SMAQMD BACT CLEARINGHOUSE

EXPIRED

CATEGORY Type: **IC ENGINE SPARK - STANDBY**

BACT Category: MINOR SOURCE

BACT Determination Number: 208	**BACT Determination Date:** **12/28/2018**

Equipment Information

Permit Number: N/A -- Generic BACT Determination

Equipment Description: IC ENGINE STANDBY

Unit Size/Rating/Capacity: < 500 BHP

Equipment Location:

BACT Determination Information

District Contact: Jeffrey Quok Phone No.: 916-874-4863 email: jquok@airquality.org

ROCs	**Standard:**	See Description
	Technology Description:	Lean burn: 206 ppmv @ 15% O2 as methane (1.0 g/bhp-hr), Rich burn: 60 ppmv @ 15% O2 as methane (0.29 g/hp-hr)
	Basis:	Achieved in Practice
NOx	**Standard:**	See Description
	Technology Description:	Lean burn: 1.0 g/hp-hr, Rich burn: 25 ppmvd @ 15 O2 (0.44 g/hp-hr) OR 96% weight reduction
	Basis:	Achieved in Practice
SOx	**Standard:**	Natural gas fuel or equivalent fuel
	Technology Description:	
	Basis:	Achieved in Practice
PM10	**Standard:**	Natural gas fuel or equivalent fuel
	Technology Description:	
	Basis:	Achieved in Practice
PM2.5	**Standard:**	Natural gas fuel or equivalent fuel
	Technology Description:	
	Basis:	Achieved in Practice
CO	**Standard:**	2.0 g/hp-hr
	Technology Description:	
	Basis:	Achieved in Practice
LEAD	**Standard:**	
	Technology Description:	
	Basis:	

Comments: T-BACT is equivalent to BACT for VOC. This BACT was last reviewed on 12/28/2018, and amended on 8/9/2019.

SMAQMD BACT CLEARINGHOUSE

EXPIRED

CATEGORY Type: **IC ENGINE SPARK - STANDBY**

BACT Category: MINOR SOURCE

BACT Determination Number: 209	**BACT Determination Date:** 12/28/2018

Equipment Information

Permit Number: N/A -- Generic BACT Determination

Equipment Description: IC ENGINE STANDBY

Unit Size/Rating/Capacity: ≥ 500 BHP

Equipment Location:

BACT Determination Information

District Contact: Jeffrey Quok Phone No.: 916-874-4863 email: jquok@airquality.org

ROCs	**Standard:**	See Description
	Technology Description:	Lean burn: 206 ppmv @ 15% O2 as methane (1.0 g/bhp-hr), Rich burn: 60 ppmv @ 15% O2 as methane (0.29 g/hp-hr)
	Basis:	Achieved in Practice
NOx	**Standard:**	See Description
	Technology Description:	Lean burn: 0.5 g/hp-hr, Rich burn: 25 ppmvd @ 15% O2 (0.44 g/hp-hr) OR 96% weight reduction
	Basis:	Achieved in Practice
SOx	**Standard:**	Natural gas fuel or equivalent fuel
	Technology Description:	
	Basis:	Achieved in Practice
PM10	**Standard:**	0.0099 lb/MMBtu
	Technology Description:	
	Basis:	Achieved in Practice
PM2.5	**Standard:**	0.0099 lb/MMBtu
	Technology Description:	
	Basis:	Achieved in Practice
CO	**Standard:**	1.5 g/bhp-hr
	Technology Description:	
	Basis:	Achieved in Practice
LEAD	**Standard:**	
	Technology Description:	
	Basis:	

Comments: T-BACT is equivalent to BACT for VOC. This BACT was last reviewed on 12/28/2018, and amended on 8/9/2019.

Printed: 2/4/2021

777 12th Street, Third Floor

SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT

Sacramento, CA 95814

ADDENDUM TO BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION

DETERMINATION NO.: 208 & 209

DATE: July 8, 2019

ENGINEER: Jeffrey Quok

Category/General Equip Description:	Internal Combustion (I.C.) Engine
Equipment Specific Description:	I.C. Engine Spark – Standby, Gaseous-fueled (Excluding Biogas)
Equipment Size/Rating:	Engines < 500 BHP (BACT #208) Engines ≥ 500 BHP (BACT #209)
Previous BACT Det. No.:	No. 122 & 123

This BACT determination addendum will update BACT determinations #208 & #209 to update VOC emission standards that were based on SJVAPCD's BACT Guideline 3.1.5. This update will change the lean burn VOC emissions standard from 86 ppmv at 15% O_2 to 206 ppmv at 15% O_2 and add a rich burn VOC concentration standard of 60 ppmv at 15% O_2 to the original standard of 0.29 g/hp-hr.

SJVAPCD's VOC emission standard for lean burn engines was originally based on the EPA NSPS JJJJ VOC standard of 86 ppmv or 1.0 g/hp-hr (above 130 HP). SJVAPCD discovered that the NSPS standard is referenced as propane. SJVAPCD updated their BACT guideline to reference methane to be consistent with their rules. This change in reference switched the standard from 86 ppmv @ 15% O_2 (measured as propane) to 206 ppmv @ 15% O_2 (measured as methane). SJVAPCD also added a concentration standard of 60 ppmv at 15% O_2 (measured as methane) to the original standard of 0.29 g/hp-hr to be consistent with the lean burn VOC Standard.

BACT/T-BACT ANALYSIS

A. <u>ACHIEVED IN PRACTICE (Rule 202, §205.1a):</u>

The following control technologies are currently employed as BACT/T-BACT for gaseous-fueled and propane/LPG standby engines by the following agencies and air pollution control districts:

<table>
<tr>
<td>San Joaquin Valley Unified APCD</td>
<td>
<u>BACT</u>
Source: SJVUAPCD BACT
<u>Guideline 3.1.5 – Emergency Gas-Fired IC Engine</u> (7/16/18)
<table>
<tr><td colspan="2">Emergency Gas-Fired IC Engine</td></tr>
<tr><td>VOC</td><td><u>Lean Burn</u>: 206 ppmv @ 15% O_2 as methane (1.0 g/bhp-hr)

<u>Rich Burn</u>: 60 ppmv @ 15% O_2 as methane (0.29 g/hp-hr)</td></tr>
<tr><td>NOx</td><td><u>Lean Burn < 500 BHP</u>: 1.0 g/bhp-hr
<u>Lean Burn ≥ 500 BHP</u>: 0.5 g/bhp-hr

<u>Rich Burn</u>: 25 ppmvd @ 15% O_2 (0.44 g/bhp-hr)</td></tr>
<tr><td>SOx</td><td>Natural gas, LPG, or Propane fuel</td></tr>
<tr><td>PM10</td><td>Natural gas, LPG, or Propane fuel</td></tr>
<tr><td>PM2.5</td><td>No Standard</td></tr>
<tr><td>CO</td><td>2.0 g/bhp-hr</td></tr>
</table>
<u>T-BACT</u>
There are no T-BACT standards published in the clearinghouse for this category.

<u>RULE REQUIREMENTS:</u>
<u>Rule 4702 – Internal Combustion Engines</u> (Amended 11/14/13)

Standby Engines are exempt from the emission limitations of this rule.
</td>
</tr>
</table>

C. <u>SELECTION OF BACT/T-BACT:</u>

Based on the above analysis, BACT for VOC, NOx, SOx, PM10, and CO will remain at what is currently achieved in practice and BACT for PM2.5 will be set to be the same as for PM10.

Volatile hazardous air pollutants (VHAP) are the primary driver for health risks associated with gaseous fueled engines. VHAPs are emitted as VOC, and the same control technologies that control VOC also control VHAPs. Therefore, the BACT for VOC and T-BACT for VHAPs are the same.

Table 1: BACT #208 FOR SPARK IGNITED I.C. ENGINES, STANDBY, GASEOUS-FUELED (EXCLUDING BIOGAS) < 500 BHP		
Pollutant	**Standard**	**Source**
VOC	Lean Burn 206 ppmv @ 15% O_2 as methane (1.0 g/bhp-hr) Rich Burn 60 ppmv @ 15% O_2 as methane (0.29 g/hp-hr)	SJVAPCD
NOx	Lean-Burn: 1.0 g/bhp-hr Rich Burn: 25 ppmvd @ 15 O_2 (0.44 g/hp-hr) OR 96% weight reduction	SMAQMD & SJVAPCD
SOx	Natural gas fuel or equivalent fuel	SMAQMD, SCAQMD, SJVUAPCD, and BAAQMD
PM10	Natural gas fuel or equivalent fuel	SMAQMD, SCAQMD, SJVUAPCD, and BAAQMD
PM2.5	Natural gas fuel or equivalent fuel	SMAQMD, SCAQMD, SJVUAPCD, and BAAQMD
CO	2.0 g/bhp-hr	SMAQMD, SCAQMD, SJVAPCD

Table 2: T-BACT #208 FOR SPARK IGNITED I.C. ENGINES, STANDBY, GASEOUS-FUELED (EXCLUDING BIOGAS) < 500 BHP		
Pollutant	**Standard**	**Source**
VHAP[(A)]	Lean Burn 206 ppmv @ 15% O_2 as methane (1.0 g/bhp-hr) Rich Burn 60 ppmv @ 15% O_2 as methane (0.29 g/hp-hr)	SJVAPCD

(A) A full list of the volatile hazardous air pollutants (VHAP) from natural gas combustion can be found in AP-42, Section 3.2 Natural Gas-fired Reciprocating Engines, Tables 3.2-1, 3.2-2, and 3.2-3.

