



## BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION

**DETERMINATION NO.:** 109  
**DATE:** June 3, 2015  
**ENGINEER:** Jeffrey Quok

**Category/General Equip Description:** Boiler/Heater – Natural gas or LPG  
**Equipment Specific Description:** Boiler/heater greater or equal to 5 and less than 20 MMBTU/hr, fired on natural gas or LPG  
**Equipment Size/Rating:** Minor Source BACT  
**Previous BACT Det. No.:** 38

This BACT determination will update Determination #38 for boilers/heaters greater or equal to 5 and less than 20 MMBtu/hr.

This BACT was determined under the project for A/Cs 24469, 24471, and 24471 (Paramount Petroleum Corporation).

### BACT ANALYSIS

#### A: ACHIEVED IN PRACTICE (Rule 202, §205.1a)

The following control technologies are currently employed as BACT for boilers/heaters greater or equal to 5 and less than 20 MMBTU/hr by the following air pollution control districts:

District/Agency	Best Available Control Technology (BACT)/Requirements
US EPA	<b>BACT</b>
	Source: EPA RACT/BACT/LAER Clearinghouse
	For units with a rating of 5 to <25 MMBtu/hr
	<b>VOC</b>   N/A – No BACT determinations found in the ≥ 5 to <20 MMBtu/hr range
	<b>NOx</b>   N/A – No BACT determinations found in the ≥ 5 to <20 MMBtu/hr range
	<b>SOx</b>   N/A – No BACT determinations found in the ≥ 5 to <20 MMBtu/hr range
	<b>PM10</b>   N/A – No BACT determinations found in the ≥ 5 to <20 MMBtu/hr range
	<b>PM2.5</b>   N/A – No BACT determinations found in the ≥ 5 to <20 MMBtu/hr range
	<b>CO</b>   N/A – No BACT determinations found in the ≥ 5 to <20 MMBtu/hr range
	<b>RULE REQUIREMENTS:</b>
<u>40 CFR 60 Subpart Dc – Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units</u>	
This regulation applies to steam generating units rated at between 10-100 MMBtu/hr. However, no standards within the subpart are applicable to units fired by natural gas only. Therefore, this NSPS is not applicable.	

