OC2F5961
FIN: OC2L9F596
Greenhouse Gas Emissions - Pressure-Assisted Flare, GF-596

EPN	FIN	Description	Average Heat Input[1] (MMBtu/yr)	Average Fuel Gas Flow[2] (MMscf/yr)	Fuel Type	Fuel Carbon Content[3] (kg C/kg Gas)	Fuel MW[3] (kg/kg-mol)	Emission Factors[4] (kg/MMBtu)		Molar Volume Conversion Factor @ 68F (scf/kg-mol)	Global Warming Potential[5] (100 yr)			Annual Emissions (ton/yr)			
								CH_4	N_2O		CO_2	CH_4	N_2O	CO_2[6]	CH_4[7]	N_2O[7]	CO_2e
OC2F5961	OC2L9F596	Pressure-Assisted Flare, GF-596	62,555	61.33	Natural Gas Pilots	0.72	17.2	1.00E-03	1.00E-04	849.5	1	25	298	3,646	0.07	0.01	3,650
			300,603	324.09	Routine Vents	0.59	19.2	3.00E-03	6.00E-04					17,554	0.99	0.20	17,639
			35,940	35.91	Startup Stream #1	0.76	18.83	3.00E-03	6.00E-04					2,451	0.12	0.02	2,461
			51,013	50.22	Startup Stream #2	0.79	18.04	3.00E-03	6.00E-04					3,422	0.17	0.03	3,437
			6,248	16.51	Startup Stream #3	0.47	4.46	3.00E-03	6.00E-04					163.58	0.02	0.00	165.33
			86,528	56.90	Startup Stream #4	0.83	28.81	3.00E-03	6.00E-04					6,503	0.29	0.06	6,527
			8,418	8.40	Shutdown Stream #1	0.76	18.83	3.00E-03	6.00E-04					574	0.03	0.01	576
			24,272	15.03	Shutdown Stream #2	0.84	30.77	3.00E-03	6.00E-04					1,847	0.08	0.02	1,854
			16,765	13.94	Shutdown Stream #3	0.81	22.11	3.00E-03	6.00E-04					1,188	0.06	0.01	1,192
			6,478	19.25	Shutdown Stream #4	0.19	24.02	3.00E-03	6.00E-04					425	0.02	0.00	427
			10,949	15.01	Maintenance Stream #1	0.76	18.83	3.00E-03	6.00E-04					1,025	0.04	0.01	1,028
			11,424	15.66	Maintenance Stream #2	0.79	18.04	3.00E-03	6.00E-04					1,067	0.04	0.01	1,071
			46,259	63.43	Maintenance Stream #3	0.47	4.46	3.00E-03	6.00E-04					629	0.15	0.03	641
			7,155	9.81	Maintenance Stream #4	0.83	28.81	3.00E-03	6.00E-04					1,121	0.02	0.00	1,123
			7,350	10.08	Maintenance Stream #5	0.86	28.05	3.00E-03	6.00E-04					1,152	0.02	0.00	1,154
			4,863	6.67	Maintenance Stream #6	0.85	42.39	3.00E-03	6.00E-04					1,143	0.02	0.00	1,144
													Total:	**43,910**	**2.13**	**0.42**	**44,089**

Notes:

1. Based on the annual average heat input (MMBtu/hr) * 8,760 hr/yr
   For Natural Gas:
   MMBtu/yr = 7.14 * 8,760 hr/yr
   MMBtu/yr = 62,555
2. Based on the annual average fuel gas rate (scfm) * 60 * 8,760 hr/yr / 1,000,000
   For Natural Gas:
   MMscf/yr = 116.68 * 60 min/hr * 8,760 hr/yr / 1,000,000
   MMscf/yr = 61.33
3. For Fuel Carbon Content and MW data, see LHC-9 Stream Analysis.
4. Factors for ethylene production processes designated in Table C-2 of 40 CFR Part 98 Subpart C .
5. Global Warming Potential from Table A-1 to Subpart A of Part 98.
6. CO_2 emissions calculated in accordance with Tier 3 Calculation Methodology; Equation C-5 of 40 CFR Part 98 Subpart C.
7. CH_4 and N_2O emissions calculated in accordance with Equation C-8 of 40 CFR Part 98 Subpart C.

Example Calculations (From Natural Gas)

CO_2 Emissions:

tpy = MW CO2 (lb/lbmol) / MW CO (lb/lbmol) * Avg. Fuel Flow (MMscf/yr) * 1,000,000 * Fuel Carbon Content (kg C/kg Gas) * (MW of Fuel (lb/lbmol) / Molar Volume Conversion Factor) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = (44/12) * 61 (MMscf/yr) * 1,000,000 * 0.72 (kg C/kg Gas) * (17.2 (lb/lbmol) / 849.5 (scf/kg-mol)) * 2.20463 (lb/kg) / 2,000 (lb/ton)
tpy = 3,646

CH_4 Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * CH4 Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 62,555 (MMBtu/yr) * 0.001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.07

N_2O Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * N2O Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 62,555 (MMBtu/yr) * 0.0001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.01

CO2e Emissions:

tpy = (CO2 Emissions (tpy) * CO2 Global Warming Potential) + (CH4 Emissions (tpy) * CH4 Global Warming Potential) + (N2O Emissions (tpy) * N2O Global Warming Potential)
tpy = (3,646 (tpy) * 1) + (0.07 (tpy) * 25) + (0.01 (tpy) * 298)
tpy = 3,650

Attachment 5

GHG Calculations for multipoint ground flare

(for FGR Analysis only – reflects the separation of the routine vent stream into continuous and intermittent streams)

EPN: OC2F5961
FIN: OC2L9F596
Greenhouse Gas Emissions - Pressure-Assisted Flare, GF-596

EPN	FIN	Description	Average Heat Input[1] (MMBtu/yr)	Average Fuel Gas Flow[2] (MMscf/yr)	Fuel Type	Fuel Carbon Content[3] (kg C/kg Gas)	Fuel MW[3] (kg/kg-mol)	Emission Factors[4] (kg/MMBtu)		Molar Volume Conversion Factor @ 68F (scf/kg-mol)	Global Warming Potential[5] (100 yr)			Annual Emissions (ton/yr)			
								CH_4	N_2O		CO_2	CH_4	N_2O	CO_2[6]	CH_4[7]	N_2O[7]	CO_2e
OC2F5961	OC2L9F596	Pressure-Assisted Flare, GF-596	48,889	47.93	Natural Gas Pilots	0.72	17.2	1.00E-03	1.00E-04	849.5	1	25	298	2,849	0.05	0.01	2,852
			13,666	13.40	Natural Gas Flare Header Purge	0.72	17.2	1.00E-03	1.00E-04					796	0.02	0.00	797
			203,299	225.67	Routine vents, continuous	0.55	20.0	3.00E-03	6.00E-04					11,734	0.67	0.13	11,791
			91,284	98.42	Routine vents, intermittent	0.71	17.5	3.00E-03	6.00E-04					5,831	0.30	0.06	5,856
			35,940	35.91	Startup Stream #1	0.76	18.83	3.00E-03	6.00E-04					2,451	0.12	0.02	2,461
			51,013	50.22	Startup Stream #2	0.79	18.04	3.00E-03	6.00E-04					3,422	0.17	0.03	3,437
			6,248	16.51	Startup Stream #3	0.47	4.46	3.00E-03	6.00E-04					163.58	0.02	0.00	165.33
			86,528	56.90	Startup Stream #4	0.83	28.81	3.00E-03	6.00E-04					6,503	0.29	0.06	6,527
			8,418	8.40	Shutdown Stream #1	0.76	18.83	3.00E-03	6.00E-04					574	0.03	0.01	576
			24,272	15.03	Shutdown Stream #2	0.84	30.77	3.00E-03	6.00E-04					1,847	0.08	0.02	1,854
			16,765	13.94	Shutdown Stream #3	0.81	22.11	3.00E-03	6.00E-04					1,188	0.06	0.01	1,192
			6,478	19.25	Shutdown Stream #4	0.19	24.02	3.00E-03	6.00E-04					425	0.02	0.00	427
			10,949	15.01	Maintenance Stream #1	0.76	18.83	3.00E-03	6.00E-04					1,025	0.04	0.01	1,028
			11,424	15.66	Maintenance Stream #2	0.79	18.04	3.00E-03	6.00E-04					1,067	0.04	0.01	1,071
			46,259	63.43	Maintenance Stream #3	0.47	4.46	3.00E-03	6.00E-04					629	0.15	0.03	641
			7,155	9.81	Maintenance Stream #4	0.83	28.81	3.00E-03	6.00E-04					1,121	0.02	0.00	1,123
			7,350	10.08	Maintenance Stream #5	0.86	28.05	3.00E-03	6.00E-04					1,152	0.02	0.00	1,154
			4,863	6.67	Maintenance Stream #6	0.85	42.39	3.00E-03	6.00E-04					1,143	0.02	0.00	1,144
													Total:	**43,921**	**2.11**	**0.42**	**44,097**

Notes:
1. Based on the annual average heat input (MMBtu/hr) * 8,760 hr/yr
For Natural Gas:
MMBtu/yr = 7.14 * 8,760 hr/yr
MMBtu/yr = 48,889
2. Based on the annual average fuel gas rate (scfm) * 60 * 8,760 hr/yr / 1,000,000
For Natural Gas:
MMscf/yr = 116.68 * 60 min/hr * 8,760 hr/yr / 1,000,000
MMscf/yr = 47.93
3. For Fuel Carbon Content and MW data, see LHC-9 Stream Analysis.
4. Factors for ethylene production processes designated in Table C-2 of 40 CFR Part 98 Subpart C .
5. Global Warming Potential from Table A-1 to Subpart A of Part 98.
6. CO_2 emissions calculated in accordance with Tier 3 Calculation Methodology; Equation C-5 of 40 CFR Part 98 Subpart C.
7. CH_4 and N_2O emissions calculated in accordance with Equation C-8 of 40 CFR Part 98 Subpart C.

	tons, CO2e
NG purge	797
Routine Cont. vents	11,791
Routine Int. vents	5,856
NG Pilots	2,852
MSS	22,800
Total, w/o FGR	**44,097**

NG purge, 30%	239
Routine Cont. vents, 30%	3537
Routine Int. vents	5,856
NG pilots	2,852
MSS	22,800
Total w/FGR	**35,285**

Difference **8,812**

Example Calculations (From Natural Gas)

CO_2 Emissions:
tpy = MW CO2 (lb/lbmol) / MW CO (lb/lbmol) * Avg. Fuel Flow (MMscf/yr) * 1,000,000 * Fuel Carbon Content (kg C/kg Gas) * (MW of Fuel (lb/lbmol) / Molar Volume Conversion Factor) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = (44/12) * 48 (MMscf/yr) * 1,000,000 * 0.72 (kg C/kg Gas) * (17.2 (lb/lbmol) / 849.5 (scf/kg-mol)) * 2.20463 (lb/kg) / 2,000 (lb/ton)
tpy = 2,849

CH_4 Emissions:
tpy = Avg. Heat Input (MMBtu/yr) * CH4 Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 48,889 (MMBtu/yr) * 0.001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.05

N_2O Emissions:
tpy = Avg. Heat Input (MMBtu/yr) * N2O Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 48,889 (MMBtu/yr) * 0.0001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.01

CO2e Emissions:
tpy = (CO2 Emissions (tpy) * CO2 Global Warming Potential) + (CH4 Emissions (tpy) * CH4 Global Warming Potential) + (N2O Emissions (tpy) * N2O Global Warming Potential)
tpy = (2,849 (tpy) * 1) + (0.05 (tpy) * 25) + (0.01 (tpy) * 298)
tpy = 2,852

The Dow Chemical Company
2301 N. Brazosport Blvd.
Freeport, Texas 77541
USA

December 19, 2013

Certified Mail 7013 2250 0001 2961 4607
Return Receipt Requested

Mr. Brad Toups
U.S. EPA Region 6, 6PD
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: The Dow Chemical Company
PSD Greenhouse Gas (GHG) Permit Application
Additional Information for the Ethylene Production Facility (LHC-9)

Dear Mr. Toups,

Enclosed please find an updated BACT analysis for the flare system for the proposed Light Hydrocarbon 9 production unit. The attached Section 4.4 is being presented to replace the previously submitted Section 4.4. We have also updated the emission calculations to reflect the recent change in global warming potential for methane and nitrous oxide. The updated emission calculations and associated summary tables are also attached.

Should you have any questions regarding this information, I can be contacted at (979) 238-5832 or via e-mail at clsteves@dow.com.