Table 3: BACT #209 FOR SPARK IGNITED I.C. ENGINES, STANDBY, GASEOUS-FUELED (EXCLUDING BIOGAS) ≥ 500 BHP		
Pollutant	**Standard**	**Source**
VOC	Lean Burn 206 ppmv @ 15% O_2 as methane (1.0 g/bhp-hr) Rich Burn 60 ppmv @ 15% O_2 as methane (0.29 g/hp-hr)	SJVAPCD
NOx	Lean-Burn: 0.5 g/bhp-hr Rich Burn: 25 ppmvd @ 15 O_2 (0.44 g/hp-hr) OR 96% weight reduction	SMAQMD & SJVAPCD
SOx	Natural gas fuel or equivalent fuel	BAAQMD
PM10	0.0099 lb/MMBtu	SMAQMD & EPA (MI-00401)
PM2.5	0.0099 lb/MMBtu	SMAQMD & EPA (MI-00401)
CO	1.5 g/p-hr	SMAQMD

Table 4: T-BACT #209 FOR SPARK IGNITED I.C. ENGINES, STANDBY, GASEOUS-FUELED (EXCLUDING BIOGAS) ≥ 500 BHP		
Pollutant	**Standard**	**Source**
VHAP$^{(A)}$	Lean Burn 206 ppmv @ 15% O_2 as methane (1.0 g/bhp-hr) Rich Burn 60 ppmv @ 15% O_2 as methane (0.29 g/hp-hr)	SJVAPCD

(A) A full list of the volatile hazardous air pollutants (VHAP) from natural gas combustion can be found in AP-42, Section 3.2 Natural Gas-fired Reciprocating Engines, Tables 3.2-1, 3.2-2, and 3.2-3.

APPROVED BY: Brian F Kind (signature) **DATE:** 8-9-19

Attachment A

SJVAPCD BACT Determination and Email Contact

San Joaquin Valley
Unified Air Pollution Control District

Best Available Control Technology (BACT) Guideline 3.1.5*

Last Update: 07/16/2018

Emergency Gas-Fired IC Engine

Pollutant	Achieved in Practice or contained in the SIP	Technologically Feasible	Alternate Basic Equipment
VOC	1) LEAN BURN: 206 ppmv @ 15% O2 (1.0 g/bhp-hr) 2) RICH BURN: 60 ppmv @ 15% O2 (0.29 g/bhp-hr)		
SOx	Natural Gas, LPG, or Propane as fuel		
PM10	Natural Gas, LPG, or Propane as fuel		
NOx	1) LEAN BURN: < 500 BHP: 1.0 g/bhp-hr ≥ 500 BHP: 0.5 g/bhp-hr 2) RICH BURN: 25 ppmv @ 15% O2 (0.44 g/bhp-hr)		
CO	2.0 g/bhp-hr		

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a State Implementation Plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

***This is a Summary Page for this Class of Source**

Jeffrey Quok

From:	Matthew Baldwin
Sent:	Tuesday, May 07, 2019 4:47 PM
To:	Jeffrey Quok
Subject:	FW: Question on BACT 3.1.5
Categories:	Red Category

Jeff,

Here's a summary of what Silvana Procopio told me regarding BACT 3.1.5.

The lean burn VOC BACT was based on EPA NSPS JJJJ. This standard is 86 ppmv or 1.0 g/hp-hr (above 130 HP). However, not stated is the reference pollutant. San Joaquin investigated and discovered that it was referenced as propane. San Joaquin then updated their standard to reference methane, which is consistent with their rules. The change in reference switched the standard from 86 ppmv @ 15% oxygen to 206 ppmv @ 15% Oxygen. Likewise, they added a concentration standard to be consistent with the Lean Burn VOC standard, which is why they updated the original standard (0.29 g/hp-hr) to reference a 60 ppmv @ 15% Oxygen. Silvana stated that this is also referenced as methane.

Matt Baldwin
Sacramento Metropolitan AQMD
(916) 874-4858

From: Silvana Procopio [mailto:Silvana.Procopio@valleyair.org]
Sent: Tuesday, May 07, 2019 1:28 PM
To: Matthew Baldwin <MBaldwin@airquality.org>
Cc: Leonard Scandura <Leonard.Scandura@valleyair.org>; Errol Villegas <errol.villegas@valleyair.org>
Subject: RE: Question on BACT 3.1.5

Hi Matt,

It was a pleasure speaking with you earlier. Let me know if you have any further questions regarding the BACT Guideline Determination 3.1.5.

Kind regards,

Silvana Procopio
Air Quality Engineer
San Joaquin Valley APCD
34946 Flyover Ct.,
Bakersfield, CA 93308
Ph.: 661.392.5606
www.valleyair.org

San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

From: Leonard Scandura <Leonard.Scandura@valleyair.org>
Sent: Tuesday, May 7, 2019 11:55 AM
To: Errol Villegas <errol.villegas@valleyair.org>
Cc: Silvana Procopio <Silvana.Procopio@valleyair.org>
Subject: RE: Question on BACT 3.1.5

Errol - Well give him a call back.

Thanks

Leonard

From: Errol Villegas <errol.villegas@valleyair.org>
Sent: Tuesday, May 7, 2019 10:20 AM
To: Leonard Scandura <Leonard.Scandura@valleyair.org>
Subject: FW: Question on BACT 3.1.5

Leonard – It looks like Sylvana did this proactive BACT update… Can you please assist with answering this question from Sac Metro?

Thanks,
Errol

From: Matthew Baldwin <MBaldwin@airquality.org>
Sent: Tuesday, May 7, 2019 9:34 AM
To: Errol Villegas <errol.villegas@valleyair.org>
Subject: Question on BACT 3.1.5

Errol,

Just had a question regarding one of your BACT determinations. During a review for a permit application, I noticed that the VOC standard for BACT 3.1.5 (Emergency Gas-fired engine) had been corrected or changed. When we did our BACT determination for this category, we referenced the following standards:

1) Lean burn: 86 ppmv @ 15% O2 (0.4 g/bhp-hr) 2) Rich burn: 0.29 g/hp-hr (SMAQMD BACT Determination 208 & 209)

When looking more recently at the same BACT, it looks like the standard changed to:

1) Lean Burn: 206 ppmv @ 15% O2 (1.0 g/bhp-hr) 2) Rich Burn: 60 ppmv @ 15% O2 (0.29 g/bhp-hr)

Could you please clarify? We just want to be sure we have referenced the correct standards, and update our BACT if necessary.

Thanks,

Matt Baldwin
Air Quality Engineer
Sacramento Metropolitan Air Quality Management District
777 12th Street, 3rd Floor | Sacramento, CA 95814
Tel: (916) 874-4858 | Front Desk: (916) 874-4800
www.airquality.org

Attachment B

Original BACTs #208 & #209 (12/18/2018)

CATEGORY: **IC ENGINE SPARK - STANDBY**

BACT Size: Minor Source BACT **IC ENGINE STANDBY**

BACT Determination Number: 208	**BACT Determination Date:** 12/18/2018

Equipment Information

Permit Number: N/A -- Generic BACT Determination

Equipment Description: IC ENGINE STANDBY

Unit Size/Rating/Capacity: < 500 BHP

Equipment Location:

BACT Determination Information

ROCs	**Standard:**	See Description
	Technology Description:	Lean burn: 86 ppmv @ 15% O2 (0.4 g/bhp-hr), Rich burn: 0.29 g/hp-hr
	Basis:	Achieved in Practice
NOx	**Standard:**	See Description
	Technology Description:	Lean burn: 1.0 g/hp-hr, Rich burn: 25 ppmvd @ 15 O2 (0.44 g/hp-hr) OR 96% weight reduction
	Basis:	Achieved in Practice
SOx	**Standard:**	Natural gas fuel or equivalent fuel
	Technology Description:	
	Basis:	Achieved in Practice
PM10	**Standard:**	Natural gas fuel or equivalent fuel
	Technology Description:	
	Basis:	Achieved in Practice
PM2.5	**Standard:**	Natural gas fuel or equivalent fuel
	Technology Description:	
	Basis:	Achieved in Practice
CO	**Standard:**	2.0 g/hp-hr
	Technology Description:	
	Basis:	Achieved in Practice
LEAD	**Standard:**	
	Technology Description:	
	Basis:	

Comments: T-BACT is equivalent to BACT for VOC.

District Contact:

CATEGORY: **IC ENGINE SPARK - STANDBY**

BACT Size: Minor Source BACT **IC ENGINE STANDBY**

BACT Determination Number: 209	**BACT Determination Date:** 12/18/2018

Equipment Information

Permit Number: N/A -- Generic BACT Determination

Equipment Description: IC ENGINE STANDBY

Unit Size/Rating/Capacity: ≥ 500 BHP

Equipment Location:

BACT Determination Information

ROCs	**Standard:**	See Description
	Technology Description:	Lean burn: 86 ppmv @ 15% O2 (0.4 g/bhp-hr), Rich burn: 0.29 g/hp-hr
	Basis:	Achieved in Practice
NOx	**Standard:**	See Description
	Technology Description:	Lean burn: 0.5 g/hp-hr, Rich burn: 25 ppmvd @ 15 O2 (0.44 g/hp-hr) OR 96% weight reduction
	Basis:	Achieved in Practice
SOx	**Standard:**	Natural gas fuel or equivalent fuel
	Technology Description:	
	Basis:	Achieved in Practice
PM10	**Standard:**	0.0099 lb/MMBtu
	Technology Description:	
	Basis:	Achieved in Practice
PM2.5	**Standard:**	0.0099 lb/MMBtu
	Technology Description:	
	Basis:	Achieved in Practice
CO	**Standard:**	1.5 g/bhp-hr
	Technology Description:	
	Basis:	Achieved in Practice
LEAD	**Standard:**	
	Technology Description:	
	Basis:	

Comments: T-BACT is equivalent to BACT for VOC.