District/Agency	Best Available Control Technology (BACT)/Requirements														
ARB	<p><b><u>BACT</u></b>            Source: ARB BACT Clearinghouse</p> <p>Note: All BACT determinations published in the ARB BACT Clearinghouse are at least 10 years old.</p> <table border="1"> <thead> <tr> <th colspan="2">ARB BACT Clearinghouse*</th> </tr> </thead> <tbody> <tr> <td><b>VOC</b></td> <td>No standard</td> </tr> <tr> <td><b>NOx</b></td> <td>11 ppmvd at 3% O<sub>2</sub> [SCAQMD]</td> </tr> <tr> <td><b>SOx</b></td> <td>No standard</td> </tr> <tr> <td><b>PM10</b></td> <td>No standard</td> </tr> <tr> <td><b>PM2.5</b></td> <td>No standard</td> </tr> <tr> <td><b>CO</b></td> <td>50 ppmvd corrected to 3% O<sub>2</sub> [SCAQMD]</td> </tr> </tbody> </table> <p>* This BACT determination was found to be the most stringent Achieved in Practice BACT determination published in the ARB clearinghouse. See Attachment A for more information.</p> <p><b><u>RULE REQUIREMENTS:</u></b>            None</p>	ARB BACT Clearinghouse*		<b>VOC</b>	No standard	<b>NOx</b>	11 ppmvd at 3% O <sub>2</sub> [SCAQMD]	<b>SOx</b>	No standard	<b>PM10</b>	No standard	<b>PM2.5</b>	No standard	<b>CO</b>	50 ppmvd corrected to 3% O <sub>2</sub> [SCAQMD]
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SMAQMD	<p><b><u>BACT</u></b></p> <table border="1"> <thead> <tr> <th colspan="2">For units with a rating of 5 to &lt;25 MMBtu/hr</th> </tr> </thead> <tbody> <tr> <td><b>VOC</b></td> <td>No standard</td> </tr> <tr> <td><b>NOx</b></td> <td>9 ppmvd at 3% O<sub>2</sub>, low NOx boiler</td> </tr> <tr> <td><b>SOx</b></td> <td>No standard</td> </tr> <tr> <td><b>PM10</b></td> <td>No standard</td> </tr> <tr> <td><b>PM2.5</b></td> <td>No standard</td> </tr> <tr> <td><b>CO</b></td> <td>No standard</td> </tr> </tbody> </table> <p><b><u>RULE REQUIREMENTS:</u></b></p> <p><b><u>Rule 411</u></b>            For units with a rating of 5 to &lt;20 MMBtu/hr emissions shall not exceed the following levels:            1. 15 ppmvd of NOx corrected to 3% O<sub>2</sub>            2. 400 ppmvd of CO corrected to 3% O<sub>2</sub></p>	For units with a rating of 5 to <25 MMBtu/hr		<b>VOC</b>	No standard	<b>NOx</b>	9 ppmvd at 3% O <sub>2</sub> , low NOx boiler	<b>SOx</b>	No standard	<b>PM10</b>	No standard	<b>PM2.5</b>	No standard	<b>CO</b>	No standard
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South Coast AQMD	<p><b>BACT</b>            Source: <u>SCAQMD BACT Guidelines for Non-Major Polluting Facilities, page 13.</u>            Note: SCAQMD's published BACT is less stringent than Rule 1146.1</p> <table border="1"> <tr> <td colspan="2">For natural gas or propane fired units with a rating of less than 20 MMBtu/hr:</td> </tr> <tr> <td><b>VOC</b></td> <td>No standard</td> </tr> <tr> <td><b>NOx</b></td> <td>12 ppmvd corrected to 3% O<sub>2</sub></td> </tr> <tr> <td><b>SOx</b></td> <td>Use of Natural gas</td> </tr> <tr> <td><b>PM10</b></td> <td>Use of Natural Gas</td> </tr> <tr> <td><b>PM2.5</b></td> <td>No standard</td> </tr> <tr> <td><b>CO</b></td> <td>Firetube Boiler: 50 ppmvd corrected to 3% O<sub>2</sub> Watertube Boiler: 100 ppmvd corrected to 3% O<sub>2</sub></td> </tr> </table> <p><b>RULE REQUIREMENTS:</b>  <u>Reg XI, Rule 1146.1</u>            Requirements Table 1146-1 &amp; Table 1146-2</p> <table border="1"> <thead> <tr> <th>Category</th> <th>NOx Limit</th> <th>Unit Shall be in Full Compliance on or before</th> </tr> </thead> <tbody> <tr> <td>Group III Units 100% of units (by heat input)</td> <td>9 ppm or 0.011 lbs/10<sup>6</sup> BTU</td> <td>Applications submitted before 1-1-2014 unit shall be in full compliance on or before 1-1-2015</td> </tr> </tbody> </table> <p>Where: GROUP III UNIT means any unit burning gaseous fuels, excluding digester and landfill gases, and thermal fluid heaters with a rated heat input less than 20 million Btu per hour down to and including 5 million Btu per hour, and all units operated at schools and universities greater than or equal to 5 million Btu per hour. Excludes NOx RECLAIM facilities.</p>	For natural gas or propane fired units with a rating of less than 20 MMBtu/hr:		<b>VOC</b>	No standard	<b>NOx</b>	12 ppmvd corrected to 3% O <sub>2</sub>	<b>SOx</b>	Use of Natural gas	<b>PM10</b>	Use of Natural Gas	<b>PM2.5</b>	No standard	<b>CO</b>	Firetube Boiler: 50 ppmvd corrected to 3% O <sub>2</sub> Watertube Boiler: 100 ppmvd corrected to 3% O <sub>2</sub>	Category	NOx Limit	Unit Shall be in Full Compliance on or before	Group III Units 100% of units (by heat input)	9 ppm or 0.011 lbs/10 <sup>6</sup> BTU	Applications submitted before 1-1-2014 unit shall be in full compliance on or before 1-1-2015