Sincerely,

Cheryl Steves

Cheryl Steves
Environmental Manager, The Dow Chemical Company

Enclosures/cls

Cc via Email:	Ms. Cindy Rodriguez	The Dow Chemical Company
	Ms. Mary Schwartz	The Dow Chemical Company

The Dow Chemical Company

Dow Texas Operations – Freeport

Prevention of Significant Deterioration

Greenhouse Gas

Permit Application

for

Ethylene Production Facility (LHC-9)

December 19, 2013

4.4 BACT FOR FLARE SYSTEM

The small elevated flare is designed to control fugitive emissions from process compressor seals. There is also a continuous N_2 and natural gas purge to maintain header velocity and heating value. The pressure-assisted flare manages excess off-gas from LHC-9 operations. This is a necessary pressure control mechanism to address changes in off-gas consumption by other consumer plants at the site. Fuel line purging to safely isolate LHC-9 cracking furnaces burners is routinely flared for OC2L9HH1 – OC2L9HH8. Additionally, there is a continuous natural gas purge to the flare to maintain header velocity. The flare's pilots are fueled by low-carbon pipeline natural gas and are in operation 8,760 hours per year. Both flares will be subject to TCEQ HRVOC and Federal 40 CFR 60.18 requirements.

4.4.1 Step 1 – Identify Available Control Technologies

A search of the RBLC database did not identify any GHG control technologies for control devices such as the small elevated or pressure-assisted flares, particularly since the flares themselves are considered add-on control units. However, to expedite this permit issuance process, Dow considered the following technologies as potential GHG control measures for the flares at the LHC-9 facility:

1. Good plant design to minimize flaring
2. Use of low-carbon assist gas
3. Good flare design and operation
4. Carbon Capture and Storage
5. Flare Gas Recovery

4.4.1.1 Good plant design to minimize flaring

The current plant design incorporates minimum-flaring attributes such as recovery of low flow vent streams and off-spec recycle to minimize material that would otherwise be routed to the flare. It is inherent in Dow's plant design to re-use as much of the hydrocarbons as possible within the plant that would otherwise be routed to a flare. The only routine materials that will go to the flare are vent streams that cannot be recycled to the process for safety or other technical reasons. These streams include compressor seal vents and minor leaks from relief valves which are variable and unpredictable in flow and composition

4.4.1.2 Low-Carbon Assist Gas

The use of natural gas as assist gas is the lowest-carbon fuel available for the proposed project. Dow proposes to use natural gas for the flares' pilot gas and as supplemental fuel, if needed, to maintain the appropriate vent stream heating value as required by applicable air quality regulations.

4.4.1.3 Good Flare Design and Operation

Good operating and maintenance practices for flares include appropriate maintenance of equipment (such as periodic flare tip maintenance) and operating within the recommended heating value and flare tip velocity as specified by its design. The use of good operating and maintenance practices results in longer life of the equipment and more efficient operation. Therefore, such practices indirectly reduce GHG emissions by supporting operation as designed by the flare manufacturer. Good flare design includes pilot flame monitoring, flow measurement, and monitoring/control of waste gas heating value.

4.4.1.4 Carbon Capture and Storage

The primary source of GHG emissions from a flare is the result of combustion of the hydrocarbon-containing gas stream in the flare. CCS requires separation of CO_2 from the flare exhaust, compression of the CO_2, and transportation to an injection/storage location.

4.4.1.5 Flare Gas Recovery

Flare gas recovery (FGR) would be sized to recover the continuous expected vent streams to the flare not currently recovered and recycled internally, such as small leakage rates across compressor seals and minor leaks from closed vent control and pressure relief valves. These streams cannot be recycled to the process for safety and technical reasons as follows:

- Process safety concern includes the potential for a relief episode that would disrupt the compositions to the flare gas recovery stream, resulting in a process upset that would subsequently result in increased flaring to manage the event. A relief episode has unpredictable flow and composition.
- Technical concerns associated with the periodic maintenance activities that require purging of nitrogen through equipment to clear it – this surge in nitrogen would have significant impact to the flare gas recovery system by adding significant amounts of nitrogen and changing the composition and overall heat value of the recovered flare gas stream, rendering this type of stream unsuitable for FGR. This abrupt change could also trigger a plant upset, resulting in significant flaring to manage the event.

4.4.2 Step 2 – Eliminate Technically Infeasible Options

4.4.2.1 Good Plant Design to Minimize Flaring

Good plant design that recovers and recycles materials to minimize flaring is considered technically feasible.

4.4.2.2 Low-Carbon Assist Gas

Use of low-carbon assist gas is considered technically feasible.

4.4.2.3 Good Flare Design and Operation

Use of good flare design and operation is considered technically feasible.

4.4.2.4 Carbon Capture and Storage

The primary source of GHG emissions from a flare is the result of combustion of the hydrocarbon-containing gas stream in the flare. Flare exhaust cannot be captured for CO_2 separation unless the flare device is enclosed, which poses a safety hazard for a flare system designed for an ethylene production facility. Post-combustion capture is not a feasible control technique for flare exhaust, therefore CCS is considered a technically infeasible option and is not considered further in this BACT analysis.

4.4.2.5 Flare Gas Recovery

FGR is used in refineries; it is not commonly used in olefins production. There is a significant process risk associated with recovering and recycling the vents from compressor seals, emergency pressure relief valves, pressure vent control valves, and purge nitrogen in that these systems are in place to manage maintenance and episodic events safely. Waste gases routed to the flare from these sources are not suited for recovery into a fuel gas system because they can contain maintenance, startup, shutdown, and emergency relief streams that vary greatly in composition and flow. Routing these streams to the fuel system can impact the overall stability of the entire process unit. Operation of these cracking furnaces is significantly more sensitive to changes in fuel quality than some processes like boilers or heat recovery units. Dow believes installing an FGR system for these vents is technically infeasible, however because FGR systems are existing technology and have been installed in certain petrochemical applications this technology will be included for further evaluation.

4.4.3 Step 3 – Rank According to Effectiveness

Use of good plant design to minimize flaring, low-carbon assist gas, good flare design and operation, and flare gas recovery are being proposed for this project. These techniques are ranked as follows:

1. Good plant design to minimize flaring is ranked first. This technique is a source reduction approach as various routine, stable vent streams are collected and routed back to the process for recovery. This the most effective manner in which to inherently recover valuable product from the plant vent system as well as minimize the vents that are flared. Implementation of this minimum-flaring attribute significantly reduces the quantity of materials that are flared on a routine basis.
2. Low-carbon assist gas is ranked next – the low carbon assist gas is natural gas, which is primarily methane.
3. Good flare design and operation is ranked third. This attribute does not involve extensive capital cost or annual operating costs; examples of good flare design and operation include pilot flare monitoring, control of flare exit velocity, and maintaining a minimum heating value for the flared waste stream.
4. FGR is ranked last as it will require significant capital investment, has a relatively high emission control cost, has a high process risk element,and will have minimal impact on overall GHG emissions from the project.

4.4.4 Step 4 – Evaluate the Most Effective Controls

Use of good plant design to minimize flaring, low-carbon assist gas, and good flare design and operation are being incorporated as control measures therefore an evaluation of the energy, environmental, and economic impacts of the proposed measures is not necessary for this application.

An economic feasibility analysis was completed for a FGR system. Dow has developed an estimate based on design criteria for the proposed LHC-9 project as actual vent flows and compositions are not available. The FGR cost estimate is based on a potential reduction of 8,638 tons/yr of CO_2 (1.2% of the total GHG emissions) that would be generated when flaring the material in lieu of recovering and using as a furnace fuel. The estimated cost per ton of CO_2e reduced is $148/ton making an FGR economically infeasible.

Due to the plant design to minimize flaring and the variability in the composition and flow to the FGR system, Dow has determined that an FGR system is not technically feasible.

Figure 4.4.4 Flare Gas Recovery Unit Cost Analysis

Source Name: GF-596
Pollutant: CO2
Control Option: Flare Gas Recovery Unit

I.	**DIRECT COSTS (DC)**	**COST $**	**COST BASIS**
A.	Primary control device & ancillary equipment cost (A)	$3,871,000	Estimated Cost = A
	Instrumentation	$193,550	0.05 A
	Sales Tax	$270,970	0.07 A
	Freight	$193,550	0.05 A
	Subtotal Purchased Equipment Cost (B)	$4,529,070	Estimated A*1.17 = B
B.	Direct Installation Costs		Cost Factors from *Aspen ICARUS*
	Foundation & Support	$181,163	4% TDC
	Handling & Erection	$45,291	1% TDC
	Electrical	$90,581	2% TDC
	Piping	$905,814	20% TDC
	Insulation	$45,291	1% TDC
	Painting	$158,517	3.5% TDC
	Total Direct Installation Costs	$1,426,657	
C.	Site Preparation	$50,000	
D.	Buildings	$0	
E.	TOTAL DIRECT COSTS	**$6,005,727**	
II.	**INDIRECT COSTS(Installation, IC)**		
A.	Final engineering design	$997,000	10% TCI
B.	Construction expense, including permits, insurance, temporary facilities, and clean-up	$452,907	10% Purchased Equipment
C.	Contractor's fee and overhead	$452,907	10% Purchased Equipment
D.	Startup	$45,291	1% Purchased Equipment
E.	Performance Tests	$45,291	1% Purchased Equipment
F	Contingency	$1,996,000	20% TCI
G	TOTAL INDIRECT COSTS	**$3,989,395**	
III	**TOTAL CAPITAL INVESTMENT (TCI=DC+IC)**		
A.	Sum of Total Direct and Indirect Costs	$9,995,122	
B.	Retrofit Factor (Dependent upon system complexity)	0%	2% to 50% for retrofits on existing sources
C.	ADJUSTED TOTAL CAPITAL INVESTMENT	**$9,995,122**	

ANNUAL OPERATING COSTS (AOC)		COST $	COST BASIS
I.	**DIRECT ANNUAL COSTS (DAC)**		
A.	Labor		
	Operator (1 hr/shift, 3 shifts)	$29,751	$ 27.17
	Supervisory	$4,463	15% of Operator Cost
	Maintenance (1.5% of purchased equipment)	$67,936	$ 27.97
B.	Maintenance Materials(set to zero, normally = mtc labor)		
C.	Operational Materials		
	Chemicals	0	
	Other (Carbon, Catalyst etc)		
	Value of any recovered material for sale or credit		
D.	Utilities		
	Natural Gas	-800,226	- 26.1 MM Btu/hr @ $5/MMBtu
	Other Fuel		
	Electricity	$173,448	330 kw @ $0.06/kwh
	Other	$0	
E	TOTAL DIRECT ANNUAL COSTS	-$524,628	
II.	**INDIRECT ANNUAL COSTS (IAC)**		
A.	Capital Recovery (CR=CRF*TCI)	$1,338,781	
	Capital Recovery Factor	0.1339	Based on APR & Term below
	Annual Interest Rate	0.057	10 yr @ 5.7%;
	Investment Term (yr)	10	
B.	Labor Overhead	$61,290	60% of Total Labor & Mtc
C.	Administration, Taxes & Insurance	$399,805	4% of TCI
E.	TOTAL INDIRECT ANNUAL COSTS	$1,799,886	
III	**TOTAL ANNUAL OPERATING COSTS (AOC=DAC+IAC)**	**$1,275,258**	
	POLLUTANT CONTROL EFFECTIVENESS		
A.	Typical Emission Rate W/O FGRU	713,051.0	Tons/yr
B.	Emission Rate with FGRU	704,412.6	Tons/yr
C.	Total Emission Reduction	8,638.4	Tons/yr
EMISSION CONTROL COST EFFECTIVENESS			
A.	Overall Cost Effectiveness ($/Ton)	$148	

4.4.5 Step 5 – Select BACT

Dow proposes to incorporate low-carbon assist gas and good flare design and operation discussed in Section 4.4.1 as BACT for controlling CO_2 emissions from the flares.

Table 4-7: Proposed Practices and MRR for Flare System

Practices	Monitoring*	Recordkeeping*	Reporting
Good flare design and operation	Continuous monitoring of waste gas heating value and flow rate	Continuous recording of waste gas heating value and flow rate	None
	Continuous monitoring of flare pilot flame	Continuous recording of pilot flame monitoring	None

* Continuous monitoring, continuous record and continuous recorder shall have the same definitions as in the Hazardous Organic NESHAP, 40 CFR 63.152(f) and 63.152(g).