District Contact:

777 12th Street, Third Floor

SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT

Sacramento, CA 95814

BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION

DETERMINATION NO.:	208 & 209
DATE:	December 18, 2018
ENGINEER:	Jeffrey Quok

Category/General Equip Description:	Internal Combustion (I.C.) Engine
Equipment Specific Description:	I.C. Engine Spark – Standby, Gaseous-fueled (Excluding Biogas)
Equipment Size/Rating:	Engines < 500 BHP (BACT #208) Engines ≥ 500 BHP (BACT #209)
Previous BACT Det. No.:	No. 122 & 123

This BACT determination will update the following determinations:

#122 & #123 which were made on August 5, 2016 for I.C. Engine Spark - Standby, < 500 BHP and ≥ 500 BHP

BACT/T-BACT ANALYSIS

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

The following control technologies are currently employed as BACT/T-BACT for gaseous-fueled and propane/LPG standby engines by the following agencies and air pollution control districts:

Note: Tables 3.2-1, 3.2-2, and 3.2-3 of AP-42 list benzene, formaldehyde, PAHs, naphthalene, acetaldehyde, acrolein, propylene, toluene, xylenes, ethyl benzene, and hexane as the primary drivers for health risks associated with natural gas combustion. These VHAPs/organic compounds are emitted as VOC and the same control technologies that control VOCs also control the listed VHAPs.

District/Agency	Best Available Control Technology (BACT)/Requirements

US EPA

BACT

Source: EPA RACT/BACT/LAER Clearinghouse (See Attachment A)
RBLC ID: N/A IA-0102 (VOC) & CA-1225 (NOx, PM10, & CO)

For standby natural gas (includes propane & LPG) units with a rating of < 500 BHP	
VOC	0.66 lb/hr (IA-0102)[A]
NOx	0.78 lb/hr (CA-1225)[B]
SOx	N/A – No BACT determinations found in the < 500 BHP range
PM10	0.216 lb/hr (CA-1225)[B]
PM2.5	N/A – No BACT determinations found in the < 500 BHP range
CO	4.0 g/hp-hr (CA-1225)[B]

(A) IA-0102 was a BACT Determination for a 225 KW engine. This determination did not identify if the engine was lean or rich burn.
(B) CA-1225 was a BACT Determination for a 256 BHP engine. This determination did not identify if the engine was lean or rich burn.

Source: EPA RACT/BACT/LAER Clearinghouse (See Attachment A)
RBLC ID: OK-0153 (VOC, NOx, & CO), IN-0167 (SOx), & MI-0401 (PM10 & PM2.5)

For standby natural gas (includes propane & LPG) units with a rating of ≥ 500 BHP	
VOC	0.44 g/hp-hr (OK-0153)[A]
NOx	0.5 g/hp-hr (OK-0153)[A]
SOx	0.0015 g/kwh (0.0011 g/hp-hr) (IN-0167)[B]
PM10	0.0099 lb/MMBtu (MI-0401)[C]
PM2.5	0.0099 lb/MMBtu (MI-0401)[C]
CO	0.43 g/hp-hr (OK-0153)[A]

(A) OK-0153 was a BACT Determination for a 2,889 BHP engine. This determination did not identify if the engine was lean or rich burn.
(B) IN-0167 was a BACT Determination for a 620 BHP engine. This determination did not identify if the engine was lean or rich burn.
(C) MI-0401 was a BACT Determination for a 1,200 kW engine. This determination did not identify if the engine was lean or rich burn.

T-BACT

There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:

40 CFR Part 60 Subpart JJJJ – Standards of Performance for Stationary Spark Ignition Internal Combustion Engines: This regulation applies to owners/operators of new stationary spark ignition engines that commenced construction after June 12, 2006. [40 CFR §60.4230(a)(4)]

<table>
<tr><td>District/Agency</td><td>Best Available Control Technology (BACT)/Requirements</td></tr>
<tr><td>US EPA</td><td>

40 CFR §60.4233(d) & §60.4233(e)
Owners and operators of stationary SI ICE with a maximum engine power greater than 19 KW (25 BHP) must comply with the emission standards of Table 1 to this subpart for their emergency stationary SI ICE (applies to both lean and rich burn engines).

<table>
<tr><td colspan="6">40 CFR Subpart JJJJ Table 1: Emission Standards (g/kW-hr)</td></tr>
<tr><td rowspan="3">Engine Type and Fuel</td><td rowspan="3">Maximum Engine Power</td><td rowspan="3">Manufacture Date</td><td colspan="3">Emission Standards[A]</td></tr>
<tr><td colspan="3">g/bhp-hr
(ppmvd at 15% O_2)</td></tr>
<tr><td>NOx</td><td>CO</td><td>VOC[C]</td></tr>
<tr><td>Emergency[D]</td><td>25<BHP<130</td><td>1/1/2009</td><td>10[B]
(N/A)</td><td>387
(N/A)</td><td>N/A</td></tr>
<tr><td></td><td>BHP≥130</td><td></td><td>2.0
(160)</td><td>4.0
(540)</td><td>1.0
(86)</td></tr>
</table>

(A) Owners and operators of stationary non-certified SI engines may choose to comply with the emission standards in units of either g/bhp-hr or ppmvd at 15% O2
(B) The emission standards applicable to emergency engines between 25 BHP and 130 BHP are in terms of NOx + HC.
(C) For purposes of this subpart, when calculating emissions of VOC compounds, emissions of formaldehyde should not be included.
(D) Applies to both lean and rich burn emergency engines.

</td></tr>
<tr><td>Air Resources Board (ARB)</td><td>

BACT
Source: ARB BACT Clearinghouse (SCAQMD) (See Attachment B)

<table>
<tr><td colspan="2">For standby spark ignition natural gas fired units[A]</td></tr>
<tr><td>VOC</td><td>1.5 g/bhp-hr, 3-way catalyst converter with air/fuel ratio controller</td></tr>
<tr><td>NOx</td><td>1.5 g/bhp-hr, 3-way catalyst converter with air/fuel ratio controller</td></tr>
<tr><td>SOx</td><td>N/A – No BACT determinations found</td></tr>
<tr><td>PM10</td><td>N/A – No BACT determinations found</td></tr>
<tr><td>PM2.5</td><td>N/A – No BACT determinations found</td></tr>
<tr><td>CO</td><td>2.0 g/bhp-hr, 3-way catalyst converter with air/fuel ratio controller</td></tr>
</table>

(A) This BACT determination was for a 1334 bhp engine. The determination doesn’t specify if the engine is rich or lean burn.

</td></tr>
</table>

<table>
<tr><th>District/Agency</th><th>Best Available Control Technology (BACT)/Requirements</th></tr>
<tr><td>Air Resources Board (ARB)</td><td>
<u>T-BACT</u>
There are no T-BACT standards published in the clearinghouse for this category.
<u>RULE REQUIREMENTS:</u>
None
<u>CARB RACT/BARCT Guidelines for Stationary Spark-Ignited Internal Combustion Engines</u> (11/2001)
This document presents the determination of reasonably available control technology (RACT) and best available retrofit control technology (BARCT) for controlling NOx, VOC, and CO from stationary, spark-ignited reciprocating internal combustion engines. On page IV-14 of the document, emergency standby engines are listed as exempt from the recommended emission limits. Therefore, this guideline is not applicable to this BACT determination.
</td></tr>
<tr><td>SMAQMD</td><td>
<u>BACT</u>
<u>Source: SMAQMD BACT Clearinghouse, BACT Determination #122 & #123</u> (8/5/16)
<table>
<tr><td colspan="2">For standby spark ignition units with a rating of < 500 BHP</td></tr>
<tr><td>VOC</td><td><u>Lean Burn</u>
1.0 g/bhp-hr

<u>Rich Burn</u>
50% Control efficiency, 3-way catalyst with air-to-fuel ratio controller</td></tr>
<tr><td>NOx</td><td><u>Lean-Burn:</u>
1.0 g/bhp-hr

<u>Rich Burn:</u>
25 ppmvd @ 15% O_2 OR 96% weight reduction</td></tr>
<tr><td>SOx</td><td>Natural gas or equivalent fuel</td></tr>
<tr><td>PM10</td><td>Natural gas or equivalent fuel</td></tr>
<tr><td>PM2.5</td><td>Natural gas or equivalent fuel</td></tr>
<tr><td>CO</td><td>2.0 g/bhp-hr</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>District/Agency</th><th>Best Available Control Technology (BACT)/Requirements</th></tr>
<tr><td>SMAQMD</td><td>

<table>
<tr><td colspan="2">For standby spark ignition units with a rating of ≥ 500 BHP(A)</td></tr>
<tr><td>VOC</td><td><u>Lean Burn</u>
0.6 g/bhp-hr

<u>Rich Burn</u>
50% Control efficiency, 3-way catalyst with air-to-fuel ratio controller</td></tr>
<tr><td>NOx</td><td><u>Lean-Burn:</u>
0.5 g/bhp-hr

<u>Rich-Burn:</u>
25 ppmvd @ 15% O_2 OR 96% weight reduction</td></tr>
<tr><td>SOx</td><td>Natural gas or equivalent fuel</td></tr>
<tr><td>PM10</td><td>0.0099 lb/MMBtu</td></tr>
<tr><td>PM2.5</td><td>0.0099 lb/MMBtu</td></tr>
<tr><td>CO</td><td>1.5 g/p-hr</td></tr>
</table>

<u>T-BACT</u>
Source: SMAQMD BACT Clearinghouse, BACT Determination #122 & #123 (8/5/16)

<table>
<tr><td colspan="2">For standby spark ignition units with a rating of < 500 BHP(A)</td></tr>
<tr><td>VHAP(A)</td><td>1.0 g/bhp-hr</td></tr>
</table>

(A) A full list of the volatile hazardous air pollutants (VHAP) from natural gas combustion can be found in AP-42, Section 3.2 Natural Gas-fired Reciprocating Engines, Tables 3.2-1, 3.2-2, and 3.2-3.