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San Diego County APCD	<p><b>BACT</b>            Source: <u>NSR Requirements for BACT, page 27.</u></p> <table border="1"> <tr> <td colspan="2">For boilers with a rating of less than 50 MMBtu/hr:</td> </tr> <tr> <td><b>VOC</b></td> <td>NG or LPG fuel (If using NG or LPG fuel)</td> </tr> <tr> <td><b>NOx</b></td> <td>1. 9 ppmvd corrected to 3% O<sub>2</sub> 2. Low NOx burner, FGR, and oxygen controller (If using NG or LPG fuel) 3. Low NOx burner, FGR, and oxygen controller (If using No. 2 oil as a backup fuel)</td> </tr> <tr> <td><b>SOx</b></td> <td>1. NG or LPG fuel (If using NG or LPG fuel) 2. No. 2 fuel oil with &lt;0.05% sulfur content (If using No. 2 oil as a backup fuel)</td> </tr> <tr> <td><b>PM10</b></td> <td>1. 0.10 gr/dscf (verified by use of NG or LPG fuel) 2. NG or LPG fuel (If using NG or LPG fuel) 3. Low ash fuel (If using No. 2 oil as a backup fuel)</td> </tr> <tr> <td><b>PM2.5</b></td> <td>No standard</td> </tr> <tr> <td><b>CO</b></td> <td>No standard</td> </tr> </table>	For boilers with a rating of less than 50 MMBtu/hr:		<b>VOC</b>	NG or LPG fuel (If using NG or LPG fuel)	<b>NOx</b>	1. 9 ppmvd corrected to 3% O <sub>2</sub> 2. Low NOx burner, FGR, and oxygen controller (If using NG or LPG fuel) 3. Low NOx burner, FGR, and oxygen controller (If using No. 2 oil as a backup fuel)	<b>SOx</b>	1. NG or LPG fuel (If using NG or LPG fuel) 2. No. 2 fuel oil with <0.05% sulfur content (If using No. 2 oil as a backup fuel)	<b>PM10</b>	1. 0.10 gr/dscf (verified by use of NG or LPG fuel) 2. NG or LPG fuel (If using NG or LPG fuel) 3. Low ash fuel (If using No. 2 oil as a backup fuel)	<b>PM2.5</b>	No standard	<b>CO</b>	No standard						
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District/Agency	Best Available Control Technology (BACT)/Requirements														
	<p><b><u>RULE REQUIREMENTS:</u></b></p> <p><b><u>Regulation 4, Rule 69.2</u></b>            For any unit with a heat input rating less than or equal to 50 million Btu/hr and an annual heat input of 220,000 therms or more, or for any unit with a heat input rating greater than 50 million Btu/hr and an annual capacity factor 10% or greater, emissions shall not exceed the following levels:</p> <ol style="list-style-type: none"> <li>1. 30 ppmvd of NOx when operated on a gaseous fuel, corrected to 3% O<sub>2</sub></li> <li>2. 40 ppmvd of NOx when operated on a liquid fuel, corrected to 3% O<sub>2</sub></li> <li>3. 400 ppmvd of CO corrected to 3% O<sub>2</sub></li> </ol>														
<p>Bay Area AQMD</p>	<p><b><u>BACT</u></b>            Source: <u>BAAQMD BACT Guideline</u></p> <table border="1"> <tr> <td colspan="2">For boilers with a rating of 5 MMBtu/hr to less than 33.5 MMBtu/hr:</td> </tr> <tr> <td><b>VOC</b></td> <td>Good combustion practice</td> </tr> <tr> <td><b>NOx</b></td> <td>Low NOx burners + flue gas recirculation</td> </tr> <tr> <td><b>SOx</b></td> <td>Natural gas or treated refinery gas fuel with ≤100 ppmv total reduced sulfur</td> </tr> <tr> <td><b>PM10</b></td> <td>Natural gas or treated refinery gas fuel</td> </tr> <tr> <td><b>PM2.5</b></td> <td>No standard</td> </tr> <tr> <td><b>CO</b></td> <td>Firetube Boilers: 50 ppmvd corrected to 3% O<sub>2</sub> Watertube Boilers: 100 ppmvd corrected to 3% O<sub>2</sub></td> </tr> </table> <p><b><u>RULE REQUIREMENTS:</u></b></p> <p><b><u>Reg 9, Rule 7</u></b>            For units with a rating of greater than 5 MMBtu/hr and less than 20 MMBtu/hr:</p> <ol style="list-style-type: none"> <li>1. NOx limit of 15 ppmvd corrected to 3% O<sub>2</sub></li> <li>2. CO limit of 400 ppmvd corrected to 3% O<sub>2</sub></li> </ol> <p>For units with a rating of 20 MMBtu/hr and less than 75 MMBtu/hr:</p> <ol style="list-style-type: none"> <li>1. NOx limit of 9 ppmvd corrected to 3% O<sub>2</sub></li> <li>2. CO limit of 400 ppmvd corrected to 3% O<sub>2</sub></li> </ol>	For boilers with a rating of 5 MMBtu/hr to less than 33.5 MMBtu/hr:		<b>VOC</b>	Good combustion practice	<b>NOx</b>	Low NOx burners + flue gas recirculation	<b>SOx</b>	Natural gas or treated refinery gas fuel with ≤100 ppmv total reduced sulfur	<b>PM10</b>	Natural gas or treated refinery gas fuel	<b>PM2.5</b>	No standard	<b>CO</b>	Firetube Boilers: 50 ppmvd corrected to 3% O <sub>2</sub> Watertube Boilers: 100 ppmvd corrected to 3% O <sub>2</sub>
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<p>San Joaquin Valley APCD</p>	<p><b><u>BACT</u></b>            Source: <u>SJVUAPCD BACT Guideline (Rescinded)</u>            The boiler BACT determinations listed in the SJVAPCD Clearinghouse have been rescinded.</p> <p><b><u>RULE REQUIREMENTS:</u></b></p> <p><b><u>Rule 4306</u></b>            For units ≤ 20 MMBtu/hr</p> <ol style="list-style-type: none"> <li>1. 9 ppm of NOx corrected to 3% O<sub>2</sub></li> <li>2. 400 ppm of CO corrected to 3% O<sub>2</sub></li> </ol>														