Table 3-1 Proposed GHG Emission Limits

Date:	December 19, 2013	Permit No.:	TBD	RN Number:	100225945
Area Name:	LHC-9 Unit			CN Number:	600356976

AIR CONTAMINANT DATA				
1. EMISSION POINT			2. COMPONENT NAME	3. AIR CONTAMINANT EMISSION RATE
EPN (A)	FIN (B)	NAME (C)		TPY
OC2H121	OC2L9H121	Cracking Furnace, F-121	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H122	OC2L9H122	Cracking Furnace, F-122	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H123	OC2L9H123	Cracking Furnace, F-123	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H124	OC2L9H124	Cracking Furnace, F-124	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H125	OC2L9H125	Cracking Furnace, F-125	CO2	278,357
			CH4	5.19
			N2O	0.52
			CO2e	278,641
OC2H126	OC2L9H126	Cracking Furnace, F-126	CO2	301,855
			CH4	5.63
			N2O	0.56
			CO2e	302,164
OC2H127	OC2L9H127	Cracking Furnace, F-127	CO2	301,855
			CH4	5.63
			N2O	0.56
			CO2e	302,164
OC2H128	OC2L9H128	Cracking Furnace, F-128	CO2	301,855
			CH4	5.63
			N2O	0.56
			CO2e	302,164
OC2F597	OC2L9F597	Low Pressure Flare, FS-597	CO2	14,034
			CH4	0.22
			N2O	0.02
			CO2e	14,046
OC2F5961	OC2L9F596	Pressure-Assisted Flare, GF-596	CO2	43,910
			CH4	2.13
			N2O	0.42
			CO2e	44,089
OC2FU2	OC2L9FU2	Process Area Fugitives	CO2	0.02
			CH4	3.82
			CO2e	80.31
OC2GE1	OC2L9GE1	Backup Diesel Generator No. 1	CO2	16.04
			CH4	0.001
			N2O	0.0001
			CO2e	16.10
OC2GE2	OC2L9GE2	Backup Diesel Generator No. 2	CO2	16.04
			CH4	0.001
			N2O	0.0001
			CO2e	16.10
OC2TOX	OC2L9TOX	LHC-9 TOX	CO2	3,320.21
			CH4	0.06
			N2O	0.007
			CO2e	3,323.92

Total GHG Emissions

Component	TPY
CO2	2,358,647
CH4	49.07
N2O	4.73
CO2e	2,361,269

Table 4-11 GHG Emissions Summary
Annual Facility Emission Limits and BACT Selection
Permit Application for a New Facility - LHC-9 Unit

EPN	FIN	Description	GHG Mass Basis Emission Rates Pollutant	GHG Mass Basis Emission Rates Ton per Year	CO_2e Ton per Year	BACT Selection
OC2H121	OC2L9H121	Cracking Furnace, F-121	CO2	278,357	278,641	Flue Gas Exit Temperature ≤ 330° F. Fuel for the furnace will have ≤ 0.74 lbs carbon per lb fuel (CC). Fuel rate not to exceed 598 MMBtu/hr. Annual output based limit of 1.1 lbs GHG/lbs of ethylene.
			CH4	5.19		
			N2O	0.52		
OC2H122	OC2L9H122	Cracking Furnace, F-122	CO2	278,357	278,641	
			CH4	5.19		
			N2O	0.52		
OC2H123	OC2L9H123	Cracking Furnace, F-123	CO2	278,357	278,641	
			CH4	5.19		
			N2O	0.52		
OC2H124	OC2L9H124	Cracking Furnace, F-124	CO2	278,357	278,641	
			CH4	5.19		
			N2O	0.52		
OC2H125	OC2L9H125	Cracking Furnace, F-125	CO2	278,357	278,641	
			CH4	5.19		
			N2O	0.52		
OC2H126	OC2L9H126	Cracking Furnace, F-126	CO2	301,855	302,164	Flue Gas Exit Temperature ≤ 330° F. Fuel for the furnace will have ≤ 0.74 lbs carbon per lb fuel (CC). Fuel rate not to exceed 599 MMBtu/hr. Annual output based limit of 1.1 lbs GHG/lbs of ethylene.
			CH4	5.63		
			N2O	0.56		
OC2H127	OC2L9H127	Cracking Furnace, F-127	CO2	301,855	302,164	
			CH4	5.63		
			N2O	0.56		
OC2H128	OC2L9H128	Cracking Furnace, F-128	CO2	301,855	302,164	
			CH4	5.63		
			N2O	0.56		
OC2F597	OC2L9F597	Low Pressure Flare, FS-597	CO2	14,034	14,046	Use of good combustion practices.
			CH4	0.22		
			N2O	0.02		
OC2F5961	OC2L9F596	Pressure-Assisted Flare, GF-596	CO2	43,910	44,089	Use of good combustion practices.
			CH4	2.13		
			N2O	0.42		
OC2FU2	OC2L9FU2	Process Area Fugitives	CO2	0.02	80.31	Use of 28VHP LDAR TCEQ program
			CH4	3.82		
OC2GE1	OC2L9GE1	Backup Diesel Generator No. 1	CO2	16.04	16.10	Use of good combustion practices.
			CH4	0.001		
			N2O	0.0001		
OC2GE2	OC2L9GE2	Backup Diesel Generator No. 2	CO2	16.04	16.10	
			CH4	0.001		
			N2O	0.0001		
OC2TOX	OC2L9TOX	LHC-9 TOX	CO2	3,320	3,324	Use of good combustion practices.
			CH4	0.06		
			N2O	0.007		

Total GHG Emissions

Component	TPY
CO2	2,358,647
CH4	49.07
N2O	4.73
CO2e	2,361,269

EPN: OC2H121, OC2H122, OC2H123, OC2H124, OC2H125, OC2H126, OC2H127, OC2H128
FIN: OC2L9H121, OC2L9H122, OC2L9H123, OC2L9H124, OC2L9H125, OC2L9H126, OC2L9H127, OC2L9H128
Greenhouse Gas Emissions - Cracking Furnaces, F-121 - F-128

EPN	FIN	Description	Average Heat Input[1] (MMBtu/yr)	Average Fuel Gas Flow[2] (MMscf/yr)	Fuel Type	Fuel Carbon Content[3] (kg C/kg Gas)	Fuel MW[3] (kg/kg-mol)	Emission Factors[4] (kg/MMBtu)		Molar Volume Conversion Factor @ 68F (scf/kg-mol)	Global Warming Potential[5] (100 yr)			Annual Emissions (ton/yr)			
								CH_4	N_2O		CO_2	CH_4	N_2O	CO_2[6]	CH_4[7]	N_2O[7]	CO_2e
OC2H121	OC2L9H121	Cracking Furnace, F-121	4,708,266	4,682	Natural Gas	0.72	17.2	1.0E-03	1.0E-04	849.5	1	25	298	278,357	5.19	0.52	278,641
					Off Gas	0.50	4.9	3.0E-03	6.0E-04					53,819	15.57	3.11	55,136
													Max:	**278,357**	**15.57**	**3.11**	**278,641**
OC2H122	OC2L9H122	Cracking Furnace, F-122	4,708,266	4,682	Natural Gas	0.72	17.2	1.0E-03	1.0E-04	849.5	1	25	298	278,357	5.19	0.52	278,641
					Off Gas	0.50	4.9	3.0E-03	6.0E-04					53,819	15.57	3.11	55,136
													Max:	**278,357**	**15.57**	**3.11**	**278,641**
OC2H123	OC2L9H123	Cracking Furnace, F-123	4,708,266	4,682	Natural Gas	0.72	17.2	1.0E-03	1.0E-04	849.5	1	25	298	278,357	5.19	0.52	278,641
					Off Gas	0.50	4.9	3.0E-03	6.0E-04					53,819	15.57	3.11	55,136
													Max:	**278,357**	**15.57**	**3.11**	**278,641**
OC2H124	OC2L9H124	Cracking Furnace, F-124	4,708,266	4,682	Natural Gas	0.72	17.2	1.0E-03	1.0E-04	849.5	1	25	298	278,357	5.19	0.52	278,641
					Off Gas	0.50	4.9	3.0E-03	6.0E-04					53,819	15.57	3.11	55,136
													Max:	**278,357**	**15.57**	**3.11**	**278,641**
OC2H125	OC2L9H125	Cracking Furnace, F-125	4,708,266	4,682	Natural Gas	0.72	17.2	1.0E-03	1.0E-04	849.5	1	25	298	278,357	5.19	0.52	278,641
					Off Gas	0.50	4.9	3.0E-03	6.0E-04					53,819	15.57	3.11	55,136
													Max:	**278,357**	**15.57**	**3.11**	**278,641**
OC2H126	OC2L9H126	Cracking Furnace, F-126	5,105,726	5,077	Natural Gas	0.72	17.2	1.0E-03	1.0E-04	849.5	1	25	298	301,855	5.63	0.56	302,164
					Off Gas	0.50	4.9	3.0E-03	6.0E-04					58,362	16.88	3.38	59,790
													Max:	**301,855**	**16.88**	**3.38**	**302,164**
OC2H127	OC2L9H127	Cracking Furnace, F-127	5,105,726	5,077	Natural Gas	0.72	17.2	1.0E-03	1.0E-04	849.5	1	25	298	301,855	5.63	0.56	302,164
					Off Gas	0.50	4.9	3.0E-03	6.0E-04					58,362	16.88	3.38	59,790
													Max:	**301,855**	**16.88**	**3.38**	**302,164**
OC2H128	OC2L9H128	Cracking Furnace, F-128	5,105,726	5,077	Natural Gas	0.72	17.2	1.0E-03	1.0E-04	849.5	1	25	298	301,855	5.63	0.56	302,164
					Off Gas	0.50	4.9	3.0E-03	6.0E-04					58,362	16.88	3.38	59,790
													Max:	**301,855**	**16.88**	**3.38**	**302,164**
													Total:	**2,297,351**	**128**	**26**	**2,299,698**

Notes:
1. Based on the annual average heat input (MMBtu/hr) * 8,760 hr/yr
For Natural Gas:
MMBtu/yr = 537.47 * 8,760 hr/yr
MMBtu/yr = 4,708,266
2. Based on the annual average fuel gas rate (Mscf/hr) * 8,760 hr/yr / 1,000
For Natural Gas:
MMscf/yr = 534.49 * 8,760 hr/yr / 1,000
MMscf/yr = 4,682
3. For Fuel Carbon Content and MW data, see LHC-9 Stream Analysis.
4. Factors for ethylene production processes designated in Table C-2 of 40 CFR Part 98 Subpart C .
5. Global Warming Potential from Table A-1 to Subpart A of Part 98.
6. CO_2 emissions calculated in accordance with Tier 3 Calculation Methodology; Equation C-5 of 40 CFR Part 98 Subpart C.
7. CH_4 and N_2O emissions calculated in accordance with Equation C-8 of 40 CFR Part 98 Subpart C.

Example Calculations (From Natural Gas)

CO_2 Emissions:
tpy = MW CO2 (lb/lbmol) / MW CO (lb/lbmol) * Avg. Fuel Flow (MMscf/yr) * 1,000,000 * Fuel Carbon Content (kg C/kg Gas) * (MW of Fuel (lb/lbmol) / Molar Volume Conversion Factor) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = (44/12) * 4,682 (MMscf/yr) * 1,000,000 * 0.72 (kg C/kg Gas) * (17.2 (lb/lbmol) / 849.5 (scf/kg-mol)) * 2.20463 (lb/kg) / 2,000 (lb/ton)
tpy = 278,357

CH_4 Emissions:
tpy = Avg. Heat Input (MMBtu/yr) * CH4 Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 4,708,266 (MMBtu/yr) * 0.001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 5.19

N_2O Emissions:
tpy = Avg. Heat Input (MMBtu/yr) * N2O Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 4,708,266 (MMBtu/yr) * 0.0001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.52

CO2e Emissions:
tpy = (CO2 Emissions (tpy) * CO2 Global Warming Potential) + (CH4 Emissions (tpy) * CH4 Global Warming Potential) + (N2O Emissions (tpy) * N2O Global Warming Potential)
tpy = (278,357 (tpy) * 1) + (5.19 (tpy) * 25) + (0.52 (tpy) * 298)
tpy = 278,641

EPN: OC2F597
FIN: OC2L9F597
Greenhouse Gas Emissions - Low Pressure Flare, FS-597

EPN	FIN	Description	Average Heat Input[1] (MMBtu/yr)	Average Fuel Gas Flow[2] (MMscf/yr)	Fuel Type	Fuel Carbon Content[3] (kg C/kg Gas)	Fuel MW[3] (kg/kg-mol)	Emission Factors[4] (kg/MMBtu)		Molar Volume Conversion Factor @ 68F (scf/kg-mol)	Global Warming Potential[5] (100 yr)			Annual Emissions (ton/yr)			
								CH_4	N_2O		CO_2	CH_4	N_2O	CO_2[6]	CH_4[7]	N_2O[7]	CO_2e
OC2F597	OC2L9F597	Low Pressure Flare, FS-597	197,855	232	Natural Gas Pilots and Purge	0.72	17.2	1.00E-03	1.00E-04	849.5	1	25	298	13,795	0.22	0.02	13,807
			1,908	274	Routine Vents	0.01	27.7	3.00E-03	6.00E-04					239	0.01	0.00	239
													Total:	**14,034**	**0.22**	**0.02**	**14,046**

__Notes:__

1. Based on the annual average heat input (MMBtu/hr) * 8,760 hr/yr
   For Natural Gas:
   MMBtu/yr = 22.59 * 8,760 hr/yr
   MMBtu/yr = 197,855
2. Based on the annual average fuel gas rate (scfm) * 60 * 8,760 hr/yr / 1,000,000
   For Natural Gas:
   MMscf/yr = 441.49 * 60 min/hr * 8,760 hr/yr / 1,000,000
   MMscf/yr = 232.05
3. For Fuel Carbon Content and MW data, see LHC-9 Stream Analysis.
4. Factors for ethylene production processes designated in Table C-2 of 40 CFR Part 98 Subpart C .
5. Global Warming Potential from Table A-1 to Subpart A of Part 98.
6. CO_2 emissions calculated in accordance with Tier 3 Calculation Methodology; Equation C-5 of 40 CFR Part 98 Subpart C.
7. CH_4 and N_2O emissions calculated in accordance with Equation C-8 of 40 CFR Part 98 Subpart C.