<table>
<tr><td colspan="2">For standby spark ignition units with a rating of ≥ 500 BHP(A)</td></tr>
<tr><td>VHAP(A)</td><td>0.6 g/bhp-hr</td></tr>
</table>

(A) A full list of the volatile hazardous air pollutants (VHAP) from natural gas combustion can be found in AP-42, Section 3.2 Natural Gas-fired Reciprocating Engines, Tables 3.2-1, 3.2-2, and 3.2-3.

<u>RULE REQUIREMENTS:</u>
Rule 412 – Stationary Internal Combustion Engines Located at Major Stationary Sources of NOx (Adopted 6/1/1995)
This rule applies to any stationary internal combustion engine rated at more than 50 BHP located at a major stationary source of NOx. Section 110 of this rule states that operation of stationary internal combustion engines used for emergency standby are exempt from the standards of this rule. Therefore, this rule is not applicable to this BACT determination.
</td></tr>
</table>

District/Agency	Best Available Control Technology (BACT)/Requirements

South Coast AQMD

BACT
Source: SCAQMD BACT Guidelines for Non-Major Polluting Facilities, page 74 (2/2/18)

BACT Guideline, I.C. Engine Spark Ignition, Stationary, Emergency – g/bhp-hr					
Rating/Size	VOC	NOx	SOx	CO	PM
< 130 HP	1.5 g/bhp-hr	1.5 g/bhp-hr	Use of clean fuels (A)	2.0 g/bhp-hr	Use of clean fuels (A)
≥ 130 HP	1.0 g/bhp-hr	1.5 g/bhp-hr	Use of clean fuels (A)	2.0 g/bhp-hr	Use of clean fuels (A)

(A) Clean fuel is defined as one that produces air emissions equivalent to or lower than natural gas for NOx, SOx, ROG, and fine particulate matter (PM10).

T-BACT
There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:
Reg IX, Rule 1110.2 – Emissions from Gaseous- and Liquid-Fueled Engines (Amended 6/3/16)

Emergency standby engines are exempt from this Rule.

San Joaquin Valley Unified APCD

BACT
Source: SJVUAPCD BACT
Guideline 3.1.5 – Emergency Gas-Fired IC Engine (7/16/18)

Emergency Gas-Fired IC engine	
VOC	Lean Burn: 86 ppmv @ 15% O2 (0.4 g/bhp-hr) Rich Burn: 0.29 g/hp-hr
NOx	Lean Burn < 500 BHP: 1.0 g/bhp-hr Lean Burn ≥ 500 BHP: 0.5 g/bhp-hr Rich Burn: 25 ppmvd @ 15% O2 (0.44 g/bhp-hr)
SOx	Natural gas, LPG, or Propane fuel
PM10	Natural gas, LPG, or Propane fuel
PM2.5	No Standard
CO	2.0 g/bhp-hr

<table>
<tr><th>District/Agency</th><th>Best Available Control Technology (BACT)/Requirements</th></tr>
<tr><td>San Joaquin Valley Unified APCD</td><td>
<u>T-BACT</u>
There are no T-BACT standards published in the clearinghouse for this category.
<u>RULE REQUIREMENTS:</u>
Rule 4702 – Internal Combustion Engines (Amended 11/14/13)
Standby Engines are exempt from the emission limitations of this rule.
</td></tr>
<tr><td>San Diego APCD</td><td>
<u>BACT</u>
Source: NSR Requirements for BACT
The engine BACT determinations listed in the SDAPCD Clearinghouse do not apply to standby engines.
<u>T-BACT</u>
There are no T-BACT standards published in the clearinghouse for this category.
<u>RULE REQUIREMENTS:</u>
Regulation 4, Rule 69.4 – Stationary Reciprocating Internal Combustion Engines – Reasonably Available Control Technology (7/30/03)
This rule applies to stationary I.C. Engines ≥ 50 BHP located at a stationary source which emits or has a potential to emit 50 tons per year or more of NOx.
Standby Engines are exempt from the emission limitations of this rule.
Regulation 4, Rule 69.4.1 – Stationary Reciprocating Internal Combustion Engines – Best Available Retrofit Control Technology (11/15/00)
This rule applies to stationary I.C. Engines ≥ 50 BHP.
<table>
<tr><th colspan="4">New or replacement rich-burn engines using fossil derived gaseous fuel</th></tr>
<tr><th colspan="2">Published Value</th><th>Conversion for Naturally Aspirated Engines (g/bhp-hr)[(A)]</th><th>Conversion for Turbocharged Engines (g/bhp-hr)[(B)]</th></tr>
<tr><td>VOC</td><td>250 ppmvd @ 15% O_2</td><td>1.53</td><td>1.47</td></tr>
<tr><td>NOx</td><td>25 ppmvd @ 15% O_2 OR 96% weight reduction</td><td>0.44</td><td>0.42</td></tr>
<tr><td>SOx</td><td>No standard</td><td>-</td><td>-</td></tr>
<tr><td>PM10</td><td>No standard</td><td>-</td><td>-</td></tr>
<tr><td>PM2.5</td><td>No standard</td><td>-</td><td>-</td></tr>
<tr><td>CO</td><td>4,500 ppmvd @ 15% O_2</td><td>48.4</td><td>46.4</td></tr>
</table>
(A) Based on Santa Barbara County APCD Piston IC Engine Technical Reference Document (11/1/02) emission factor conversions, Section II(B)(B7)(e)(vi).
(B) Based on Santa Barbara County APCD Piston IC Engine Technical Reference Document (11/1/02) emission factor conversions, Section II(B)(B7)(e)(vii).
</td></tr>
</table>

<table>
<tr><th>District/Agency</th><th>Best Available Control Technology (BACT)/Requirements</th></tr>
<tr><td>San Diego APCD</td><td>
<table>
<tr><td colspan="4">New or replacement lean-burn engines using gaseous fuel</td></tr>
<tr><td colspan="2">Published Value</td><td>Conversion for Naturally Aspirated Engines (g/bhp-hr)(A)</td><td>Conversion for Turbocharged Engines (g/bhp-hr)(B)</td></tr>
<tr><td>VOC</td><td>250 ppmvd @ 15% O_2</td><td>1.53</td><td>1.47</td></tr>
<tr><td>NOx</td><td>65 ppmvd @ 15% O_2 OR 90% weight reduction</td><td>1.14</td><td>1.10</td></tr>
<tr><td>SOx</td><td>No standard</td><td>-</td><td>-</td></tr>
<tr><td>PM10</td><td>No standard</td><td>-</td><td>-</td></tr>
<tr><td>PM2.5</td><td>No standard</td><td>-</td><td>-</td></tr>
<tr><td>CO</td><td>4,500 ppmvd @ 15% O_2</td><td>48.4</td><td>46.4</td></tr>
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(A) Based on Santa Barbara County APCD Piston IC Engine Technical Reference Document (11/1/02) emission factor conversions, Section II(B)(B7)(e)(vi).
(B) Based on Santa Barbara County APCD Piston IC Engine Technical Reference Document (11/1/02) emission factor conversions, Section II(B)(B7)(e)(vii).
</td></tr>
<tr><td>Bay Area AQMD</td><td>
<u>BACT</u>
Source: BAAQMD BACT
Guideline 96.3.4 (5/7/03)
<table>
<tr><td colspan="2">IC Engine - Spark Ignition, Natural Gas Fired Emergency Engine ≥ 50 BHP</td></tr>
<tr><td>VOC</td><td>1. 1.0 g/bhp-hr (Achieved in Practice)
2. Lean burn technology or equivalent (Achieved in Practice)</td></tr>
<tr><td>NOx</td><td>1. 1.0 g/bhp-hr (Achieved in Practice)
2. Lean burn technology or equivalent (Achieved in Practice)</td></tr>
<tr><td>SOx</td><td>1. Natural Gas Fuel (Achieved in Practice)</td></tr>
<tr><td>PM10</td><td>1. Natural Gas Fuel (Achieved in Practice)</td></tr>
<tr><td>PM2.5</td><td>No Standard</td></tr>
<tr><td>CO</td><td>1. 2.75 g/bhp-hr (Achieved in Practice)
2. Lean burn technology or equivalent (Achieved in Practice)</td></tr>
</table>
<u>T-BACT</u>
There are no T-BACT standards published in the clearinghouse for this category.