The following control technologies have been identified and are ranked based on stringency:

<b>SUMMARY OF ACHIEVED IN PRACTICE CONTROL TECHNOLOGIES</b>	
<b>VOC</b>	1. Good combustion practice – [BAAQMD] 2. NG or LPG fuel (If using NG or LPG fuel) – [SDCAPCD] 3. No standard – [SMAQMD, SCAQMD, SJVAPCD]
<b>NOx</b>	1. 9 ppmvd at 3% O <sub>2</sub> – [SMAQMD, SCAQMD, SJVAPCD, SDCAPCD] 2. 15 ppmvd corrected to 3% O <sub>2</sub> – [BAAQMD] 3. Low NOx burner, FGR, and oxygen controller (If using NG or LPG fuel) – [SDCAPCD] 4. Low NOx burner, FGR, and oxygen controller (If using No. 2 oil as a backup fuel) – [SDCAPCD]
<b>SOx</b>	1. Use of natural gas – [SCAQMD] <sup>1</sup> 2. Use of natural gas or LPG fuel (If using NG or LPG fuel) – [SDCAPCD] 3. Natural gas or treated refinery gas fuel with $\leq 100$ ppmv total reduced sulfur – [BAAQMD] 4. No. 2 fuel oil with $< 0.05\%$ sulfur content (If using No. 2 oil as a backup fuel) – [SDCAPCD] 5. No standard – [SMAQMD, SJVAPCD]
<b>PM10</b>	1. Use of natural gas – [SCAQMD] <sup>1</sup> 2. 0.10 gr/dscf (verified by use of NG or LPG fuel) – [SDCAPCD] <sup>2</sup> 3. NG or LPG fuel (If using NG or LPG fuel) – [SDCAPCD] 4. Natural gas or treated refinery gas fuel – [BAAQMD] 5. Low ash fuel (If using No. 2 oil as a backup fuel) – [SDCAPCD] 6. No standard – [SMAQMD, SJVAPCD]
<b>PM2.5</b>	N/A – [SMAQMD, SCAQMD, SDCAPCD, BAAQMD, SJVAPCD]
<b>CO</b>	1. Firetube Boilers: 50 ppmvd corrected to 3% O <sub>2</sub> – [SCAQMD, BAAQMD] Watertube Boilers: 100 ppmvd corrected to 3% O <sub>2</sub> – [SCAQMD, BAAQMD] 2. 400 ppm of CO corrected to 3% O <sub>2</sub> – [SMAQMD, SDCAPCD, BAAQMD & SJVAPCD] 3. No standard

