ATTACHMENT 1

BACT ANALYSIS

Santa Maria Refinery

EIR Mitigation Plan – Crude Throughput Increase

Pursuant to Item 7 of the Conditions of Approval, this Project requires a BACT analysis as follows:

> *Item 7. (AQ 1.1) Prior to issuance of the Notice to Proceed authorizing an increase in Refinery throughput, the Applicant shall apply BACT on the crude heaters, coker heaters and boilers, vacuum heaters and superheaters, and/or utilize an equivalent method onsite with other equipment, to reduce the NOx emissions to less than the SLOCAPCD thresholds.*

In response to this item, Phillips 66 conducted a BACT analysis. The results are provided in the following paragraphs.

PROJECT EMISSION INCREASES

A summary of the Crude Throughput Project emissions, taken from Tables 4.1-16 of the EIR dated October 2012 is included below, as **Table 1**. As this table shows, there needs to be 18.82 Tons per year of NOx + ROG reduction from mitigation measures.

Table 1. Crude Throughput Project Emission Increases

		NOx	DPM
Project Increase	(lb/d)	128.1	2.7
Threshold	(lb/d)	-25	-1.25
Amount to Mitigate	(lb/d)	103.1	1.45
	(Tons/yr)	18.82	0.265

BACT EVALUATION

Because NOx needs to be mitigated for the Crude Throughput Project, mitigation measure AQ-1.1 requires a Best Available Control Technology (BACT) determination that includes cost effectiveness of new technology. The evaluation involves the following heaters and boilers:

- B-2A and B-2B Heaters
- B-102A and B-102B Heaters
- B-504 Boiler
- B-506 Boiler

The San Luis Obispo Air Pollution Control District (APCD) does not have a BACT standard. Other Air districts within California do have BACT standards in place. The Bay Area Air

Quality Management District (BAAQMD) has a written standard. This standard will be used for the evaluation.

Engineering consultants were hired to identify the best achievable NOx control levels for each of the combustion devices. Jacobs Engineering Company provided the heater evaluation and North American Manufacturing Co. provided the boiler assessment.

The evaluation considered all burners with today's best available Ultra-Low NOx design and the refinery's fuel gas composition. The conclusion is that NOx emissions can be reduced from permitted level of 30 ppm to 20 ppm. This is substantiated with current operation of the newest boiler, B-507 which was installed in 2007. This boiler has the most current Ultra-Low NOX burner design and incorporates flue gas recirculation. The NOx level measured during the 2012 source test was 19.5 ppm.

In Table 2, below is a summary of NOx emission reductions anticipated if the newest NOx control technology, was installed at each combustion device.

Table 2: Anticipated NOx Reductions
If Install Ultra-Low NOX burners

Device	Description	NOx Reduction With New Burners lbs/Yr	NOx Reduction With New Burners Tons/Yr
B2A	Crude Heater	2,894	1.447
B2B	Crude Heater	3,523	1.761
B102A	Coker Heater	2,512	1.256
B102B	Coker Heater	3,783	1.892
B504	Utility Boiler	3,330	1.665
B506	Utility Boiler	3,226	1.613

The BAAQMD adopted the "levelized cash flow method" otherwise commonly referred to as the annualized cost method to determine emission control cost-effectiveness for BACT (www.baaqmd.gov/pmt/bactworkbook/default.htm). The calculations are:

1) **Cost-effectiveness =**
   (Annualized Cost of Abatement System ($/yr)) / (Reduction in Annual Pollutant Emissions (ton/yr))

The annualized cost is estimated as follows:

2) Annualized cost = Direct Costs + Indirect Costs

Where:

Direct Costs = (Sum of the Following): Labor, Raw Materials, Replacement Parts, Utilities

Indirect Costs = (Sum of the Following): Overhead (80% of Labor Costs),Property Tax (1% of Total Capital Cost), Insurance (1% of Total Capital Cost),General & Administrative (2% of Total Capital Cost), Capital Recovery (CRF x Total Capital Cost)

Total Capital Cost = Installed Equipment Cost

For simple cases of cost-effectiveness, determinations where the details of operating and maintenance costs, etc. are not readily available, a rough estimate of cost-effectiveness can be obtained as follows:

Annualized Cost = Installed Equipment Cost x [Capital Recovery Factor + Tax Factor + Insurance Factor + G & A Factor + Annual Operating/Maintenance Factor]

Where Factors are:	CR = 0.136	Tax = 0.01	Insurance = 0.01
	G&A = 0.02	O&M = 0.05	

For the Crude Throughput Project, the following installed equipment cost estimates were made:

- Jacobs Engineering Company estimated cost for new Ultra Low NOx burners for the four heaters as follows.

  B-2A and B-2B Installed costs = $690,000 each heater
  B-102A and B-102B Installed costs = $1,230,000 each heater

- North American Manufacturing Co, (North American) estimated cost for new Ultra Low NOx burners with Flue Gas Recirculation for the two boilers as follows

  B-504 and B-506 Installed costs = $299,000 each boiler.

Using these installed cost estimates, an Annual cost can be calculated to determine cost effectiveness, per BAAQMD BACT guidance. A summary table of these calculations is provided in Table 3.

Table 3: Cost Effectiveness of NOx Reductions with Ultra-Low NOx Burners

Device	Description	NOx Reduction With New Burners lbs/Yr	NOx Reduction With New Burners Tons/Yr	Installed Cost	Annualized cost	Cost Effectiveness $/Ton
B2A	Crude Heater	2,894	1.447	$690,000	$155,940	$107,765
B2B	Crude Heater	3,523	1.761	$690,000	$155,940	$88,534
B102A	Coker Heater	2,512	1.256	$1,230,000	$277,980	$221,309
B102B	Coker Heater	3,783	1.892	$1,230,000	$277,980	$146,956
B504	Utility Boiler	3,330	1.665	$299,000	$67,574	$40,586
B506	Utility Boiler	3,226	1.613	$299,000	$67,574	$41,889

Per the current BAAQMD guidelines, the maximum cost effectiveness for NOx control is $17,500 per ton. The cost effectiveness for installation of Ultra-Low NOx burner technology to mitigate the Crude Throughput Project emission increases indicates that costs would be far above the effective application.