__Example Calculations (From Natural Gas)__

CO_2 Emissions:

tpy = MW CO2 (lb/lbmol) / MW CO (lb/lbmol) * Avg. Fuel Flow (MMscf/yr) * 1,000,000 * Fuel Carbon Content (kg C/kg Gas) * (MW of Fuel (lb/lbmol) / Molar Volume Conversion Factor) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = (44/12) * 232.05 (MMscf/yr) * 1,000,000 * 0.72 (kg C/kg Gas) * (17.2 (lb/lbmol) / 849.5 (scf/kg-mol)) * 2.20463 (lb/kg) / 2,000 (lb/ton)
tpy = 13,795

CH_4 Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * CH4 Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 197,855 (MMBtu/yr) * 0.001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.22

N_2O Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * N2O Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 197,855 (MMBtu/yr) * 0.0001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.02

CO2e Emissions:

tpy = (CO2 Emissions (tpy) * CO2 Global Warming Potential) + (CH4 Emissions (tpy) * CH4 Global Warming Potential) + (N2O Emissions (tpy) * N2O Global Warming Potential)
tpy = (13,795 (tpy) * 1) + (0.22 (tpy) * 25) + (0.02 (tpy) * 298)
tpy = 13,807

EPN: OC2F5961
FIN: OC2L9F596
Greenhouse Gas Emissions - Pressure-Assisted Flare, GF-596

EPN	FIN	Description	Average Heat Input[1] (MMBtu/yr)	Average Fuel Gas Flow[2] (MMscf/yr)	Fuel Type	Fuel Carbon Content[3] (kg C/kg Gas)	Fuel MW[3] (kg/kg-mol)	Emission Factors[4] (kg/MMBtu)		Molar Volume Conversion Factor @ 68F (scf/kg-mol)	Global Warming Potential[5] (100 yr)			Annual Emissions (ton/yr)			
								CH_4	N_2O		CO_2	CH_4	N_2O	CO_2[6]	CH_4[7]	N_2O[7]	CO_2e
OC2F5961	OC2L9F596	Pressure-Assisted Flare, GF-596	62,555	61.33	Natural Gas Pilots and Purge	0.72	17.2	1.00E-03	1.00E-04	849.5	1	25	298	3,646	0.07	0.01	3,650
			300,603	324.09	Routine Vents	0.59	19.25	3.00E-03	6.00E-04					17,554	0.99	0.20	17,639
			35,940	35.91	Startup Stream #1	0.76	18.83	3.00E-03	6.00E-04					2,451	0.12	0.02	2,461
			51,013	50.22	Startup Stream #2	0.79	18.04	3.00E-03	6.00E-04					3,422	0.17	0.03	3,437
			6,248	16.51	Startup Stream #3	0.47	4.46	3.00E-03	6.00E-04					163.58	0.02	0.00	165.33
			86,528	56.90	Startup Stream #4	0.83	28.81	3.00E-03	6.00E-04					6,503	0.29	0.06	6,527
			8,418	8.40	Shutdown Stream #1	0.76	18.83	3.00E-03	6.00E-04					574	0.03	0.01	576
			24,272	15.03	Shutdown Stream #2	0.84	30.77	3.00E-03	6.00E-04					1,847	0.08	0.02	1,854
			16,765	13.94	Shutdown Stream #3	0.81	22.11	3.00E-03	6.00E-04					1,188	0.06	0.01	1,192
			6,478	19.25	Shutdown Stream #4	0.19	24.02	3.00E-03	6.00E-04					425	0.02	0.00	427
			10,949	15.01	Maintenance Stream #1	0.76	18.83	3.00E-03	6.00E-04					1,025	0.04	0.01	1,028
			11,424	15.66	Maintenance Stream #2	0.79	18.04	3.00E-03	6.00E-04					1,067	0.04	0.01	1,071
			46,259	63.43	Maintenance Stream #3	0.47	4.46	3.00E-03	6.00E-04					629	0.15	0.03	641
			7,155	9.81	Maintenance Stream #4	0.83	28.81	3.00E-03	6.00E-04					1,121	0.02	0.00	1,123
			7,350	10.08	Maintenance Stream #5	0.86	28.05	3.00E-03	6.00E-04					1,152	0.02	0.00	1,154
			4,863	6.67	Maintenance Stream #6	0.85	42.39	3.00E-03	6.00E-04					1,143	0.02	0.00	1,144
													Total:	**43,910**	**2.13**	**0.42**	**44,089**

Notes:

1. Based on the annual average heat input (MMBtu/hr) * 8,760 hr/yr
   For Natural Gas:
   MMBtu/yr = 7.14 * 8,760 hr/yr
   MMBtu/yr = 62,555
2. Based on the annual average fuel gas rate (scfm) * 60 * 8,760 hr/yr / 1,000,000
   For Natural Gas:
   MMscf/yr = 116.68 * 60 min/hr * 8,760 hr/yr / 1,000,000
   MMscf/yr = 61.33
3. For Fuel Carbon Content and MW data, see LHC-9 Stream Analysis.
4. Factors for ethylene production processes designated in Table C-2 of 40 CFR Part 98 Subpart C .
5. Global Warming Potential from Table A-1 to Subpart A of Part 98.
6. CO_2 emissions calculated in accordance with Tier 3 Calculation Methodology; Equation C-5 of 40 CFR Part 98 Subpart C.
7. CH_4 and N_2O emissions calculated in accordance with Equation C-8 of 40 CFR Part 98 Subpart C.

Example Calculations (From Natural Gas)

CO_2 Emissions:

tpy = MW CO2 (lb/lbmol) / MW CO (lb/lbmol) * Avg. Fuel Flow (MMscf/yr) * 1,000,000 * Fuel Carbon Content (kg C/kg Gas) * (MW of Fuel (lb/lbmol) / Molar Volume Conversion Factor) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = (44/12) * 61 (MMscf/yr) * 1,000,000 * 0.72 (kg C/kg Gas) * (17.2 (lb/lbmol) / 849.5 (scf/kg-mol)) * 2.20463 (lb/kg) / 2,000 (lb/ton)
tpy = 3,646

CH_4 Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * CH4 Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 62,555 (MMBtu/yr) * 0.001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.07

N_2O Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * N2O Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 62,555 (MMBtu/yr) * 0.0001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.01

CO2e Emissions:

tpy = (CO2 Emissions (tpy) * CO2 Global Warming Potential) + (CH4 Emissions (tpy) * CH4 Global Warming Potential) + (N2O Emissions (tpy) * N2O Global Warming Potential)
tpy = (3,646 (tpy) * 1) + (0.07 (tpy) * 25) + (0.01 (tpy) * 298)
tpy = 3,650

EPN: OC2TOX
FIN: OC2L9TOX
Greenhouse Gas Emissions - LHC9 TOX

EPN	FIN	Description	Average Heat Input[1] (MMBtu/yr)	Average Fuel Gas Flow[2] (MMscf/yr)	Fuel Type	Fuel Carbon Content[3] (kg C/kg Gas)	Fuel MW[3] (kg/kg-mol)	Emission Factors[4] (kg/MMBtu)		Molar Volume Conversion Factor @ 68F (scf/kg-mol)	Global Warming Potential[5] (100 yr)			Annual Emissions (ton/yr)			
								CH_4	N_2O		CO_2	CH_4	N_2O	CO_2[6]	CH_4[7]	N_2O[7]	CO_2e
OC2TOX	OC2L9TOX	LHC-9 TOX	52,560	52	Natural Gas	0.72	17.2	1.00E-03	1.00E-04	849.5	1	25	298	3,082	0.06	0.01	3,085
			1,908	274	Routine Vents	0.01	27.7	3.00E-03	6.00E-04					239	0.01	0.00	239
													Total:	**3,320**	**0.06**	**0.01**	**3,324**

Notes:

1. Based on the annual average heat input (MMBtu/hr) * 8,760 hr/yr
   For Natural Gas:
   MMBtu/yr = 6.00 * 8,760 hr/yr
   MMBtu/yr = 52,560
2. Based on the annual average fuel gas rate (Mscf/hr) * 8,760 hr/yr / 1,000
   For Natural Gas:
   MMscf/yr = 5.92 * 8,760 hr/yr / 1,000
   MMscf/yr = 52
3. For Fuel Carbon Content and MW data, see LHC-9 Stream Analysis.
4. Factors for ethylene production processes designated in Table C-2 of 40 CFR Part 98 Subpart C .
5. Global Warming Potential from Table A-1 to Subpart A of Part 98.
6. CO_2 emissions calculated in accordance with Tier 3 Calculation Methodology; Equation C-5 of 40 CFR Part 98 Subpart C.
7. CH_4 and N_2O emissions calculated in accordance with Equation C-8 of 40 CFR Part 98 Subpart C.

Example Calculations (From Natural Gas)

CO_2 Emissions:

tpy = MW CO2 (lb/lbmol) / MW CO (lb/lbmol) * Avg. Fuel Flow (MMscf/yr) * 1,000,000 * Fuel Carbon Content (kg C/kg Gas) * (MW of Fuel (lb/lbmol) / Molar Volume Conversion Factor) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = (44/12) * 52 (MMscf/yr) * 1,000,000 * 0.72 (kg C/kg Gas) * (17.2 (lb/lbmol) / 849.5 (scf/kg-mol)) * 2.20463 (lb/kg) / 2,000 (lb/ton)
tpy = 3,082

CH_4 Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * CH4 Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 52,560 (MMBtu/yr) * 0.001 (kg/MMBtu) *2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.06

N_2O Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * N2O Emission Factor (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 52,560 (MMBtu/yr) * 0.0001 (kg/MMBtu) * 2.20462 (lb/kg) / 2,000 (lb/ton)
tpy = 0.01

CO2e Emissions:

tpy = (CO2 Emissions (tpy) * CO2 Global Warming Potential) + (CH4 Emissions (tpy) * CH4 Global Warming Potential) + (N2O Emissions (tpy) * N2O Global Warming Potential)
tpy = (3,082 (tpy) * 1) + (0.06 (tpy) * 25) + (0.01 (tpy) * 298)
tpy = 3,085

EPN: OC2GE1 and OC2GE2
FIN: OC2L9GE1 and OC2L9GE2
Greenhouse Gas Emissions - Backup Diesel Generator No. 1 and No. 2

EPN	FIN	Description	Average Heat Input (MMBtu/yr)	Average Fuel Gas Flow (MMscf/yr)	Fuel Type	Emission Factors[1] (kg/MMBtu)			Global Warming Potential[2] (100 yr)			Annual Emissions (ton/yr)			
						CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2[3]	CH_4[3]	N_2O[3]	CO_2e
OC2GE1	OC2L9GE1	Backup Diesel Generator No. 1	197	N/A	Diesel	73.96	3.00E-03	6.00E-04	1	25	298	16.04	0.001	0.0001	16.10
											Total :	**16.04**	**0.001**	**0.0001**	**16.10**
OC2GE2	OC2L9GE2	Backup Diesel Generator No. 2	197	N/A	Diesel	73.96	3.00E-03	6.00E-04	1	25	298	16.04	0.001	0.0001	16.10
											Total :	**16.04**	**0.001**	**0.0001**	**16.10**

Notes:
1. Factors for CO2 designated in Table C-1 of 40 CFR Part 98 Subpart C, factors for CH4 and N2O designated in Table C-2 of 40 CFR Part 98 Subpart C .
2. Global Warming Potential from Table A-1 to Subpart A of Part 98.
3. CO2, CH4, and N2O emissions calculated in accordance with Equation C-8 of 40 CFR Part 98 Subpart C.