- 1 – The use of natural gas has been achieved in practice only where natural gas is available. It is not an “Achieved in Practice BACT” determination for areas where natural gas is not available. Therefore the use of natural gas or LPG where natural gas is not available will be considered Achieved in Practice BACT.
- 2 – The 0.10 gr/dscf limit has not been demonstrated to be achieved in practice by source testing, it has only been assumed to be achievable by the use of natural gas or LPG. Therefore, the use of natural gas or LPG when natural gas is not available will be considered Achieved in Practice BACT.

The following control technologies have been identified as the most stringent, achieved in practice control technologies:

<b>BEST CONTROL TECHNOLOGIES ACHIEVED</b>		
<b>Pollutant</b>	<b>Standard</b>	<b>Source</b>
VOC	Good combustion practice	BAAQMD
NOx	9 ppm at 3% O <sub>2</sub>	SMAQMD (current BACT), SDCAPCD (BACT), SCAQMD (Rule 1146.1), SJVAPCD (Rule 4306)
SOx	Use of natural gas or LPG if natural gas is not available	SDCAPCD (BACT)
PM10	Use of natural gas or LPG if natural gas is not available	SDCAPCD (BACT)
PM2.5	No standard	
CO	Firetube Boilers: 50 ppmvd corrected to 3% O <sub>2</sub> Watertube Boilers: 100 ppmvd corrected to 3% O <sub>2</sub>	BAAQMD (BACT), SCAQMD (Rule 1146.1)

**B. TECHNOLOGICALLY FEASIBLE AND COST EFFECTIVE (Rule 202, §205.1.b.):**

**Technologically Feasible Alternatives:**

Any alternative basic equipment, fuel, process, emission control device or technique, singly or in combination, determined to be technologically feasible by the Air Pollution Control Officer.

The table below shows the technologically feasible alternatives identified as capable of reducing emissions beyond the levels determined to be "Achieved in Practice" as per Rule 202, §205.1.a.

<b>VOC</b>	No other technologically feasible option identified
<b>NOx</b>	1. Selective Catalytic Reduction
<b>SOx</b>	No other technologically feasible option identified
<b>PM10</b>	No other technologically feasible option identified
<b>PM2.5</b>	Use of natural gas or LPG if natural gas is not available (same as achieved in practice BACT for PM10)
<b>CO</b>	No other technologically feasible option identified

**Cost Effective Determination:**

After identifying the technologically feasible control options, a cost analysis is performed to take into consideration economic impacts for all technologically feasible controls identified.