<u>RULE REQUIREMENTS:</u>
Reg 9, Rule 8 – Nitrogen Oxides and Carbon Monoxide from Stationary Internal Combustion Engines (7/25/07)

Standby Engines are exempt from the emission limitations of this rule.
</td></tr>
</table>

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

SUMMARY OF ACHIEVED IN PRACTICE CONTROL TECHNOLOGIES	
VOC	For Spark Ignition, Emergency Standby Engines < 500 BHP 1. Lean burn: 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich burn: 0.29 g/hp-hr [SJVAPCD] 2. 0.66 g/bhp-hr (0.99 g/-bhp-hr)(A) [EPA, IA-0102] 3. Lean burn: 1.0 g/hp-hr Rich burn: 50% Control efficiency, 3-way catalyst with air-to-fuel ratio controller [SMAQMD] 4. 1.0 g/bhp-hr [BAAQMD] 5. 1.5 g/bhp-hr [SCAQMD] 6. 250 ppmvd @ 15% O_2 [SDAPCD] (1.53 g/bhp for naturally aspirated engines) (1.47 g/bhp for turbocharged engines) For Spark Ignition, Emergency Standby Engines ≥ 500 BHP 1. Lean burn: 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich burn: 0.29 g/hp-hr [SJVAPCD] 2. 0.44 g/bhp-hr [EPA, OK-0153] 3. Lean burn: 0.6 g/hp-hr Rich burn:50% Control efficiency, 3-way catalyst with air-to-fuel ratio controller [SMAQMD] 4. 1.0 g/bhp-hr [SCAQMD, BAAQMD] 5. 250 ppmvd @ 15% O_2 [SDAPCD] (1.53 g/bhp for naturally aspirated engines) (1.47 g/bhp for turbocharged engines)
NOx	For Spark Ignition, Emergency Standby Engines < 500 BHP 1. Lean burn: 1.0 g/hp-hr Rich burn: 25 ppmvd @ 15 O_2OR 96% weight reduction [SMAQMD] 2. Lean burn: 1.0 g/bhp-hr Rich Burn: 25 ppmvd @ 15% O_2 (0.44 g/bhp-hr) [SJVAPCD] 3. 1.0 g/bhp-hr [BAAQMD] 4. Rich Burn: 25 ppmvd @ 15% O_2 OR 96% NOx weight reduction [SDAPCD] (0.44 g/bhp-hr for naturally aspirated engines) (0.42 g/bhp-hr for turbocharged engines) Lean Burn:65 ppmvd @ 15% O_2 OR 90% NOx weight reduction (1.14 g/bhp-hr for naturally aspirated engines) (1.10 g/bhp-hr for turbocharged engines) 5. 0.78 lb/hr (1.35 g/bhp-hr)(B) [EPA, CA-1225] 6. 1.5 g/bhp-hr [SCAQMD]

SUMMARY OF ACHIEVED IN PRACTICE CONTROL TECHNOLOGIES	
NOx	For Spark Ignition, Emergency Standby Engines ≥ 500 BHP 1. Lean burn: 0.5 g/bhp-hr, Rich Burn: 25 ppmvd @ 15% O_2 (0.44 g/bhp-hr) [SJVAPCD] 2. Lean burn: 0.5 g/hp-hr, Rich burn: 25 ppmvd @ 15 O_2OR 96% weight reduction [SMAQMD] 3. Rich Burn: 25 ppmvd @ 15% O_2 OR 96% NOx weight reduction [SDAPCD] (0.44 g/bhp-hr for naturally aspirated engines) (0.42 g/bhp-hr for turbocharged engines) Lean Burn:65 ppmvd @ 15% O_2 OR 90% NOx weight reduction (1.14 g/bhp-hr for naturally aspirated engines) (1.10 g/bhp-hr for turbocharged engines) 4. 0.5 g/bhp-hr(B) [EPA, OK-0153] 5. 1.0 g/bhp-hr [BAAQMD] 6. 1.5 g/bhp-hr [SCAQMD]
SOx	For Spark Ignition, Emergency Standby Engines < 500 BHP 1. Natural gas fuel [BAAQMD] 2. Natural gas or equivalent fuel [SMAQMD] 3. Use of clean fuels(C) [SCAQMD] 4. Natural gas, LPG, or Propane fuel [EPA, SJVAPCD] 5. No standard [SDAPCD] For Spark Ignition, Emergency Standby Engines ≥ 500 BHP 1. 0.0015 g/kwh (0.0011 g/hp-hr) [EPA, IN-0167 & IN-0185](E) 2. Natural gas fuel [BAAQMD] 3. Natural gas or equivalent fuel [SMAQMD] 4. Use of clean fuels(C) [SCAQMD] 5. Natural gas, LPG, or Propane fuel [SJVAPCD] 6. No standard [SDAPCD]
PM10	For Spark Ignition, Emergency Standby Engines < 500 BHP 1. 0.0216 lb/hr [EPA, CA-1225](F) 2. Natural gas fuel [BAAQMD] 3. Natural gas or equivalent fuel [SMAQMD] 4. Use of clean fuels(C) [SCAQMD] 5. Natural gas, LPG, or Propane fuel [SJVAPCD] 6. No standard [SDAPCD] For Spark Ignition, Emergency Standby Engines ≥ 500 BHP 1. 0.0099 lb/MMBtu [EPA, MI-0401] 2. 0.0099 lb/MMBtu [SMAQMD] 3. Natural gas fuel [BAAQMD] 4. Use of clean fuels(C) [SCAQMD] 5. Natural gas, LPG, or Propane fuel [SJVAPCD] 6. No standard [SDAPCD]

SUMMARY OF ACHIEVED IN PRACTICE CONTROL TECHNOLOGIES	
PM2.5	For Spark Ignition, Emergency Standby Engines < 500 BHP 1. Natural gas or equivalent fuel [SMAQMD] 2. Use of clean fuels [SCAQMD] 3. No standard [EPA, SJVAPCD, SDACPD, BAAQMD] For Spark Ignition, Emergency Standby Engines ≥ 500 BHP 1. 0.0099 lb/MMBtu [EPA, MI-0401] 2. 0.0099 lb/MMBtu [SMAQMD] 3. Use of clean fuels[c] [SCAQMD] 4. No Standard [SJVAPCD, SDAPCD, BAAQMD]
CO	For Spark Ignition, Emergency Standby Engines < 500 BHP 1. 2.0 g/hp-hr [SMAQMD, SCAQMD, SJVAPCD] 2. 2.75 g/bhp-hr [BAAQMD] 3. 4.0 g/bhp-hr [EPA, CA-1225] 4. 4,500 ppmvd @ 15% O_2 [SDAPCD] (48.4 g/bhp-hr for naturally aspirated engines) (46.4 g/bhp-hr for turbocharged engines) For Spark Ignition, Emergency Standby Engines ≥ 500 BHP 1. 0.43 g/bhp-hr [EPA, OK-0153][G] 2. 1.5 g/bhp-hr [SMAQMD] 3. 2.0 g/bhp-hr [SCAQMD, SJVAPCD] 4. 2.75 g/bhp-hr [BAAMQD] 5. 4,500 ppmvd @ 15% O_2 [SDAPCD] (48.4 g/bhp-hr for naturally aspirated engines) (46.4 g/bhp-hr for turbocharged engines)
VHAP[D] (T-BACT)	For Spark Ignition, Emergency Standby Engines < 500 BHP 1. 1.0 g/bhp-hr [SMAQMD] 2. No standard [EPA, ARB, SCAQMD, BAAQMD, SDAPVD, SJVAPCD] For Spark Ignition, Emergency Standby Engines ≥ 500 BHP 1. 0.6 g/bhp-hr [SMAQMD] 2. No standard [EPA, ARB, SCAQMD, BAAQMD, SDAPVD, SJVAPCD]

(A) Conversion from lb/hr to g/bhp-hr based on a 225 KW engine and a conversion factor of 0.7457 kw/hp.
(B) Conversion from lb/hr to g/bhp-hr based on a 256 BHP engine.
(C) Clean fuels is defined as one that produces air emissions equivalent to or lower than natural gas for NOx, SOx, ROG, and fine particulate matter (PM10).
(D) A full list of the volatile hazardous air pollutants (VHAP) from natural gas combustion can be found in AP-42, Section 3.2 Natural Gas-fired Reciprocating Engines, Tables 3.2-1, 3.2-2, and 3.2-3.
(E) This BACT Determination did not specify if this was for a rich or lean burn engine. Compliance verification is listed as not verified. Therefore, this limit will not be considered achieved in practice.
(F) This BACT Determination did not specify if this was for a rich or lean burn engine. Compliance verification is listed as unknown. Therefore, this limit will not be considered achieved in practice.
(G) This BACT Determination did not specify if this was for a rich or lean burn engine. Compliance verification is listed as unknown. Therefore, this limit will not be considered achieved in practice.

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

BEST CONTROL TECHNOLOGIES ACHIEVED		
Pollutant	**Standard**	**Source**
VOC	**For gaseous or propane/LPG fired emergency IC Engines < 500 BHP (excluding biogas)** Lean burn: 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich burn: 0.29 g/hp-hr **For gaseous or propane/LPG fired emergency IC Engines ≥ 500 BHP (excluding biogas)** Lean burn: 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich burn: 0.29 g/hp-hr	SJVAPCD SJVAPCD
NOx	**For gaseous or propane/LPG fired emergency IC Engines < 500 BHP (excluding biogas)** Lean burn: 1.0 g/hp-hr Rich burn: 25 ppmvd @ 15 O_2 (0.44 g/hp-hr) OR 96% weight reduction **For gaseous or propane/LPG fired emergency IC Engines ≥ 500 BHP (excluding biogas)** Lean burn: 0.5 g/hp-hr Rich burn: 25 ppmvd @ 15 O_2 (0.44 g/hp-hr) OR 96% weight reduction	SMAQMD & SJVAPCD SJVAPCD
SOx	**For gaseous or propane/LPG fired emergency IC Engines < 500 BHP (excluding biogas)** Natural gas fuel or equivalent fuel **For gaseous or propane/LPG fired emergency IC Engines ≥ 500 BHP (excluding biogas)** Natural gas fuel or equivalent fuel	SMAQMD, SCAQMD, SJVUAPCD, and BAAQMD
PM10	**For gaseous or propane/LPG fired emergency IC Engines < 500 BHP (excluding biogas)** Natural gas fuel or equivalent fuel **For gaseous or propane/LPG fired emergency IC Engines ≥ 500 BHP (excluding biogas)** 0.0099 lb/MMBtu	SMAQMD, SCAQMD, SJVUAPCD, and BAAQMD SMAQMD, EPA MI-0401

BEST CONTROL TECHNOLOGIES ACHIEVED		
Pollutant	**Standard**	**Source**
PM2.5[A]	**For gaseous or propane/LPG fired emergency IC Engines < 500 BHP (excluding biogas)** Natural gas fuel or equivalent fuel **For gaseous or propane/LPG fired emergency IC Engines ≥ 500 BHP (excluding biogas)** 0.0099 lb/MMBtu	BAAQMD SMAQMD, EPA MI-0401
CO	**For gaseous or propane/LPG fired emergency IC Engines < 500 BHP (excluding biogas)** 2.0 g/hp-hr **For gaseous or propane/LPG fired emergency IC Engines ≥ 500 BHP (excluding biogas)** 1.5 g/bhp-hr	SMAQMD, SCAQMD, SJVAPCD SMAQMD
VHAP	**For gaseous or propane/LPG fired emergency IC Engines < 500 BHP (excluding biogas)** Lean burn: 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich burn: 0.29 g/hp-hr **For gaseous or propane/LPG fired emergency IC Engines ≥ 500 BHP (excluding biogas)** Lean burn: 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich burn: 0.29 g/hp-hr	SJVAPCD SJVAPCD

(A) All PM is expected to be less than 1.0 micrometer in diameter and therefore PM10 BACT is equivalent to PM2.5 BACT.