Example Calculations (From Natural Gas)

CO_2 Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * CO2 Emission Factor (kg/MMBtu) * 2.204 (lb/kg) / 2,000 (lb/ton)
tpy = 197 (MMBtu/yr) * 73.960 (kg/MMBtu) * 2.204 (lb/kg) / 2,000 (lb/ton)
tpy = 16.04

CH_4 Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * CH4 Emission Factor (kg/MMBtu) * 2.204 (lb/kg) / 2,000 (lb/ton)
tpy = 197 (MMBtu/yr) * 0.003 (kg/MMBtu) * 2.204 (lb/kg) / 2,000 (lb/ton)
tpy = 0.001

N_2O Emissions:

tpy = Avg. Heat Input (MMBtu/yr) * N2O Emission Factor (kg/MMBtu) * 2.204 (lb/kg) / 2,000 (lb/ton)
tpy = 197 (MMBtu/yr) * 0.0006 (kg/MMBtu) * 2.204 (lb/kg) / 2,000 (lb/ton)
tpy = 0.0001

CO2e Emissions:

tpy = (CO2 Emissions (tpy) * CO2 Global Warming Potential) + (CH4 Emissions (tpy) * CH4 Global Warming Potential) + (N2O Emissions (tpy) * N2O Global Warming Potential)
tpy = (16.04 (tpy) * 1) + (0.001 (tpy) * 25) + (0.0001 (tpy) * 298)
tpy = 16.10

LHC-9 Stream Analysis

Natural Gas

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Hydrogen	H_2	0.00	2.02	0.00	0.00	0	0.00	0.00
Nitrogen	N_2	1.14	28.01	0.04	0.70	0	0.20	0.00
Carbon Dioxide	CO_2	4.09	44.01	0.09	1.60	1	0.70	0.27
Carbon Monoxide	CO	0.00	28.01	0.00	0.00	1	0.00	0.43
Methane	CH_4	87.77	16.04	5.47	94.32	1	15.13	0.75
Ethylene	C_2H_4	0.00	28.05	0.00	0.00	2	0.00	0.86
Ethane	C_2H_6	4.36	30.07	0.15	2.50	2	0.75	0.80
Propane	C_3H_8	1.36	44.10	0.03	0.53	3	0.23	0.82
Butane	C_4H_{10}	0.74	58.12	0.01	0.22	4	0.13	0.83
Pentane	C_5H_{12}	0.54	72.15	0.01	0.13	5	0.09	0.83
		100.0		5.8	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Natural Gas = 17.2

Average Carbon Content of Natural Gas = 0.72

Off Gas

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Hydrogen	H_2	33.22	2.02	16.47	80.14	0	1.62	0.00
Nitrogen	N_2	0.15	28.01	0.01	0.03	0	0.01	0.00
Carbon Dioxide	CO_2	0.55	44.01	0.01	0.06	1	0.03	0.27
Carbon Monoxide	CO	0.29	28.01	0.01	0.05	1	0.01	0.43
Methane	CH_4	64.26	16.04	4.01	19.50	1	3.13	0.75
Ethylene	C_2H_4	0.55	28.05	0.02	0.10	2	0.03	0.86
Ethane	C_2H_6	0.61	30.07	0.02	0.10	2	0.03	0.80
Propane	C_3H_8	0.18	44.10	0.00	0.02	3	0.01	0.82
Butane	C_4H_{10}	0.10	58.12	0.00	0.01	4	0.00	0.83
Pentane	C_5H_{12}	0.07	72.15	0.00	0.00	5	0.00	0.83
		100.0		20.6	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Off Gas = 4.9

Average Carbon Content of Off Gas = 0.50

Startup Stream #1/Shutdown Stream #1/Maitenance Stream #1

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Water	H_2O	4.59	18.02	0.25	4.80	0	0.86	0.00
Carbon Dioxide	CO_2	0.07	44.01	0.00	0.03	1	0.01	0.27
Carbon Monoxide	CO	0.03	28.01	0.00	0.02	1	0.01	0.43
Hydrogen	H_2	3.66	2.02	1.81	34.13	0	0.69	0.00
Methane	CH_4	5.97	16.04	0.37	7.00	1	1.12	0.75
Acetylene	C_2H_2	0.33	26.04	0.01	0.24	2	0.06	0.92
Ethylene	C_2H_4	47.82	28.05	1.70	32.10	2	9.00	0.86
Ethane	C_2H_6	31.57	30.07	1.05	19.76	2	5.94	0.80
Methyl Acetylene	C_3H_4	0.01	40.07	0.00	0.01	3	0.00	0.90
Propadiene	C_3H_5	0.01	40.07	0.00	0.01	3	0.00	0.90
Proylene	C_3H_8	1.13	42.08	0.03	0.51	3	0.21	0.86
Propane	C_3H_8	0.25	44.10	0.01	0.11	3	0.05	0.82
Vinyl Acetylene	C_4H_4	0.04	52.08	0.00	0.02	4	0.01	0.92
1,3-Butadiene	C_4H_6	1.22	54.09	0.02	0.42	4	0.23	0.89
1-Butene	C_4H_8	0.17	56.11	0.00	0.06	4	0.03	0.86
Iso-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
n-Butane	C_4H_{10}	0.32	58.12	0.01	0.10	4	0.06	0.83
1-Pentene	C_5H_{12}	0.93	67.10	0.01	0.26	5	0.17	0.89
Benzene	C_6H_6	1.39	78.12	0.02	0.33	6	0.26	0.92
Toluene	C_7H_8	0.14	92.14	0.00	0.03	7	0.03	0.91
Styrene	C_8H_8	0.09	104.15	0.00	0.02	8	0.02	0.92
Ethyl Benzene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
M-Xylene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
C6 Nonaro	C6 Nonaro	0.10	81.79	0.00	0.02	6	0.02	0.88
C7 Nonaro	C7 Nonaro	0.03	94.54	0.00	0.01	7	0.01	0.89
C8 Nonaro	C8 Nonaro	0.00	110.20	0.00	0.00	8	0.00	0.87
C9 Aro	C9 Aro	0.01	118.19	0.00	0.00	9	0.00	0.91
C9 Nonaro	C9 Nonaro	0.00	127.29	0.00	0.00	9	0.00	0.85
C10s	C10s	0.05	128.58	0.00	0.01	10	0.01	0.93
C11+	C11+	0.05	249.58	0.00	0.00	11	0.01	0.53
Hydrogen Sulfide	H2S	0.01	34.08	0.00	0.01	0	0.00	0.00
		100.0		5.3	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Startup Stream #1/Shutdown Stream #1 = 18.8

Average Carbon Content of Startup Stream #1/Shutdown Stream #1 = 0.76

Startup Stream #2/Maintenance Stream #2

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Water	H_2O	0.00	18.02	0.00	0.00	0	0.00	0.00
Carbon Dioxide	CO_2	0.00	44.01	0.00	0.00	1	0.00	0.27
Carbon Monoxide	CO	0.04	28.01	0.00	0.02	1	0.01	0.43
Hydrogen	H_2	4.10	2.02	2.03	36.60	0	0.74	0.00
Methane	CH_4	6.68	16.04	0.42	7.51	1	1.20	0.75
Acetylene	C_2H_2	0.37	26.04	0.01	0.26	2	0.07	0.92
Ethylene	C_2H_4	53.50	28.05	1.91	34.42	2	9.65	0.86
Ethane	C_2H_6	35.32	30.07	1.17	21.19	2	6.37	0.80
Methyl Acetylene	C_3H_4	0.00	40.07	0.00	0.00	3	0.00	0.90
Propadiene	C_3H_5	0.00	40.07	0.00	0.00	3	0.00	0.90
Proylene	C_3H_8	0.00	42.08	0.00	0.00	3	0.00	0.86
Propane	C_3H_8	0.00	44.10	0.00	0.00	3	0.00	0.82
Vinyl Acetylene	C_4H_4	0.00	52.08	0.00	0.00	4	0.00	0.92
1,3-Butadiene	C_4H_6	0.00	54.09	0.00	0.00	4	0.00	0.89
1-Butene	C_4H_8	0.00	56.11	0.00	0.00	4	0.00	0.86
Iso-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
n-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
1-Pentene	C_5H_{12}	0.00	67.10	0.00	0.00	5	0.00	0.89
Benzene	C_6H_6	0.00	78.12	0.00	0.00	6	0.00	0.92
Toluene	C_7H_8	0.00	92.14	0.00	0.00	7	0.00	0.91
Styrene	C_8H_8	0.00	104.15	0.00	0.00	8	0.00	0.92
Ethyl Benzene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
M-Xylene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
C6 Nonaro	C6 Nonaro	0.00	81.79	0.00	0.00	6	0.00	0.88
C7 Nonaro	C7 Nonaro	0.00	94.54	0.00	0.00	7	0.00	0.89
C8 Nonaro	C8 Nonaro	0.00	110.20	0.00	0.00	8	0.00	0.87
C9 Aro	C9 Aro	0.00	118.19	0.00	0.00	9	0.00	0.91
C9 Nonaro	C9 Nonaro	0.00	127.29	0.00	0.00	9	0.00	0.85
C10s	C10s	0.00	128.58	0.00	0.00	10	0.00	0.93
		100.0		5.5	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Startup Stream #2/Maintenance Stream #2 = 18.0

Average Carbon Content of Startup Stream #2/Maintenance Stream #2 = 0.79

Startup Stream #3/Maintenance Stream #3

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Water	H_2O	0.00	18.02	0.00	0.00	0	0.00	0.00
Carbon Dioxide	CO_2	0.00	44.01	0.00	0.00	1	0.00	0.27
Carbon Monoxide	CO	0.34	28.01	0.01	0.05	1	0.02	0.43
Hydrogen	H_2	37.51	2.02	18.57	82.75	0	1.67	0.00
Methane	CH_4	61.57	16.04	3.84	17.10	1	2.74	0.75
Acetylene	C_2H_2	0.00	26.04	0.00	0.00	2	0.00	0.92
Ethylene	C_2H_4	0.57	28.05	0.02	0.09	2	0.03	0.86
Ethane	C_2H_6	0.01	30.07	0.00	0.00	2	0.00	0.80
Methyl Acetylene	C_3H_4	0.00	40.07	0.00	0.00	3	0.00	0.90
Propadiene	C_3H_5	0.00	40.07	0.00	0.00	3	0.00	0.90
Proylene	C_3H_8	0.00	42.08	0.00	0.00	3	0.00	0.86
Propane	C_3H_8	0.00	44.10	0.00	0.00	3	0.00	0.82
Vinyl Acetylene	C_4H_4	0.00	52.08	0.00	0.00	4	0.00	0.92
1,3-Butadiene	C_4H_6	0.00	54.09	0.00	0.00	4	0.00	0.89
1-Butene	C_4H_8	0.00	56.11	0.00	0.00	4	0.00	0.86
Iso-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
n-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
1-Pentene	C_5H_{12}	0.00	67.10	0.00	0.00	5	0.00	0.89
Benzene	C_6H_6	0.00	78.12	0.00	0.00	6	0.00	0.92
Toluene	C_7H_8	0.00	92.14	0.00	0.00	7	0.00	0.91
Styrene	C_8H_8	0.00	104.15	0.00	0.00	8	0.00	0.92
Ethyl Benzene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
M-Xylene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
C6 Nonaro	C6 Nonaro	0.00	81.79	0.00	0.00	6	0.00	0.88
C7 Nonaro	C7 Nonaro	0.00	94.54	0.00	0.00	7	0.00	0.89
C8 Nonaro	C8 Nonaro	0.00	110.20	0.00	0.00	8	0.00	0.87
C9 Aro	C9 Aro	0.00	118.19	0.00	0.00	9	0.00	0.91
C9 Nonaro	C9 Nonaro	0.00	127.29	0.00	0.00	9	0.00	0.85
C10s	C10s	0.00	128.58	0.00	0.00	10	0.00	0.93
		100.0		22.4	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Startup Stream #3/Maintenance Stream #3 = 4.5