**Maximum Cost per Ton of Air Pollutants Controlled**

1. A control technology is considered to be cost-effective if the cost of controlling one ton of that air pollutant is less than the limits specified below (except coating

operations):

<u>Pollutant</u>	<u>Maximum Cost (\$/ton)</u>
ROG	17,500
NO <sub>x</sub>	24,500
PM <sub>10</sub>	11,400
SO <sub>x</sub>	18,300
CO	TBD if BACT triggered

#### Cost Effectiveness Analysis Summary

##### **SRC:**

As shown in Attachment B, the cost effectiveness for the add on SCR system to control NO<sub>x</sub> to a 5 ppm level was calculated to be **\$53,084/ton** (see attached Boiler Cost Effectiveness Analysis). Since BACT for a 20 mmBTU/hr boiler is never triggered for CO (141 lbs/day max) even with a boiler meeting Rule 411 limits (400 ppmv CO at 3%O<sub>2</sub>), the cost for the added CO control was not analyzed. The following basic parameters were used in the analysis.

NO<sub>x</sub> Control Level = 5 ppmv

NO<sub>x</sub> Baseline Level = 15 ppmv

Boiler Rating = 20 mmBtu/hr

Equipment Life = 20 years

Direct Cost = \$334,448

Direct Annual Cost = \$11,974 per year

Indirect Annual Cost = \$44,447 per year

Total Annual Cost = \$56,421 per year

NO<sub>x</sub> Removed = 1.06 tons per year

**Cost of NO<sub>x</sub> Removal = \$56,084 per ton reduced**

Therefore, the add on SCR system is considered not cost effective and is eliminated.

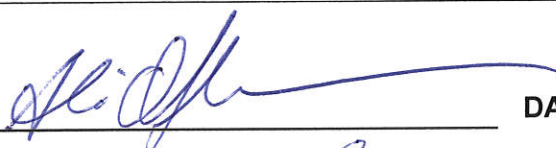
##### **Using the PM10 BACT standard for PM2.5:**

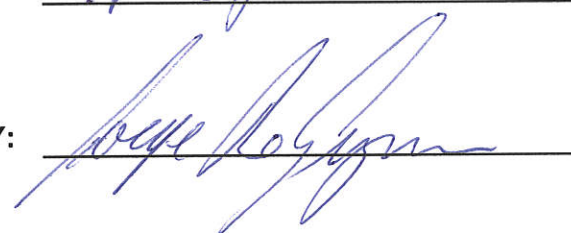
Natural gas is already required as BACT for PM10. Since both, PM10 and PM2.5 trigger BACT at  $> 0$  lb/day and PM2.5 is a subset of PM10, BACT for PM2.5 will be triggered whenever BACT is triggered for PM10. Therefore there is no additional cost associated with requiring natural gas as BACT for PM2.5 for new emission units.

##### **C. SELECTION OF BACT:**

Based on the cost effectiveness determinations, BACT for NO<sub>x</sub> will remain at what is currently achieved in practice and BACT for PM2.5 will be set to be the same as for PM10 (use of natural gas).

BACT FOR BOILERS $\geq 5$ AND $< 20$ MMBTU/HR		
Pollutant	Standard	Source
VOC	Good combustion practice	BAAQMD
NOx	9 ppm at 3% O <sub>2</sub>	SMAQMD (current BACT), SDCAPCD (BACT), SCAQMD (Rule 1146.1), SJVAPCD (Rule 4306)
SOx	Use of natural gas	SCAQMD (BACT)
PM10	Use of natural gas	SCAQMD (BACT)
PM2.5	Use of natural gas	New Determination
CO	Firetube Boilers: 50 ppmvd corrected to 3% O <sub>2</sub> Watertube Boilers: 100 ppmvd corrected to 3% O <sub>2</sub>	BAAQMD (BACT), SCAQMD (Rule 1146.1)

REVIEWED BY:  DATE: 6-19-15

APPROVED BY:  DATE: 6-19-15



# **Attachment A**

**Review of BACT Determinations published by ARB**

List of BACT determinations published in ARB's BACT Clearinghouse for boilers > 5 MMBtu/hr to ≤ 33.5 MMBtu/hr:

Capacity	Source	Date	NOx	VOC	CO	PM10
5.05 MMBtu/hr	SCAQMD	3/16/2000	20 ppm @ 3%O <sub>2</sub>		50 ppm @ 3%O <sub>2</sub>	
20.9 MMBtu/hr	SCAQMD					
16.5 MMBtu/hr	SCAQMD	12/7/1999	7 ppm @ 3%O <sub>2</sub>		50 ppm @ 3%O <sub>2</sub>	
6.2 MMBtu/hr	SJVUAPCD	2/1/2000	12 ppm @ 3%O <sub>2</sub>		50 ppm @ 3%O <sub>2</sub>	
10 MMBTU/HR	SCAQMD	4/24/2003	12 ppm @ 3%O <sub>2</sub>		50 ppm @ 3%O <sub>2</sub>	
21.46 MMBtu/hr	SCAQMD					
21 MMBtu/hr	SCAQMD					
16.4 MMBtu/hr	SCAQMD	2/1/2000	11 ppm @ 3%O <sub>2</sub>		50 ppm @ 3%O <sub>2</sub>	
8.5 MMBtu/hr	SCAQMD	12/21/1999	12 ppm @ 3%O <sub>2</sub>		50 ppm @ 3%O <sub>2</sub>	
16.8 MMBtu/hr	SCAQMD	3/10/2000	12 ppm @ 3%O <sub>2</sub>		50 ppm @ 3%O <sub>2</sub>	
21 MMBtu/hr	SCAQMD					
25 MMBtu/hr	SBCAPCD					
7 MMBtu/hr	SBCAPCD	9/26/2006	12 ppm @ 3%O <sub>2</sub>		50 ppm @ 3%O <sub>2</sub>	
29.4 MMBtu/hr	SDCAPCD					

☐ = Boilers outside the range (Not in the >5 MMBtu/hr and ≤ 20 MMBtu/hr rage)

☐ = Selected as the most stringent BACT determination achieved in practice.

Note: There is a 1999 BACT determination made by SCAQMD requiring a NOx concentration of 7 ppm @ 3%O<sub>2</sub>. However, all subsequent BACT determinations are much higher, including another SCAQMD BACT determination made only 2 weeks later. Therefore, 7 ppm @ 3%O<sub>2</sub> will not be considered a true BACT determination achieved in practice.

# **Attachment B**

**Cost Effectiveness Determination for SRC**

# BOILER SCR COST EFFECTIVENESS CALCULATION

EPA AIR POLLUTION CONTROL COST MANUAL, Sixth Edition, EPA/452/B-02-001, January 2002

Section 4.2 - NO<sub>x</sub> Post-Combustion, Chapter 2 - Selective Catalytic Reduction

**Cost Effectiveness = \$ 53,084.40 \$/ton**

## Equipment

Boiler rating	20	mmBTU/hr
Boiler Operating hours	8760	hours
Boiler capacity factor	1	
SCR Operating Days	365	days
Total Capacity Factor	1	
Baseline Nox (15 ppm)	0.0182	lb/mmBTU
SCR Nox (5 ppm)	0.006067	lb/mmBTU
Ammonia Slip	10	ppm
Ammonia Stoichiometric Ratio	1.05	
Stored Ammonia Conc	29	%
Ammonia Storage days	90	days
Sulfur Content	0.005	%
Pressure drop for SCR Ductwork	3	inches W.G.
Pressure drop for each Catalyst Layer	1	inches W.G.
Temperature at SCR Inlet	650	degrees F
Cost year	1998	
Equipment Life	20	years
Annual interest Rate	7	%
Catalyst cost, Initial	240	\$/ft <sup>2</sup>
Catalyst cost, replacement	290	\$/ft <sup>2</sup>
Electrical Power cost	0.05	\$/KWh
Ammonia Cost	0.101	\$/lb
Catalyst Life	24000	hr
Catalyst Layers	2 full, 1 empty	

## Boiler Calculations

Q <sub>B</sub>	20	mmBTU/hr
Q <sub>flue gas</sub>	7126.547952	acfm
N <sub>NO<sub>x</sub></sub>	0.666648352	