CONCLUSIONS:

The BACT analysis indicates that this control technology is not cost effective for the Santa Maria Refinery.

APPENDIX A

BACT NOx EMISSION CALCULATIONS

Santa Maria Refinery - Combustion Devices

EIR Mitigation Plan - Crude Throughput Increase

2010 FUEL GAS COMBUSTION - REFINERY

Device	Description	Equipment Rating (mmBtuh)	Fuel Gas (MMSCF)	Heat Content (Btu/SCF)	Total Heat Content (MMBTU/yr)	Nox (ppm)	NOx Emission Factor (lbs/mmbtu)	NOx Emissions (lbs/yr)
B2A	Crude Heater	77	294	1494	439,236	26.6	0.0324	14,231
B2B	Crude Heater	76.2	286	1505	430,430	27.1	0.033	14,204
B102A	Coker Heater	80.5	328	1494	490,032	22.9	0.0279	13,672
B102B	Coker Heater	80.5	303	1505	456,015	24.2	0.0295	13,452
B504	Utility Boiler	125	325	1445	469,625	28.8	0.0349	16,390
B506	Utility Boiler	127	302	1445	436,390	28.6	0.0347	15,143

2011 FUEL GAS COMBUSTION - REFINERY

Device	Description	Equipment Rating (mmBtuh)	Fuel Gas (MMSCF)	Heat Content (Btu/SCF)	Total Heat Content (MMBTU/yr)	Nox (ppm)	NOx Emission Factor (lbs/mmbtu)	NOx Emissions (lbs/yr)
B2A	Crude Heater	77	302	1492	450,584	25.9	0.0316	14,238
B2B	Crude Heater	76.2	275	1498	411,950	27.2	0.0331	13,636
B102A	Coker Heater	80.5	331	1492	493,852	26.6	0.0323	15,951
B102B	Coker Heater	80.5	336	1498	503,328	26.8	0.0327	16,459
B504	Utility Boiler	125	323	1355	437,665	24.9	0.0302	13,217
B506	Utility Boiler	127	304	1355	411,920	26.8	0.0326	13,429

2012 FUEL GAS COMBUSTION - REFINERY

Device	Description	Equipment Rating (mmBtuh)	Fuel Gas (MMSCF)	Heat Content (Btu/SCF)	Total Heat Content (MMBTU/yr)	Nox (ppm)	NOx Emission Factor (lbs/mmbtu)	NOx Emissions (lbs/yr)
B2A	Crude Heater	77	296	1495	442,520	23.6	0.0284	12,568
B2B	Crude Heater	76.2	276	1495	412,620	26.5	0.032	13,204
B102A	Coker Heater	80.5	303	1495	452,985	23.4	0.0281	12,729
B102B	Coker Heater	80.5	302	1495	451,490	28.9	0.0347	15,667
B504	Utility Boiler	125	411	1350	554,850	23.5	0.0287	15,924
B506	Utility Boiler	127	337	1350	454,950	23.1	0.0281	12,784

Refinery Fuel Gas Combustion Nox Emission Rates (Three-year Average)

Device	Description	Equipment Rating (mmBtuh)	Fuel Gas (MMSCF)	Heat Content (Btu/SCF)	Total Heat Content (MMBTU/yr)	Nox (ppm)	NOx Emission Factor (lbs/mmbtu)	NOx Emissions (lbs/yr)
B2A	Crude Heater	77	297	1494	444,113	25.4	0.030800898	13,679
B2B	Crude Heater	76.2	279	1499	418,333	26.9	0.032704044	13,681
B102A	Coker Heater	80.5	321	1494	478,956	24.3	0.029475332	14,117
B102B	Coker Heater	80.5	314	1499	470,278	26.6	0.032305717	15,193
B504	Utility Boiler	125	353	1381	487,380	25.6	0.031140377	15,177
B506	Utility Boiler	127	314	1382	434,420	26.1	0.031732287	13,785

Anticipated Emissions: New, Ultra-Low NOx Burners

Device	Description	Equipment Rating (mmBtuh)	Fuel Gas (MMSCF)	Heat Content (Btu/SCF)	Total Heat Content (MMBTU/yr)	Nox (ppm)	NOx Emission Factor (lbs/mmbtu)	NOx Emissions (lbs/yr)
B2A	Crude Heater	77	297	1494	444,113	20.0	0.024284365	10,785
B2B	Crude Heater	76.2	279	1499	418,333	20.0	0.024283177	10,158
B102A	Coker Heater	80.5	321	1494	478,956	20.0	0.024230297	11,605
B102B	Coker Heater	80.5	314	1499	470,278	20.0	0.024261143	11,409
B504	Utility Boiler	125	353	1381	487,380	20.0	0.024308125	11,847
B506	Utility Boiler	127	314	1382	434,420	20.0	0.02430559	10,559

Device	Description	NOx Reduction with New Burners (lbs/Yr)	NOx Reduction with New Burners (Tons/Yr)
B2A	Crude Heater	2,894	1.447
B2B	Crude Heater	3,523	1.761
B102A	Coker Heater	2,512	1.256
B102B	Coker Heater	3,783	1.892
B504	Utility Boiler	3,330	1.665
B506	Utility Boiler	3,226	1.613