Average Carbon Content of Startup Stream #3/Maintenance Stream #3 = 0.47

Startup Stream #4/Maintenance Stream #4

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Water	H_2O	0.00	18.02	0.00	0.00	0	0.00	0.00
Carbon Dioxide	CO_2	0.00	44.01	0.00	0.00	1	0.00	0.27
Carbon Monoxide	CO	0.00	28.01	0.00	0.00	1	0.00	0.43
Hydrogen	H_2	0.00	2.02	0.00	0.00	0	0.00	0.00
Methane	CH_4	0.01	16.04	0.00	0.02	1	0.00	0.75
Acetylene	C_2H_2	0.00	26.04	0.00	0.00	2	0.00	0.92
Ethylene	C_2H_4	60.80	28.05	2.17	62.44	2	17.52	0.86
Ethane	C_2H_6	39.16	30.07	1.30	37.52	2	11.28	0.80
Methyl Acetylene	C_3H_4	0.00	40.07	0.00	0.00	3	0.00	0.90
Propadiene	C_3H_5	0.00	40.07	0.00	0.00	3	0.00	0.90
Proylene	C_3H_8	0.03	42.08	0.00	0.02	3	0.01	0.86
Propane	C_3H_8	0.00	44.10	0.00	0.00	3	0.00	0.82
Vinyl Acetylene	C_4H_4	0.00	52.08	0.00	0.00	4	0.00	0.92
1,3-Butadiene	C_4H_6	0.00	54.09	0.00	0.00	4	0.00	0.89
1-Butene	C_4H_8	0.00	56.11	0.00	0.00	4	0.00	0.86
Iso-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
n-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
1-Pentene	C_5H_{12}	0.00	67.10	0.00	0.00	5	0.00	0.89
Benzene	C_6H_6	0.00	78.12	0.00	0.00	6	0.00	0.92
Toluene	C_7H_8	0.00	92.14	0.00	0.00	7	0.00	0.91
Styrene	C_8H_8	0.00	104.15	0.00	0.00	8	0.00	0.92
Ethyl Benzene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
M-Xylene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
C6 Nonaro	C6 Nonaro	0.00	81.79	0.00	0.00	6	0.00	0.88
C7 Nonaro	C7 Nonaro	0.00	94.54	0.00	0.00	7	0.00	0.89
C8 Nonaro	C8 Nonaro	0.00	110.20	0.00	0.00	8	0.00	0.87
C9 Aro	C9 Aro	0.00	118.19	0.00	0.00	9	0.00	0.91
C9 Nonaro	C9 Nonaro	0.00	127.29	0.00	0.00	9	0.00	0.85
C10s	C10s	0.00	128.58	0.00	0.00	10	0.00	0.93
		100.0		3.5	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Startup Stream #4/Maintenance Stream #4 = 28.8

Average Carbon Content of Startup Stream #4/Maintenance Stream #4 = 0.83

Shutdown Stream #2

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Water	H_2O	0.00	18.02	0.00	0.00	0	0.00	0.00
Carbon Dioxide	CO_2	0.01	44.01	0.00	0.01	1	0.00	0.27
Carbon Monoxide	CO	0.00	28.01	0.00	0.00	1	0.00	0.43
Hydrogen	H_2	0.19	2.02	0.10	2.94	0	0.06	0.00
Methane	CH_4	0.57	16.04	0.04	1.10	1	0.18	0.75
Acetylene	C_2H_2	0.02	26.04	0.00	0.02	2	0.01	0.92
Ethylene	C_2H_4	51.63	28.05	1.84	56.64	2	15.89	0.86
Ethane	C_2H_6	17.03	30.07	0.57	17.42	2	5.24	0.80
Methyl Acetylene	C_3H_4	0.17	40.07	0.00	0.13	3	0.05	0.90
Propadiene	C_3H_5	0.17	40.07	0.00	0.13	3	0.05	0.90
Proylene	C_3H_8	17.03	42.08	0.40	12.46	3	5.24	0.86
Propane	C_3H_8	12.97	44.10	0.29	9.05	3	3.99	0.82
Vinyl Acetylene	C_4H_4	0.01	52.08	0.00	0.00	4	0.00	0.92
1,3-Butadiene	C_4H_6	0.06	54.09	0.00	0.04	4	0.02	0.89
1-Butene	C_4H_8	0.01	56.11	0.00	0.01	4	0.00	0.86
Iso-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
n-Butane	C_4H_{10}	0.02	58.12	0.00	0.01	4	0.01	0.83
1-Pentene	C_5H_{12}	0.05	67.10	0.00	0.02	5	0.01	0.89
Benzene	C_6H_6	0.05	78.12	0.00	0.02	6	0.02	0.92
Toluene	C_7H_8	0.00	92.14	0.00	0.00	7	0.00	0.91
Styrene	C_8H_8	0.00	104.15	0.00	0.00	8	0.00	0.92
Ethyl Benzene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
M-Xylene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
C6 Nonaro	C6 Nonaro	0.00	81.79	0.00	0.00	6	0.00	0.88
C7 Nonaro	C7 Nonaro	0.00	94.54	0.00	0.00	7	0.00	0.89
C8 Nonaro	C8 Nonaro	0.00	110.20	0.00	0.00	8	0.00	0.87
C9 Aro	C9 Aro	0.00	118.19	0.00	0.00	9	0.00	0.91
C9 Nonaro	C9 Nonaro	0.00	127.29	0.00	0.00	9	0.00	0.85
C10s	C10s	0.00	128.58	0.00	0.00	10	0.00	0.93
C11s+	C11s+	0.00	249.58	0.00	0.00	11	0.00	0.53
		100.0		3.2	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Shtudown Stream #2 = 30.8

Average Carbon Content of Shutdown Stream #2 = 0.84

Shutdown Stream #3

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Water	H_2O	0.46	18.02	0.03	0.56	0	0.10	0.00
Carbon Dioxide	CO_2	0.02	44.01	0.00	0.01	1	0.00	0.27
Carbon Monoxide	CO	0.02	28.01	0.00	0.02	1	0.01	0.43
Hydrogen	H_2	2.63	2.02	1.30	28.77	0	0.58	0.00
Methane	CH_4	4.56	16.04	0.28	6.29	1	1.01	0.75
Acetylene	C_2H_2	0.07	26.04	0.00	0.06	2	0.02	0.92
Ethylene	C_2H_4	45.94	28.05	1.64	36.21	2	10.16	0.86
Ethane	C_2H_6	19.88	30.07	0.66	14.62	2	4.40	0.80
Methyl Acetylene	C_3H_4	0.14	40.07	0.00	0.08	3	0.03	0.90
Propadiene	C_3H_5	0.15	40.07	0.00	0.08	3	0.03	0.90
Proylene	C_3H_8	14.38	42.08	0.34	7.55	3	3.18	0.86
Propane	C_3H_8	10.90	44.10	0.25	5.46	3	2.41	0.82
Vinyl Acetylene	C_4H_4	0.01	52.08	0.00	0.00	4	0.00	0.92
1,3-Butadiene	C_4H_6	0.25	54.09	0.00	0.10	4	0.06	0.89
1-Butene	C_4H_8	0.04	56.11	0.00	0.02	4	0.01	0.86
Iso-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
n-Butane	C_4H_{10}	0.06	58.12	0.00	0.02	4	0.01	0.83
1-Pentene	C_5H_{12}	0.18	67.10	0.00	0.06	5	0.04	0.89
Benzene	C_6H_6	0.25	78.12	0.00	0.07	6	0.05	0.92
Toluene	C_7H_8	0.02	92.14	0.00	0.00	7	0.00	0.91
Styrene	C_8H_8	0.01	104.15	0.00	0.00	8	0.00	0.92
Ethyl Benzene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
M-Xylene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
C6 Nonaro	C6 Nonaro	0.02	81.79	0.00	0.01	6	0.00	0.88
C7 Nonaro	C7 Nonaro	0.01	94.54	0.00	0.00	7	0.00	0.89
C8 Nonaro	C8 Nonaro	0.00	110.20	0.00	0.00	8	0.00	0.87
C9 Aro	C9 Aro	0.00	118.19	0.00	0.00	9	0.00	0.91
C9 Nonaro	C9 Nonaro	0.00	127.29	0.00	0.00	9	0.00	0.85
C10s	C10s	0.01	128.58	0.00	0.00	10	0.00	0.93
C11s+	C11s+	0.00	249.58	0.00	0.00	11	0.00	0.53
		100.0		4.5	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Shutdown Stream #3 = 22.1

Average Carbon Content of Shutdown Stream #3 = 0.81

Shutdown Stream #4

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Nitrogen	N_2	73.67	28.00	2.63	63.20	0	17.70	0.00
Carbon Dioxide	CO_2	1.10	44.01	0.02	0.60	1	0.26	0.27
Methane	CH_4	23.30	16.04	1.45	34.89	1	5.60	0.75
Ethane	C_2H_6	1.20	30.07	0.04	0.96	2	0.29	0.80
Propane	C_3H_8	0.40	44.09	0.01	0.22	3	0.10	0.82
Pentane	C_5H_{12}	0.14	72.15	0.00	0.05	5	0.03	0.83
Butane	C_4H_{10}	0.19	58.12	0.00	0.08	4	0.05	0.83
		100.0		4.2	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Shutdown Stream #4 = 24.0
Average Carbon Content of Shutdown Stream #4 = 0.19

Maintenance Stream #5

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Hydrogen Sulfide	H_2S	0.00	34.08	0.00	0.00	0	0.00	0.00
Water	H_2O	0.00	18.02	0.00	0.00	0	0.00	0.00
Carbon Dioxide	CO_2	0.01	44.01	0.00	0.01	1	0.00	0.27
Carbon Monoxide	CO	0.00	28.01	0.00	0.00	1	0.00	0.43
Hydrogen	H_2	0.00	2.02	0.00	0.00	0	0.00	0.00
Methane	CH_4	0.01	16.04	0.00	0.03	1	0.00	0.75
Acetylene	C_2H_2	0.00	26.04	0.00	0.00	2	0.00	0.92
Ethylene	C_2H_4	99.93	28.05	3.56	99.92	2	28.03	0.86
Ethane	C_2H_6	0.05	30.07	0.00	0.05	2	0.01	0.80
Methyl Acetylene	C_3H_4	0.00	40.07	0.00	0.00	3	0.00	0.90
Propadiene	C_3H_5	0.00	40.07	0.00	0.00	3	0.00	0.90
Propylene	C_3H_8	0.00	42.08	0.00	0.00	3	0.00	0.86
Propane	C_3H_8	0.00	44.10	0.00	0.00	3	0.00	0.82
Vinyl Acetylene	C_4H_4	0.00	0.00	0.00	0.00	4	0.00	0.00
1,3-Butadiene	C_4H_6	0.00	54.09	0.00	0.00	4	0.00	0.89
1-Butene	C_4H_8	0.00	56.11	0.00	0.00	4	0.00	0.86
iso-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
n-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
C5's(1-Pentene)	C_5H_{12}	0.00	67.10	0.00	0.00	5	0.00	0.89
Benzene	C_6H_6	0.00	78.12	0.00	0.00	6	0.00	0.92
Toluene	C_7H_8	0.00	92.14	0.00	0.00	7	0.00	0.91
M-Xylene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
Styrene	C_8H_8	0.00	104.15	0.00	0.00	8	0.00	0.92
Ethylbenzene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
C6 Nonaro	C6 Nonaro	0.00	81.79	0.00	0.00	6	0.00	0.88
C7 Nonaro	C7 Nonaro	0.00	94.54	0.00	0.00	7	0.00	0.89
C8 Nonaro	C8 Nonaro	0.00	110.20	0.00	0.00	8	0.00	0.87
C9 Aro	C9 Aro	0.00	118.19	0.00	0.00	9	0.00	0.91
C9 Nonaro	C9 Nonaro	0.00	127.29	0.00	0.00	9	0.00	0.85
C10s	C10s	0.00	128.58	0.00	0.00	10	0.00	0.93
C11+ (Fuel Oil)	C11+ (Fuel Oil)	0.00	249.58	0.00	0.00	11	0.00	0.53
		100.0		3.6	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Maintenance Stream #5 = 28.1
Average Carbon Content of Maintenance Stream #5 = 0.86