## SCR Reactor Calculations

$Vol_{Catalyst}$	37.87475183	ft <sup>3</sup>
$A_{Catalyst}$	7.42348745	ft <sup>2</sup>
$A_{SCR}$	8.537010567	ft <sup>2</sup>
$l=w=$	2.921816313	ft
$n_{layer}$	2	
$h_{layer}$	3.551008006	
$n_{total}$	3	
$h_{SCR}$	40.65302402	ft

## Reagent Calculations

$m_{reagent}$	0.141466333	lb/hr
$m_{sol}$	0.487814943	lb/hr
$q_{sol}$	0.06516685	gph
Tank Volume	140.7603955	gal

## Cost Estimation

### Direct Costs

DC	\$ 334,447.66
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### Indirect Costs

General Facilities	\$ 16,722.38
Engineering and home office fees	\$ 33,444.77
Process Contingency	\$ 16,722.38
Total Indirect Installation Costs	\$ 66,889.53
Project Contingency	\$ 60,200.58
Total Plant Cost	\$ 461,537.77
Preproduction Cost	\$ 9,230.76
Inventory Capital	\$106.42
Total Capital Investment	\$ 470,874.94

### Direct Annual Costs

Maintenance Costs	\$ 7,063.12	per yr
Power	6.3254793	KW
Annual Electricity	\$ 2,770.56	per yr
Reagent Solution Cost	\$ 431.60	per yr

### Catalyst Replacement

FWF	0.311051666	
Annual Catalyst Replacement	\$ 1,708.25	per yr

Total Variable Direct Cost	\$ 4,910.40	per yr
Total Direct Annual Cost	\$ 11,973.53	per yr
CRF	0.094392926	
Indirect Annual Cost	\$ 44,447.26	per yr
Total annual Cost	\$ 56,420.79	per yr
Nox Removed	1.06	tons
<b>Cost of Nox removal</b>	<b>\$ 53,084.40</b>	<b>per ton</b>

**SMAQMD BACT CLEARINGHOUSE**

CATEGORY:

**BOILER/HEATER**

BACT Size: Minor Source BACT

**BOILER/HEATER**

<b>BACT Determination Number:</b> 109	<b>BACT Determination Date:</b> 5/8/2015
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**Equipment Information**

**Permit Number:** 24469  
**Equipment Description:** BOILER/HEATER  
**Unit Size/Rating/Capacity:** Boiler/Heater ≥5 MMBtu/hr and <20 MMBtu/hr  
**Equipment Location:** PARAMOUNT PETROLEUM CORP  
 10090 WATERMAN RD  
 ELK GROVE, CA

**BACT Determination Information**

<b>ROCs</b>	<b>Standard:</b>	
	<b>Technology Description:</b>	Good combustion practice and natural gas or LPG fuel
	<b>Basis:</b>	
<b>NOx</b>	<b>Standard:</b>	9 ppmvd at 3% O <sub>2</sub>
	<b>Technology Description:</b>	Low NOx burner, NOx limit of 9 ppmvd at 3% O <sub>2</sub>
	<b>Basis:</b>	
<b>SOx</b>	<b>Standard:</b>	
	<b>Technology Description:</b>	Natural gas or LPG fuel
	<b>Basis:</b>	
<b>PM10</b>	<b>Standard:</b>	
	<b>Technology Description:</b>	Good combustion practice and natural gas or LPG fuel
	<b>Basis:</b>	
<b>PM2.5</b>	<b>Standard:</b>	
	<b>Technology Description:</b>	Good combustion practice and natural gas or LPG fuel
	<b>Basis:</b>	
<b>CO</b>	<b>Standard:</b>	50/100 ppm @ 3% O <sub>2</sub> for firetube/watertube
	<b>Technology Description:</b>	CO limit of 50 ppmvd at 3% O <sub>2</sub> for firetube boilers, CO limit of 100 ppmvd at 3% O <sub>2</sub> for watertube boilers
	<b>Basis:</b>	
<b>LEAD</b>	<b>Standard:</b>	
	<b>Technology Description:</b>	
	<b>Basis:</b>	

**Comments:**

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