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.

During the most recent rulemaking for updates to the Airborne Toxic Control Measure for Stationary Compression Ignition Engines (Title 17, Cal. Code. Regs., §93115 to §93115.15), ARB conducted a cost effectiveness analysis to determine if selective catalytic reduction (SCR) was technologically feasible and cost effective for emergency use applications. (Initial Statement of Reasons for Proposed Rulemaking: Proposed Amendments to the Airborne Toxic Control Measure for Stationary Compression Ignition Engines, Appendix B, September 2010). Although the analysis was for stationary compression ignition engines, the listed SCR challenges due to the operational nature of emergency standby engines is also applicable for stationary spark ignition engines.

The analysis concluded that SCR may be technologically feasible, but had some additional challenges. Because standby engines routinely operate only for scheduled maintenance and testing, the engines do not operate more than 15-30 minutes, and do operate at no or low load. Because of this the exhaust would not likely reach the temperature (260 °C to 540 °C) required for the catalyst to operate. To circumvent this problem, the engine would need to be operated with higher loads and in many cases for longer periods of time. This could be a challenge for most emergency standby applications as most businesses do not have load banks in house and would have to create a larger load on the engine to get the catalyst up to operational temperature.
Urea handling and maintenance is also an important consideration. Urea crystallization in the lines can cause damage to the SCR system and to the engine itself. Crystallization in the lines is more likely in emergency standby engines due to their periodic and low hours of usage. Urea also has a shelf life of approximately two years. This could increase the cost of operating a SCR for emergency standby engines since the low number of annual hours of operation experienced by most emergency standby engines could lead to urea expiration. The urea would then have to be drained and replaced, creating an extra maintenance step and an increased cost to the end user.

ARB staff determined that while, SCR systems may be technically feasible, there are significant operational hurdles to overcome before routine use of SCR on emergency standby engines is practical. This is because the majority of operating hours for emergency standby engines occur during short 15 to 30 minute maintenance and testing checks are at low engine loads. In most cases, the temperature needed for the SCR catalyst to function will not be reached during this operation and the SCR will not provide the expected NOx reductions.

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.

Pollutant	**Technologically Feasible Alternatives**
VOC	No other technologically feasible option identified
NOx	For lean burn engines: Selective Catalytic Reduction
SOx	No other technologically feasible option identified
PM10	No other technologically feasible option identified
PM2.5	No other technologically feasible option identified
CO	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):

Pollutant	Maximum Cost ($/ton)
ROG	17,500
NO_X	24,500
PM10	11,400
SO_X	18,300
CO	TBD if BACT triggered

Cost Effectiveness Analysis Summary

SCR:
As shown in Attachment C, the cost effectiveness for the add on SCR system to control NOx to a 96% weight reduction was calculated to be **$181,576.47/ton** for a 499 bhp engine and **$152,555.04/ton** for a 1000 bhp engine (see attached Engine Cost Effectiveness Analysis). Since the cost per ton of NOx removal increases as engine size decreases and a 499 bhp engine was found to not be cost effective, the lower bound cost of a 50 bhp engine was not calculated. The following basic parameters were used in the analysis.

499 BHP Engine

NOx Control Level = 0.02356 lb/MMBtu (96% weight reduction)

NOx Baseline Level = 0.589 lb/MMBtu (160 ppmv @ 15% O2 per Subpart JJJJ)

Engine Rating = 499 BHP (4.8 MMBtu/hr)

Engine Operating Hours = 100 hours/year (maximum maintenance hours)

Equipment Life = 20 years

Direct Cost = $139,848.01

Direct Annual Cost = $8,778.86 per year

Indirect Annual Cost = $15,862.08 per year

Total Annual Cost = $24,640.94 per year

NOx Removed = 0.14 tons per year

Cost of NOx Removal = $181,576.47 per ton reduced

1,000 BHP Engine

NOx Control Level = 0.02356 lb/MMBtu (96% weight reduction)

NOx Baseline Level = 0.589 lb/MMBtu (160 ppmv @ 15% O2 per Subpart JJJJ)

Engine Rating = 1,000 BHP (9.6 MMBtu/hr)

Engine Operating Hours = 100 hours/year (maximum maintenance hours)

Equipment Life = 20 years

Direct Cost = $220,942.20

Direct Annual Cost = $16,317.19 per year

Indirect Annual Cost = $25,087.96 per year

Total Annual Cost = $41,405.15 per year

NOx Removed = 0.27 tons per year

Cost of NOx Removal = $152,555.04 per ton reduced

Therefore, the add-on SCR system is considered not cost effective for either engine size and is eliminated.

C. SELECTION OF BACT/T-BACT:

Based on the above analysis, BACT for VOC, NOx, SOx, PM10, and CO will remain at what is currently achieved in practice and BACT for PM2.5 will be set to be the same as for PM10.

Volatile hazardous air pollutants (VHAP) are the primary driver for health risks associated with gaseous fueled engines. VHAPs are emitted as VOC, and the same control technologies that control VOC also control VHAPs. Therefore, the BACT for VOC and T-BACT for VHAPs are the same.

Table 1: BACT #208 FOR SPARK IGNITED I.C. ENGINES, STANDBY, GASEOUS-FUELED (EXCLUDING BIOGAS) < 500 BHP

Pollutant	Standard	Source
VOC	Lean Burn 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich Burn 0.29 g/hp-hr	SJVAPCD
NOx	Lean-Burn: 1.0 g/bhp-hr Rich Burn: 25 ppmvd @ 15 O_2 (0.44 g/hp-hr) OR 96% weight reduction	SMAQMD & SJVAPCD
SOx	Natural gas fuel or equivalent fuel	SMAQMD, SCAQMD, SJVUAPCD, and BAAQMD
PM10	Natural gas fuel or equivalent fuel	SMAQMD, SCAQMD, SJVUAPCD, and BAAQMD
PM2.5	Natural gas fuel or equivalent fuel	SMAQMD, SCAQMD, SJVUAPCD, and BAAQMD
CO	2.0 g/bhp-hr	SMAQMD, SCAQMD, SJVAPCD

Table 2: T-BACT #208 FOR SPARK IGNITED I.C. ENGINES, STANDBY, GASEOUS-FUELED (EXCLUDING BIOGAS) < 500 BHP

Pollutant	Standard	Source
VHAP(A)	Lean Burn 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich Burn 0.29 g/hp-hr	SJVAPCD

(A) A full list of the volatile hazardous air pollutants (VHAP) from natural gas combustion can be found in AP-42, Section 3.2 Natural Gas-fired Reciprocating Engines, Tables 3.2-1, 3.2-2, and 3.2-3.

Table 3: BACT #209 FOR SPARK IGNITED I.C. ENGINES, STANDBY, GASEOUS-FUELED (EXCLUDING BIOGAS) ≥ 500 BHP

Pollutant	Standard	Source
VOC	Lean Burn 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich Burn 0.29 g/hp-hr	SJVAPCD
NOx	Lean-Burn: 0.5 g/bhp-hr Rich Burn: 25 ppmvd @ 15 O_2 (0.44 g/hp-hr) OR 96% weight reduction	SMAQMD & SJVAPCD
SOx	Natural gas fuel or equivalent fuel	BAAQMD
PM10	0.0099 lb/MMBtu	SMAQMD, EPA (MI-00401)
PM2.5	0.0099 lb/MMBtu	SMAQMD, EPA (MI-00401)
CO	1.5 g/p-hr	SMAQMD

Table 4: T-BACT #209 FOR SPARK IGNITED I.C. ENGINES, STANDBY, GASEOUS-FUELED (EXCLUDING BIOGAS) ≥ 500 BHP

Pollutant	Standard	Source
VHAP[(A)]	Lean Burn 86 ppmv @ 15% O_2 (0.4 g/bhp-hr) Rich Burn 0.29 g/hp-hr	SJVAPCD

(A) A full list of the volatile hazardous air pollutants (VHAP) from natural gas combustion can be found in AP-42, Section 3.2 Natural Gas-fired Reciprocating Engines, Tables 3.2-1, 3.2-2, and 3.2-3.