Maintenance Stream #6

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Hydrogen Sulfide	H_2S	0.00	34.08	0.00	0.00	0	0.00	0.00
Water	H_2O	0.00	18.02	0.00	0.00	0	0.00	0.00
Carbon Dioxide	CO_2	0.00	44.01	0.00	0.00	1	0.00	0.27
Carbon Monoxide	CO	0.00	28.01	0.00	0.00	1	0.00	0.43
Hydrogen	H_2	0.00	2.02	0.00	0.00	0	0.00	0.00
Methane	CH_4	0.00	16.04	0.00	0.00	1	0.00	0.75
Acetylene	C_2H_2	0.00	26.04	0.00	0.00	2	0.00	0.92
Ethylene	C_2H_4	0.00	28.05	0.00	0.00	2	0.00	0.86
Ethane	C_2H_6	0.06	30.07	0.00	0.08	2	0.02	0.80
Methyl Acetylene	C_3H_4	0.53	40.07	0.01	0.57	3	0.23	0.90
Propadiene	C_3H_5	0.69	40.07	0.02	0.73	3	0.29	0.90
Propylene	C_3H_8	80.85	42.08	1.92	81.45	3	34.27	0.86
Propane	C_3H_8	17.85	44.10	0.40	17.16	3	7.57	0.82
Vinyl Acetylene	C_4H_4	0.00	0.00	0.00	0.00	4	0.00	0.00
1,3-Butadiene	C_4H_6	0.01	54.09	0.00	0.01	4	0.01	0.89
1-Butene	C_4H_8	0.00	56.11	0.00	0.00	4	0.00	0.86
iso-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
n-Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
C5's(1-Pentene)	C_5H_{12}	0.00	67.10	0.00	0.00	5	0.00	0.89
Benzene	C_6H_6	0.00	78.12	0.00	0.00	6	0.00	0.92
Toluene	C_7H_8	0.00	92.14	0.00	0.00	7	0.00	0.91
M-Xylene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
Styrene	C_8H_8	0.00	104.15	0.00	0.00	8	0.00	0.92
Ethylbenzene	C_8H_{10}	0.00	106.17	0.00	0.00	8	0.00	0.90
C6 Nonaro	C6 Nonaro	0.00	81.79	0.00	0.00	6	0.00	0.88
C7 Nonaro	C7 Nonaro	0.00	94.54	0.00	0.00	7	0.00	0.89
C8 Nonaro	C8 Nonaro	0.00	110.20	0.00	0.00	8	0.00	0.87
C9 Aro	C9 Aro	0.00	118.19	0.00	0.00	9	0.00	0.91
C9 Nonaro	C9 Nonaro	0.00	127.29	0.00	0.00	9	0.00	0.85
C10s	C10s	0.00	128.58	0.00	0.00	10	0.00	0.93
C11+ (Fuel Oil)	C11+ (Fuel Oil)	0.00	249.58	0.00	0.00	11	0.00	0.53
		100.0		2.4	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Maintenance Stream #6 = 42.4

Average Carbon Content of Maintenance Stream #6 = 0.85

TOX/LP Flare Waste Gas (Routine Vents)

Component		Avg Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Hydrogen	H_2	0.01	2.02	0.00	0.13	0	0.00	0.00
Nitrogen	N_2	93.81	28.01	3.35	92.87	0	26.01	0.00
Carbonmonoxide	CO	0.07	28.01	0.00	0.07	1	0.02	0.43
Methane	CH_4	0.30	16.04	0.02	0.52	1	0.08	0.75
Ethylene	C_2H_4	0.27	28.05	0.01	0.26	2	0.07	0.86
Ethane	C_2H_6	0.11	30.07	0.00	0.10	2	0.03	0.80
Carbon Dioxide	CO_2	0.07	44.01	0.00	0.04	1	0.02	0.27
Acetylene	C_2H_2	0.00	26.04	0.00	0.00	2	0.00	0.92
Hydrogen Sulfide	H_2S	0.00	34.08	0.00	0.00	0	0.00	0.00
Cyclopropane	C_3H_6	0.00	42.08	0.00	0.00	3	0.00	0.86
Propane	C_3H_8	0.00	44.10	0.00	0.00	3	0.00	0.82
Isobutane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
Sulfur Dioxide	SO_2	0.00	64.06	0.00	0.00	0	0.00	0.00
Iso Butene	C_4H_8	0.00	56.11	0.00	0.00	4	0.00	0.86
n- Butene	C_4H_8	0.00	56.11	0.00	0.00	4	0.00	0.86
1,3 -Butadiene	C_4H_6	0.01	54.09	0.00	0.00	4	0.00	0.89
Butane	C_4H_{10}	0.00	58.12	0.00	0.00	4	0.00	0.83
IsoPentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
N Pentene	C_5H_{10}	0.00	70.13	0.00	0.00	5	0.00	0.86
n-Pentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
Methyl CycloPentane	C_6H_{12}	0.00	84.16	0.00	0.00	6	0.00	0.86
Benzene	C_6H_6	0.04	78.11	0.00	0.01	6	0.01	0.92
Water	H_2O	1.15	18.02	0.06	1.76	0	0.32	0.00
Toluene	C_7H_8	0.00	92.14	0.00	0.00	7	0.00	0.91
Isoproprycyclohexane	C_9H_{18}	0.00	126.24	0.00	0.00	9	0.00	0.86
Xylene	C_8H_{10}	0.00	106.16	0.00	0.00	8	0.00	0.91
Styrene	C_8H_8	0.00	104.15	0.00	0.00	8	0.00	0.92
3,3,5-Trimethylheptane	$C_{10}H_{22}$	0.00	142.32	0.00	0.00	10	0.00	0.84
Ethyltol	C_9H_{12}	0.00	120.19	0.00	0.00	9	0.00	0.90
Methanol	CH_4O	0.00	32.04	0.00	0.00	1	0.00	0.37
Oxygen	O_2	3.24	32.00	0.10	2.80	0	0.90	0.00
Argon	Ar	0.91	18.00	0.05	1.40	0	0.25	0.00
Ammonia	NH_3	0.00	17.03	0.00	0.00	0	0.00	0.00
		100.00		3.6	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of TOX/LP Flare Waste Gas = 27.7

Average Carbon Content of TOX/LP Flare Waste Gas = 0.01

Ground Flare Waste Gas (Routine Vents)

Component		Wt %	Component MW (lb/lbmol)	Moles	Mol %	Atoms Carbon	Stream MW (lb/lbmol)	Carbon Content (lb/lb fuel)
Hyrdrogen	H_2	0.84	2.02	0.41	7.97	0	0.16	0.00
Nitrogen	N_2	20.13	28.01	0.72	13.84	0	3.88	0.00
Carbon Monoxide	CO	0.00	28.01	0.00	0.00	1	0.00	0.43
Methane	CH_4	53.13	16.04	3.31	63.76	1	10.23	0.75
Ethylene	C_2H_4	9.77	28.05	0.35	6.70	2	1.88	0.86
Ethanol	C_2H_6	4.49	30.07	0.15	2.88	2	0.87	0.80
Carbon Dioxide	CO_2	2.10	44.01	0.05	0.92	1	0.40	0.27
Acetylene	C_2H_2	0.00	26.04	0.00	0.00	2	0.00	0.92
Hydrogen Sulfide	H_2S	0.00	34.08	0.00	0.00	0	0.00	0.00
Propylene	C_3H_6	2.34	42.08	0.06	1.07	3	0.45	0.86
Propane	C_3H_8	1.41	44.10	0.03	0.62	3	0.27	0.82
Isobutane	C_4H_{10}	0.06	58.12	0.00	0.02	4	0.01	0.83
Isobutene	C_4H_8	0.17	56.11	0.00	0.06	4	0.03	0.86
N-Butene	C_4H_8	0.23	56.11	0.00	0.08	4	0.04	0.86
1,3-Butadiene	C_4H_6	0.88	54.09	0.02	0.31	4	0.17	0.89
N-Butane	C_4H_{10}	0.32	58.12	0.01	0.11	4	0.06	0.83
Isopentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
N-Pentene	C_5H_{10}	1.27	70.13	0.02	0.35	5	0.24	0.86
Normal Pentane	C_5H_{12}	0.00	72.15	0.00	0.00	5	0.00	0.83
Methanol	CH_4O	1.27	32.04	0.04	0.76	1	0.24	0.37
Methyl -Cyclopentane	C_6H_{12}	0.57	84.16	0.01	0.13	6	0.11	0.86
Benzene	C_6H_6	0.00	78.11	0.00	0.00	6	0.00	0.92
Water	H_2O	0.26	18.02	0.01	0.27	0	0.05	0.00
Dimethyl Disulfide	$C_2H_6S_2$	0.76	94.20	0.01	0.16	2	0.15	0.25
		100.00		5.2	100.0			

MW Carbon	12.01	lb/lbmol

Average MW of Ground Flare Waste Gas = 19.2
Average Carbon Content of Ground Flare Waste Gas = 0.59

Example Calculation (Carbon Dioxide Component):

Carbon Content = (Component MW (lb/lbmol) * Atoms Carbon) / MW Carbon (lb/lbmol)
Carbon Content = (126.24 (lb/lbmol) * 9 (Atoms C)) / 12.01 (lb/lbmol)
Carbon Content = 0.86

FIN: OC2L9FU2
EPN: OC2FU2
LHC9 Process Area Fugitives

Fugitive Counts and Emission Summary

Stream	Valves		Hourly Emissions From Valves (lb/hr)	Flanges		Hourly Emissions From Flanges (lb/hr)	Screwed Connections		Hourly Emissions From Screwed Connections (lb/hr)	Compressors[2]	Hourly Emissions From Compressors (lb/hr)	Pumps[2]	Hourly Emissions From Pumps (lb/hr)	Relief Valves [2]	Hourly Emissions From Relief Valves (lb/hr)	Bull Plugs[3]		Hourly Emissions From Bull Plugs (lb/hr)	% Valves/ Flanges Monitored	Hourly Emissions (lb/hr)	Annual Emissions (TPY)
	Gas	LL		Gas	LL		Gas	LL		Gas		LL				Gas	LL				
SOCMI w/ C2 Factor (lb/hr)	0.0258	0.0459		0.0053	0.0052		0.0053	0.0052		0.5027		0.144		0.2293		0.0075	0.0075				
SOCMI Average Factor (lb/hr)	0.0132	0.0089		0.0039	0.0005		0.0039	0.0005		0.5027		0.0439		0.2293		0.0038	0.0038				
SOCMI w/o C2 Factor (lb/hr)	0.0089	0.0035		0.0029	0.0005		0.0029	0.0005		0.5027		0.0386		0.2293		0.004	0.004				
28VHP Control Eff. (%)	97%	97%		97%	97%		97%	97%		100%		100%		100%		100%	100%				
10401	-	102	0.014	-	168	0.003	-	8	0.0001	-	-	2	-	5	-	-	46	-	99.0	0.018	0.08
11501	-	101	0.014	-	169	0.003	-	14	0.0002	-	-	-	-	4	-	-	37	-	99.0	0.018	0.08
17502	-	88	0.012	-	181	0.004	-	4	0.0001	-	-	-	-	1	-	-	23	-	99.0	0.016	0.07
22501	-	19	0.003	-	30	0.001	-	4	0.0001	-	-	-	-	-	-	-	7	-	99.0	0.003	0.01
23501	-	17	0.002	-	33	0.001	-	-	-	-	-	-	-	-	-	-	5	-	99.0	0.003	0.01
27301	-	21	0.007	-	40	0.001	-	-	-	-	-	-	-	-	-	-	7	-	99.0	0.008	0.04
28001	-	55	0.008	-	90	0.002	-	8	0.0001	-	-	-	-	-	-	-	17	-	99.0	0.010	0.04
30102	-	70	0.010	-	117	0.002	-	3	0.00005	-	-	1	-	3	-	-	28	-	99.0	0.012	0.05
30103	-	68	0.009	-	123	0.002	-	9	0.0001	-	-	-	-	6	-	-	24	-	99.0	0.012	0.05
30705	-	22	0.008	-	45	0.001	-	-	-	-	-	-	-	-	-	-	6	-	99.0	0.009	0.04
33002	-	24	0.008	-	40	0.001	-	4	0.0001	-	-	-	-	-	-	-	8	-	99.0	0.009	0.04
33103	-	12	0.004	-	32	0.001	-	3	0.00005	-	-	-	-	-	-	-	2	-	99.0	0.005	0.02
34002	-	31	0.011	-	48	0.001	-	9	0.0001	-	-	-	-	-	-	-	7	-	99.0	0.012	0.05
34202	-	20	0.007	-	34	0.001	-	9	0.0001	-	-	-	-	-	-	-	2	-	99.0	0.008	0.03
34402	-	19	0.007	-	30	0.001	-	4	0.0001	-	-	-	-	-	-	-	7	-	99.0	0.007	0.03
34702	-	14	0.002	-	22	0.0004	-	1	0.00002	-	-	-	-	-	-	-	5	-	99.0	0.002	0.01
34903	-	16	0.002	-	31	0.001	-	4	0.0001	-	-	-	-	-	-	-	4	-	99.0	0.003	0.01
35601	-	96	0.013	-	171	0.003	-	12	0.0002	-	-	2	-	-	-	-	36	-	99.0	0.017	0.07
42104	-	123	0.017	-	230	0.005	-	9	0.0001	-	-	-	-	8	-	-	46	-	99.0	0.022	0.10
42401	-	86	0.012	-	146	0.003	-	4	0.0001	-	-	4	-	-	-	-	39	-	99.0	0.015	0.07
42902	-	9	0.001	-	19	0.0004	-	-	-	-	-	-	-	-	-	-	2	-	99.0	0.002	0.01
42904	-	9	0.001	-	17	0.0003	-	-	-	-	-	-	-	-	-	-	2	-	99.0	0.002	0.01
43401	-	136	0.019	-	224	0.004	-	5	0.0001	-	-	4	-	2	-	-	56	-	99.0	0.023	0.10
43601	-	247	0.034	-	439	0.009	-	12	0.0002	-	-	4	-	6	-	-	90	-	99.0	0.043	0.19
43605	-	127	0.018	-	244	0.005	-	9	0.0001	-	-	-	-	3	-	-	37	-	99.0	0.023	0.10
43606	-	55	0.008	-	98	0.002	-	2	0.00003	-	-	-	-	4	-	-	21	-	99.0	0.010	0.04
5913	-	6	0.001	-	10	0.0002	-	-	-	-	-	-	-	1	-	-	3	-	99.0	0.001	0.00
61400	-	206	0.029	-	377	0.007	-	9	0.0001	-	-	-	-	8	-	-	71	-	99.0	0.036	0.16
66101	-	222	0.405	-	391	0.081	-	24	0.0037	-	-	2	-	2	-	-	83	-	99.0	0.489	2.14
Acid	-	98	0.014	-	208	0.004	-	13	0.0002	-	-	1	-	1	-	-	28	-	99.0	0.018	0.08
Methanol	-	120	0.017	-	205	0.004	-	12	0.0002	-	-	1	-	5	-	-	53	-	99.0	0.021	0.09
Spent Caustic	-	939	0.130	-	1,760	0.035	-	122	0.0018	-	-	20	-	13	-	-	353	-	99.0	0.167	0.73
Wash Oil	-	274	0.038	-	442	0.009	-	13	0.0002	-	-	4	-	2	-	-	138	-	99.0	0.047	0.21
Flare Liquids	-	169	0.023	-	278	0.006	-	6	0.0001	-	-	7	-	2	-	-	71	-	99.0	0.029	0.13
61100 Liquids	-	33	0.005	-	66	0.001	-	4	0.0001	-	-	1	-	-	-	-	10	-	99.0	0.006	0.03
6401	85	-	0.030	140	-	0.016	9	-	0.0008	-	-	-	-	-	-	25	-	-	99.0	0.047	0.21
10001	1,008	-	0.356	1,223	-	0.141	644	-	0.0560	-	-	-	-	-	-	541	-	-	99.0	0.553	2.42
10003	13	-	0.005	22	-	0.003	4	-	0.0003	-	-	-	-	-	-	5	-	-	99.0	0.007	0.03
10402	2	-	0.001	4	-	0.0005	-	-	-	-	-	-	-	-	-	1	-	-	99.0	0.001	0.01
11601	72	-	0.025	120	-	0.014	6	-	0.0005	-	-	-	-	2	-	28	-	-	99.0	0.040	0.17
11602	120	-	0.042	80	-	0.009	-	-	-	-	-	-	-	-	-	96	-	-	99.0	0.052	0.23
15110	380	-	0.199	730	-	0.113	52	-	0.0061	2	-	-	-	15	-	134	-	-	99.0	0.318	1.39
20010	22	-	0.023	41	-	0.009	4	-	0.0006	-	-	-	-	-	-	6	-	-	99.0	0.032	0.14

FIN: OC2L9FU2
EPN: OC2FU2
LHC9 Process Area Fugitives

Fugitive Counts and Emission Summary

Stream	Valves		Hourly Emissions From Valves (lb/hr)	Flanges		Hourly Emissions From Flanges (lb/hr)	Screwed Connections		Hourly Emissions From Screwed Connections (lb/hr)	Compressors[2]	Hourly Emissions From Compressors (lb/hr)	Pumps[2]	Hourly Emissions From Pumps (lb/hr)	Relief Valves [2]	Hourly Emissions From Relief Valves (lb/hr)	Bull Plugs[3]		Hourly Emissions From Bull Plugs (lb/hr)	% Valves/ Flanges Monitored	Hourly Emissions (lb/hr)	Annual Emissions (TPY)
	Gas	LL		Gas	LL		Gas	LL		Gas		LL				Gas	LL				
SOCMI w/ C2 Factor (lb/hr)	0.0258	0.0459		0.0053	0.0052		0.0053	0.0052		0.5027		0.144		0.2293		0.0075	0.0075				
SOCMI Average Factor (lb/hr)	0.0132	0.0089		0.0039	0.0005		0.0039	0.0005		0.5027		0.0439		0.2293		0.0038	0.0038				
SOCMI w/o C2 Factor (lb/hr)	0.0089	0.0035		0.0029	0.0005		0.0029	0.0005		0.5027		0.0386		0.2293		0.004	0.004				
28VHP Control Eff. (%)	97%	97%		97%	97%		97%	97%		100%		100%		100%		100%	100%				
26100	278	-	0.146	518	-	0.080	24	-	0.0028	-	-	-	-	18	-	94	-	-	99.0	0.229	1.00
26501	31	-	0.011	68	-	0.008	1	-	0.0001	-	-	-	-	-	-	9	-	-	99.0	0.019	0.08
30101	21	-	0.011	35	-	0.005	2	-	0.0002	-	-	-	-	3	-	10	-	-	99.0	0.017	0.07
30104	137	-	0.072	256	-	0.040	26	-	0.0030	1	-	-	-	5	-	46	-	-	99.0	0.114	0.50
30701	54	-	0.028	101	-	0.016	8	-	0.0009	-	-	-	-	2	-	20	-	-	99.0	0.045	0.20
32500	3	-	0.001	10	-	0.001	1	-	0.0001	-	-	-	-	-	-	1	-	-	99.0	0.002	0.01
32702	24	-	0.013	37	-	0.006	5	-	0.0006	-	-	-	-	2	-	9	-	-	99.0	0.019	0.08
33106	99	-	0.052	170	-	0.026	14	-	0.0016	-	-	-	-	-	-	31	-	-	99.0	0.080	0.35
33001	12	-	0.006	31	-	0.005	1	-	0.0001	-	-	-	-	2	-	7	-	-	99.0	0.011	0.05
33101	22	-	0.012	39	-	0.006	4	-	0.0005	-	-	-	-	2	-	8	-	-	99.0	0.018	0.08
34201	30	-	0.011	49	-	0.006	2	-	0.0002	-	-	-	-	2	-	12	-	-	99.0	0.016	0.07
34302	78	-	0.041	144	-	0.022	9	-	0.0011	2	-	-	-	2	-	29	-	-	99.0	0.064	0.28
34804	4	-	0.001	8	-	0.001	3	-	0.0003	-	-	-	-	-	-	4	-	-	99.0	0.003	0.01
34805	260	-	0.092	404	-	0.047	18	-	0.0016	-	-	-	-	5	-	113	-	-	99.0	0.140	0.61
34901	35	-	0.012	68	-	0.008	2	-	0.0002	-	-	-	-	2	-	13	-	-	99.0	0.020	0.09
34906	45	-	0.016	84	-	0.010	3	-	0.0003	-	-	-	-	2	-	18	-	-	99.0	0.026	0.11
40801	196	-	0.103	391	-	0.061	20	-	0.0023	-	-	-	-	5	-	50	-	-	99.0	0.166	0.73
42101	40	-	0.014	70	-	0.008	5	-	0.0004	-	-	-	-	2	-	16	-	-	99.0	0.023	0.10
42301	63	-	0.022	100	-	0.012	9	-	0.0008	-	-	-	-	2	-	23	-	-	99.0	0.035	0.15
42801	71	-	0.025	135	-	0.016	4	-	0.0003	-	-	-	-	1	-	24	-	-	99.0	0.041	0.18
43101	38	-	0.013	69	-	0.008	6	-	0.0005	-	-	-	-	3	-	18	-	-	99.0	0.022	0.10
50200	35	-	0.012	56	-	0.006	4	-	0.0003	-	-	-	-	2	-	17	-	-	99.0	0.019	0.08
50301	1,177	-	0.416	2,072	-	0.239	65	-	0.0057	-	-	-	-	10	-	311	-	-	99.0	0.660	2.89
61100	210	-	0.074	405	-	0.047	15	-	0.0013	1	-	-	-	10	-	72	-	-	99.0	0.122	0.53
61200	57	-	0.020	96	-	0.011	6	-	0.0005	-	-	-	-	2	-	20	-	-	99.0	0.032	0.14
66401	213	-	0.218	399	-	0.084	39	-	0.0062	1	-	-	-	11	-	72	-	-	99.0	0.308	1.35
Ammonia	166	-	0.059	311	-	0.036	15	-	0.0013	-	-	-	-	9	-	88	-	-	99.0	0.096	0.42
Analyzer Gas	-	-	-	15	-	0.002	-	-	-	-	-	-	-	-	-	-	-	-	99.0	0.002	0.01
Chlorine	18	-	0.006	41	-	0.005	2	-	0.0002	-	-	-	-	-	-	9	-	-	99.0	0.011	0.05
Flare	267	-	0.140	522	-	0.081	60	-	0.0070	-	-	-	-	-	-	111	-	-	99.0	0.228	1.00
LP Flare	76	-	0.027	133	-	0.015	11	-	0.0010	-	-	-	-	-	-	37	-	-	99.0	0.043	0.19
Totals	**5462**	**3654**		**9197**	**6558**		**1103**	**340**		**7**		**53**		**197**		**2128**	**1374**			**4.80**	**21.05**

Notes:
1) Fugitive emission count based on Dow review of preliminary P&IDs
2) Compressors and relief valves are routed to operating control device (flare), therefore 100% control claimed. Pumps utilize dual mechanical seals, therefore 100% control claimed.
3) Component actually represents an open ended line equipped with a plug. Since equipped with a plug, 100% control credit utilized.

Total Speciated Fugitive Emissions

Component	Hourly Emissions (lb/hr)	Annual Emissions (TPY)
Carbon Dioxide	0.005	0.02
Carbon Monoxide	0.02	0.10
Hydrogen	0.28	1.21
Methane	0.87	3.82
Water	0.17	0.73
Nitrogen	0.07	0.30
Ammonia	0.10	0.42
Hydrogen Chloride	0.02	0.08
Chlorine	0.01	0.05
Acetylene	0.003	0.01
Ethylene	1.46	6.38
Ethanol	1.03	4.50
Methyl Acetylene	0.002	0.01
Propadiene	0.002	0.01
Propylene	0.23	0.99
Propane	0.11	0.50
Butadiene	0.07	0.30
Butenes	0.01	0.06
Butanes	0.02	0.07
C5's	0.07	0.30
Benzene	0.13	0.56
C6 Nonarom	0.01	0.04
C7's	0.02	0.11
Styrene	0.02	0.08
C8 Arom	0.01	0.04
C8 Nonarom	0.003	0.01
C9's	0.01	0.05
C10's	0.01	0.05
DMDS	0.03	0.14
Methanol	0.02	0.09
Total	4.80	21.05
Total VOC	**3.27**	**14.30**

Sample Calculation:

Stream 10003 Valves:

Emission rate = (Total # Gas Valves) x (Emission Factor) x (% Monitored Valves/Flanges) x (100% - % Control Efficiency) + (Total # Gas Valves) x (Emission Factor) x (% Unmonitored Valves/Flanges)

lb./hr = (13 Gas Valves) x (0.0089, SOCMI w/o C2) x (99% Monitored Valves/Flanges) x (100% - 97% Control Efficiency, 28VHP) + (13 Gas Valves) x (0.0089, SOCMI w/o C2) x (1.0% Unmonitored Valves/Flanges)

lb./hr = 0.005

TPY = (Emission Rate, lb/hr) x (8760 hr/yr) x (1 ton / 2000 lb)

TPY = 0.020

Speciated Sample Calculation (for Propane in the 10003 Stream):

Emission Rate for Propane (lb/hr) = (wt% Propane in 10003 Stream) x (10003 Stream Emissions lb/hr)

= (0.33) * (0.007)

lb/hr = 0.002

Emission Rate for Propane (tpy) = (0.002 lb/hr) x (8760 hr/yr) / (2000 lb/ton)

tpy = 0.01

Please note sample calculation is for one stream only. Total emissions table shown above includes all streams.