APPROVED BY: [signature] **DATE:** 12/18/18

Attachment A

Review of BACT Determinations published by EPA

List of BACT determinations published in EPA's RACT/BACT/LAER Clearinghouse (RBLC) for Natural Gas (includes propane & liquefied petroleum gas) I.C. Engines ≤ 500 BHP & > 500 BHP

RBLC#	Permit Date(A)	Process Code (B), (C)	Engine Burn Type	Rating	Pollutant	Standard	Case-By-Case Basis
MI-0426	3/24/17	17.130	Not Listed	1,818 BHP	CO	11.0 lb/hr	BACT-PSD
MI-0426	3/24/17	17.130	Not Listed	1,818 BHP	NOx	4.0 lb/hr & 2.0 g/hp-hr	BACT-PSD
MI-0426	3/24/17	17.130	Not Listed	1,818 BHP	PM10	0.01 lb/mmBtu	BACT-PSD
MI-0426	3/24/17	17.130	Not Listed	1,818 BHP	PM2.5	0.01 lb/mmBtu	BACT-PSD
CA-1240	3/17/17	17.130	Not Listed	881 BHP	VOC	25 ppmvd @ 15% O2	Other Case-By-Case
CA-1240	3/17/17	17.130	Not Listed	881 BHP	CO	54 ppmvd @ 15% O2	Other Case-By-Case
CA-1240	3/17/17	17.130	Not Listed	881 BHP	NOx	5 ppmvd @ 15% O2	Other Case-By-Case
CA-1240	3/17/17	17.130	Not Listed	881 BHP	NH3	5 ppmvd @ 15% O2	Other Case-By-Case
MI-0424	12/5/16	17.130	Not Listed	1,462 BHP	CO	0.8 g/hp-hr	BACT-PSD
MI-0424	12/5/16	17.130	Not Listed	1,462 BHP	NOx	2.0 g/hp-hr	BACT-PSD
MI-0424	12/5/16	17.130	Not Listed	1,462 BHP	PM10	0.01 lb/mmBtu	BACT-PSD
MI-0424	12/5/16	17.130	Not Listed	1,462 BHP	PM2.5	0.01 lb/mmBtu	BACT-PSD
MI-0424	12/5/16	17.130	Not Listed	1,462 BHP	VOC	0.5 g/hp-hr	BACT-PSD
MI-0420	6/3/16	17.130	Not Listed	1,506 kW	CO	9.6 lb/hr & 4.0 g/hp-hr	BACT-PSD
MI-0420	6/3/16	17.130	Not Listed	1,506 kW	NOx	4.8 lb/hr & 2.0 g/hp-hr	BACT-PSD
MI-0420	6/3/16	17.130	Not Listed	1,506 kW	PM10	0.01 lb/mmBtu	BACT-PSD
MI-0420	6/3/16	17.130	Not Listed	1,506 kW	PM2.5	0.01 lb/mmBtu	BACT-PSD

RBLC#	Permit Date[(A)]	Process Code [(B), (C)]	Engine Burn Type	Rating	Pollutant	Standard	Case-By-Case Basis
SC-0170	11/7/14	17.130	Not Listed	500 kW	CO	Tier 3 emission standards	BACT-PSD
SC-0170	11/7/14	17.130	Not Listed	500 kW	VOC	Tier 3 emission standards	BACT-PSD
LA-0287	7/21/14	17.130	Not Listed	1175 BHP	NOx	2.0 g/hp-hr	BACT-PSD
LA-0287	7/21/14	17.130	Not Listed	1175 BHP	PM10	0.004 lb/hr	BACT-PSD
LA-0287	7/21/14	17.130	Not Listed	1175 BHP	PM2.5	0.004 lb/hr	BACT-PSD
IN-0185	4/24/14	17.130	Not Listed	620 BHP	PM10	0.2 g/kWh	BACT-PSD
IN-0185	4/24/14	17.130	Not Listed	620 BHP	PM2.5	0.2 g/kWh	BACT-PSD
IN-0185	4/24/14	17.130	Not Listed	620 BHP	SO2	0.0015 g/kWh	BACT-PSD
MI-0412	12/4/13	17.130	Not Listed	1,000 kW	CO	0.8 g/hp-hr	BACT-PSD
MI-0412	12/4/13	17.130	Not Listed	1,000 kW	NOx	2.0 g/hp-hr	BACT-PSD
MI-0412	12/4/13	17.130	Not Listed	1,000 kW	PM10	0.01 lb/mmBtu	BACT-PSD
MI-0412	12/4/13	17.130	Not Listed	1,000 kW	PM2.5	0.01 lb/mmBtu	BACT-PSD
MI-0412	12/4/13	17.130	Not Listed	1,000 kW	VOC	0.5 g/hp-hr	BACT-PSD
LA-0311	7/15/13	17.130	Not Listed	2,500 BHP	CO	27.56 lb/hr	BACT-PSD
IN-0167	4/16/13	17.130	Not Listed	620 BHP	NOx	0.5 g/hp-hr	BACT-PSD
IN-0167	4/16/13	17.130	Not Listed	620 BHP	PM10	0.2 g/kw-hr	BACT-PSD
IN-0167	4/16/13	17.130	Not Listed	620 BHP	PM2.5	0.2 g/kw-hr	BACT-PSD
IN-0167	4/16/13	17.130	Not Listed	620 BHP	SO2	0.0015 g/kw-hr	BACT-PSD
OK-0153	3/1/13	17.130	Not Listed	2,889 BHP	CO	0.43 g/hp-hr	BACT-PSD
OK-0153	3/1/13	17.130	Not Listed	2,889 BHP	NOx	0.5 g/hp-hr	BACT-PSD
OK-0153	3/1/13	17.130	Not Listed	2,889 BHP	PM2.5	0.01 lb/mmBtu	BACT-PSD
OK-0153	3/1/13	17.130	Not Listed	2,889 BHP	VOC	0.44 g/hp-hr	BACT-PSD
MI-0401	12/21/11	17.130	Not Listed	1,200 kW	NOx	0.5 g/hp-hr	BACT-PSD

RBLC#	Permit Date[A]	Process Code [B], [C]	Engine Burn Type	Rating	Pollutant	Standard	Case-By-Case Basis
MI-0401	12/21/11	17.130	Not Listed	1,200 kW	PM10	0.00999 lb/mmBtu	BACT-PSD
MI-0401	12/21/11	17.130	Not Listed	1,200 kW	PM2.5	0.00999 lb/mmBtu	BACT-PSD
LA-0256	12/06/2011	17.130	Not Listed	1,818 BHP	PM10	0.01 lb/hr	BACT-PSD, Operating Permit[D]
LA-0256	12/06/2011	17.130	Not Listed	1,818 BHP	PM2.5	0.01 lb/hr	BACT-PSD, Operating Permit[D]
LA-0256	12/06/2011	17.130	Not Listed	1,818 BHP	PM (TSP)	0.01 lb/hr	BACT-PSD, Operating Permit[D]
LA-0257	12/06/2011	17.130	Not Listed	2,012 BHP	CO	4.0 lb/bhp-r	BACT-PSD[E]
LA-0257	12/06/2011	17.130	Not Listed	2,012 BHP	NOx	2.0 g/bhp-hr	BACT-PSD[E]
LA-0257	12/06/2011	17.130	Not Listed	2,012 BHP	PM (TPM)	N/A	BACT-PSD
LA-0257	12/06/2011	17.130	Not Listed	2,012 BHP	VOC	1.0 g/bhp-r	BACT-PSD[E]
CA-1192	6/21/2011	17.130	Not Listed	860 BHP (550.0 KW)	CO	N/A	BACT-PSD[F]
CA-1192	6/21/2011	17.130	Not Listed	860 BHP (550.0 KW)	NOx	N/A	BACT-PSD[F]
CA-1192	6/21/2011	17.130	Not Listed	860 BHP (550.0 KW)	PM (TPM)	N/A	BACT-PSD[F]
CA-1192	6/21/2011	17.130	Not Listed	860 BHP (550.0 KW)	PM (PM10)	N/A	BACT-PSD[F]
MI-0390	10/14/2010	17.130	Not Listed	1818 BHP	NOx	0.5 g/bhp-hr	BACT-PSD, NSPS, NESHAP
LA-0232	6/24/2008	17.130	Not Listed	838 BHP	NOx	4.8 lb/hr	BACT-PSD, Operating Permit
LA-0232	6/24/2008	17.130	Not Listed	838 BHP	VOC	1.39 lb/hr	BACT-PSD, Operating Permit
MD-0036	3/10/2006	17.130	Not Listed	1,085 BHP (770KW)	CO	1.5 g/bhp-hr	BACT-PSD
MD-0036	3/10/2006	17.130	Not Listed	1,085 BHP (770KW)	NOx	2.0 g/bhp-hr	BACT-PSD
MD-0036	3/10/2006	17.130	Not Listed	1,085 BHP (770KW)	PM (FPM10)	0.0099 lb/MMBtu	BACT-PSD[G]

RBLC#	Permit Date[(A)]	Process Code [(B), (C)]	Engine Burn Type	Rating	Pollutant	Standard	Case-By-Case Basis
MD-0036	3/10/2006	17.130	Not Listed	1,085 BHP (770 KW)	VOC	0.6 g/hp-hr	LAER
LA-0276	12/15/16	17.230	Not Listed	150 kW	VOC	Comply with NSPS Subpart JJJJ	BACT-PSD
FL-0356	3/9/16	17.230	Not Listed	25 kW	CO	387 g/hp-hr	BACT-PSD
CA-1225	4/25/14	17.230	Not Listed	256 BHP	CO	4.0 g/hp-hr	BACT-PSD
CA-1225	4/25/14	17.230	Not Listed	256 BHP	NOx	0.78 lb/hr	BACT-PSD
CA-1225	4/25/14	17.230	Not Listed	256 BHP	FPM	0.0216 lb/hr	BACT-PSD
CA-1225	4/25/14	17.230	Not Listed	256 BHP	PM10	0.0216 lb/hr	BACT-PSD
LA-0311	7/15/13	17.230	Not Listed	300 BHP	CO	3.31 lb/hr	BACT-PSD
IA-0102	2/1/2012	17.230	Not Listed	225 KW	VOC	0.66 lb/hr	BACT-PSD[(H)]
WA-0316	6/14/2006	17.230	Not Listed	450 KW	NOx	82 g/hr	BACT-PSD[(I)]
NV-0048	5/16/2006	17.230	Not Listed	771 BHP (575 KW)	CO	2.0 g/bhp-hr	Other Case-by-Case, SIP, Operating Permit
NV-0048	5/16/2006	17.230	Not Listed	771 BHP (575 KW)	NOx	21.5 g/bhp-hr	Other Case-by-Case, SIP, Operating Permit
NV-0048	5/16/2006	17.230	Not Listed	771 BHP (575 KW)	PM (FPM10)	0.0410 g/bhp-hr	Other Case-by-Case, SIP, Operating Permit
NV-0048	5/16/2006	17.230	Not Listed	771 BHP (575 KW)	SOx	0.0052 g/bhp-hr	Other Case-by-Case, SIP, Operating Permit
NV-0048	5/16/2006	17.230	Not Listed	771 BHP (575 KW)	VOC	0.23 g/bhp-hr	Other Case-by-Case, SIP, Operating Permit

(A) Due to the large number of entries only determinations made (based on Permit Date) entered since 01/01/2005 are included in the above table.
(B) Process Code 17.130 includes Large Internal Combustion Engines (> 500 BHP) fueled using natural gas (includes propane and liquid petroleum gas).
(C) Process Code 17.230 includes Small Internal Combustion Engines (≤ 500 BHP) fueled using natural gas (includes propane and liquid petroleum gas).
(D) BACT was determined to be use of natural gas fuel and good combustion practices. Emission limits for PM10, PM2.5, and PM (TSP) were determined to be <0.01 lb/hr and was established by Louisiana Department of Environmental Quality Permit PSD-LA-754 for Westlake Vinyls

Company, LP.

(E) Emission Limits are based on 40 CFR Part 60 Subpart JJJJ – Standards of Performance for Stationary Spark Ignition Internal Combustion Engines. (NSPS, Subpart IIII)

(F) The Ninth Circuit Court of Appeals issued a decision on 8/12/2014 that vacated the permit decision and remanded it to EPA. Therefore, this BACT determination has not yet been achieved in practice. Source: EPA Region IX, Avenal Energy Product.

(G) Emission limit for PM is based on AP-42 PM condensable emission factor for natural gas-fired reciprocating engines.

(H) BACT was determined to be good combustion practices. Emission limit for VOC was determined to be 0.66 lb/hr and was established by Iowa Department of Natural Resources; Air Quality Bureau, Title V Permit 03-TV-025R2 (page 133) for Alcoa, Inc.

(I) BACT was determined to be non-selective catalytic reduction. Emission limit for NOx was determined to be ≤82 g/hr and was established by Washington State Department of Ecology; Air Quality Program, Permit PSD-01-09 Amendment 6 for Northwest Pipeline Corporation

[pink box] = Not applicable to this determination. Equipment has not yet been achieved in practice or is for a specific purpose outside of the scope of this determination.

[yellow box] = Selected as the most stringent BACT determination achieved in practice.

Attachment B

Review of BACT Determinations published by ARB

List of BACT determinations published in ARB's BACT Clearinghouse for ICE: Spark Ignition, Natural Gas & ICE: Emergency, Spark Ignition:

Capacity	Source	Date	Engine Burn Type	NOx	VOC	CO	PM10	SOx
528 BHP	MBUAPCD	10/13/2005	Rich Burn	0.07 g/bhp-hr[A]	N/A	N/A	N/A	N/A
93 BHP	SCAQMD	10/06/2000	Rich Burn	0.15 g/bhp-hr[B]	0.15 g/bhp-hr	0.6 g/bhp-hr	N/A	N/A
1334 BHP	SCAQMD	12/7/1999	Rich Burn	1.5 g/bhp-hr[B]	1.5 g/bhp-hr[B]	2.0 g/bhp-hr[B]	N/A	N/A
750 BHP	SCAQMD[C]	N/A	Rich Burn	0.15 g/bhp-hr[B]	0.15 g/bhp-hr[B]	0.6 g/bhp-hr[B]	N/A	N/A
310 BHP	SMAQMD[D]	10/22/2004	Rich Burn	2.13 g/bhp-hr[A]	0.0449[A]	1.6 g/bhp-hr[A]	0.152 g/bhp-hr	0.002 g/bhp-hr

(A) Add-on control – 3-way catalytic converter,
(B) Add-on control – 3-way catalytic converter and air/fuel ratio controller
(C) SCAQMD is reconsidering the BACT requirement for future applications of this type. Source: SCAQMD Application No. 359876
(D) Emission limits are based on emissions for the specific engine and is not a standard for gaseous emergency standby engines

[light blue] = Not enough information to determine if engine is for standby purposes

[yellow] = Selected as the most stringent BACT determination achieved in practice.

Attachment C

Cost Effectiveness Calculations

ENGINE SCR COST EFFECTIVENESS CALCULATION

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

Section 4.2 - NOx Post-Combustion, Chapter 2 - Selective Catalytic Reduction

Cost Effectiveness =	**$ 181,576.47**	**$/ton**

Equipment

Engine rating (499 BHP)	4.8	mmBTU/hr
Engine Operating hours	100	hours
Engine capacity factor	1	
SCR Operating Days	365	days
Total Capacity Factor	1	
Baseline NOx (30 ppm)	0.589	lb/mmBTU
SCR NOx (5 ppm)	0.02356	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
Equipment Life	20	years
Annual interest Rate	5	%
Catalyst cost, Initial	240	$/ft2
Catalyst cost, replacement	290	$/ft2
Electrical Power cost	0.1124	$/KWh
Ammonia Cost	0.101	$/lb
Catalyst Life	24000	hr
Catalyst Layers	2 full, 1 empty	

Engine Calculations

Q_B	4.8	mmBTU/hr
$q_{flue\ gas}$	1710.371508	acfm

N_{NOx}	0.96	

SCR Reactor Calculations

$Vol_{Catalyst}$	14.47935815	ft3
$A_{Catalyst}$	1.781636988	ft2
A_{SCR}	2.048882536	ft2
l=w=	1.431391818	ft
n_{layer}	3	
h_{layer}	3.708998943	
n_{total}	4	
h_{SCR}	51.83599577	ft

Reagent Calculations

$m_{reagent}$	1.098773675	lb/hr
m_{sol}	3.788874742	lb/hr
q_{sol}	0.50615307	gph
Tank Volume	1093.290632	gal

Cost Estimation

Direct Costs

DC	$139,848.01

Indirect Costs

General Facilities	$6,992.40
Engineering and home office fees	$13,984.80
Process Contingency	$6,992.40
Total Indirect Installation Costs	$27,969.60
Project Contingency	$25,172.64
Total Plant Cost	$192,990.25
Preproduction Cost	$3,859.80
Inventory Capital	$826.58
Total Capital Investment	$197,676.63

Direct Annual Costs

Maintenance Costs	$2,965.15	per yr
Power	2.04898176	KW
Annual Electricity	$2,017.48	per yr

Reagent Solution Cost	$3,352.24	per yr

Catalyst Replacement

FWF	0.317208565		
Annual Catalyst Replacement		$443.99	per yr
Total Variable Direct Cost	$5,813.71	per yr	
Total Direct Annual Cost	$8,778.86	per yr	
CRF	0.080242587		
Indirect Annual Cost		$15,862.08	per yr
Total annual Cost	$24,640.94	per yr	
NOx Removed	0.14	tons	
Cost of NOx removal	$181,576.47	per ton	

ENGINE SCR COST EFFECTIVENESS CALCULATION

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

Section 4.2 - NOx Post-Combustion, Chapter 2 - Selective Catalytic Reduction

Cost Effectiveness = $ 152,555.04 $/ton

Equipment

Engine rating (1000 HP)	9.6	mmBTU/hr
Engine Operating hours	100	hours
Engine capacity factor	1	
SCR Operating Days	365	days
Total Capacity Factor	1	
Baseline NOx (30 ppm)	0.589	lb/mmBTU
SCR NOx (5 ppm)	0.02356	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
Equipment Life	20	years
Annual interest Rate	5	%
Catalyst cost, Initial	240	$/ft2
Catalyst cost, replacement	290	$/ft2
Electrical Power cost	0.1124	$/KWh
Ammonia Cost	0.101	$/lb
Catalyst Life	24000	hr
Catalyst Layers	2 full, 1 empty	

Boiler Calculations

Q_B	9.6	mmBTU/hr
$q_{flue\ gas}$	3420.743017	acfm

N_{NOx}	0.96	

SCR Reactor Calculations

$Vol_{Catalyst}$	28.9587163	ft3
$A_{Catalyst}$	3.563273976	ft2
A_{SCR}	4.097765072	ft2
l=w=	2.024293722	ft
n_{layer}	3	
h_{layer}	3.708998943	
n_{total}	4	
h_{SCR}	51.83599577	ft

Reagent Calculations

$m_{reagent}$	2.197547351	lb/hr
m_{sol}	7.577749485	lb/hr
q_{sol}	1.012306141	gph
Tank Volume	2186.581265	gal

Cost Estimation

Direct Costs

DC	$	220,942.20

Indirect Costs

General Facilities	$	11,047.11
Engineering and home office fees	$	22,094.22
Process Contingency	$	11,047.11
Total Indirect Installation Costs	$	44,188.44
Project Contingency	$	39,769.60
Total Plant Cost	$	304,900.24
Preproduction Cost	$	6,098.00
Inventory Capital	$	1,653.16
Total Capital Investment	$	312,651.41

Direct Annual Costs

Maintenance Costs	$	4,689.77	per yr
Power		4.09796352	KW
Annual Electricity	$	4,034.95	per yr

Reagent Solution Cost	$	6,704.49	per yr

Catalyst Replacement

FWF		0.317208565	
Annual Catalyst Replacement	$	887.98	per yr
Total Variable Direct Cost	$	11,627.42	per yr
Total Direct Annual Cost	$	16,317.19	per yr
CRF		0.080242587	
Indirect Annual Cost	$	25,087.96	per yr
Total annual Cost	$	41,405.15	per yr
NOx Removed		0.27	tons
Cost of NOx removal	$	152,555.04	per ton