ACTIVE SMAQMD BACT CLEARINGHOUSE

CATEGORY: **MISCELLANEOUS**

BACT Size: Tortilla Oven ≤ 500 °F **OVEN**

BACT Determination Number: 206	**BACT Determination Date:** 11/16/2018

Equipment Information

Permit Number: 25860
Equipment Description: OVEN
Unit Size/Rating/Capacity: ≤ 500 °F and < 19 MMBtu/hr
Equipment Location: BERBER FOOD MANUFACTURING DBA MI RANCHO
10115 IRON ROCK WAY
ELK GROVE, CA

EXPIRED

BACT Determination Information

ROCs	**Standard:**	Natural gas fuel or equivalent
	Technology Description:	
	Basis:	Cost Effective
NOx	**Standard:**	30 ppmvd @ 3%O2
	Technology Description:	30 ppmvd @ 3%O2, 2.Natural gas with optional LPG as backup fuel
	Basis:	Achieved in Practice
SOx	**Standard:**	500 ppmvd @ 3% O2
	Technology Description:	Natural gas fuel or equivalent
	Basis:	Achieved in Practice
PM10	**Standard:**	Natural gas fuel or equivalent
	Technology Description:	
	Basis:	Achieved in Practice
PM2.5	**Standard:**	Natural gas fuel or equivalent
	Technology Description:	
	Basis:	Cost Effective
CO	**Standard:**	400 ppmvd @ 3% O2
	Technology Description:	Natural gas fuel or equivalent
	Basis:	Achieved in Practice
LEAD	**Standard:**	
	Technology Description:	
	Basis:	

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

District Contact: Jeff Quok Phone No.: (916) 874 - 4863 email: smosunic@airquality.org

777 12th Street, Third Floor

SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT

Sacramento, CA 95814

BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION

EXPIRED

DETERMINATION NO.: 206

DATE: November 16, 2018

ENGINEER: Jeffrey Quok

Category/General Equip Description: Tortilla Oven

Equipment Specific Description: Tortilla Oven ≤ 500 °F

Equipment Size/Rating: < 19 MMBtu/hr

Previous BACT Det. No.: N/A

This BACT determination was determined under the project A/C 25860 (Berber Food Manufacturing dba Mi Rancho) for a tortilla oven ≤ 500 °F where the products of combustion come into direct contact with the tortillas. Tortillas don't contain yeast leavened products.

BACT/T-BACT ANALYSIS

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

The following control technologies are currently employed as BACT/T-BACT for tortilla ovens by the following air pollution control districts:

US EPA

BACT

Source: EPA RACT/BACT/LAER Clearinghouse

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

T-BACT

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

RULE REQUIREMENTS:

40 CFR Part 60 – New Source Performance Standards (NSPS):

There are currently no 40 CFR, Part 60 NSPS sections that apply to this source category.

40 CFR Part 61 – National Emission Standards for Hazardous Air Pollutants (NESHAPS):

There are currently no 40 CFR, Part 61 NESHAPs that apply to this source category.

40 CFR Part 63 – NESHAPS for Source Categories (MACT Standards):

There are currently no 40 CFR, Part 63 NESHAPs that apply to this source category

Air Resources Board (ARB)

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

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

RULE REQUIREMENTS:
ARB Airborne Toxic Control Measures (ATCM):
There are currently no ATCMs that apply to this source category.

Sacramento Metropolitan AQMD

BACT
Source: SMAQMD BACT Clearinghouse
There are no BACT standards published in the clearinghouse for this category.

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

RULE REQUIREMENTS:

Rule 419 – NOx from Miscellaneous Combustion Units (Adopted 7/26/2018)
This rule applies to any miscellaneous combustion unit with a total rated heat input capacity of 2 MMBtu/hr located at a major stationary source of NOx. The requirements of this rule do not apply to cooking units, which is defined as any oven or dryer used to heat, cook, dry, roast, or prepare food, or products for making beverages, for human consumption. Therefore, this rule is not applicable.

However, SMAQMD is in the process of amending this rule to include cooking units with a total rated heat input capacity of 5 MMBtu/hr or greater that is not located at a major stationary source of NOx. The NOx and CO emission limits for cooking units are summarized in the following table.

TABLE 2: COOKING UNIT
EMISSION LIMITS EXPRESSED AS PPMV, corrected to 3% O_2

Equipment Category	**NOx Limit ppmv, corrected to 3% O_2 (lb/MMBtu)**		**CO Limit ppmv, corrected to 3% O_2 (lb/MMBtu)**
	Effective (see Section 401)		
	Process Temperature		
	< 500 °F	≥ 500 °F	
Cooking Unit	40 (0.049)	60 (0.073)	800

Rule 406 – Specific Contaminants (Amended 12/6/1978)
This rule limits the emission of sulfur compounds and combustion contaminants.

A person shall not discharge into the atmosphere from any single source of emission equipment whatsoever:

1. Sulfur compounds in any state or combination thereof exceeding in concentration at the point of discharge: sulfur compounds, calculated as sulfur dioxide: 0.2% volume.
2. Combustion contaminants in any state or combination thereof exceeding in concentration at the point of discharge: 0.23 grams per dry standard cubic meter (0.1 grains per dry standard cubic foot) of gas calculated to 12% carbon dioxide at standard conditions.

South Coast AQMD

BACT

Source: SCAQMD BACT Guidelines for Non-Major Polluting Facilities, page 55.
(Last Revised 2/2/2018)

Food Oven	
VOC	No Standard
NOx	For Ribbon Burners ≤ 500°F 1. 30 ppmvd @ 3% O_2 Other Direct Fired Burner 1. 30 ppmvd @ 3% O_2 Infrared Burner 1. 30 ppmvd @ 3% O_2
SOx	Natural gas
PM10	Natural Gas
PM2.5	No standard
CO	Compliance with applicable SCAQMD Rules 407 or 1153.1

(A) SCAQMD's does not require a permit for combustion equipment that has a rated maximum heat input capacity of 2.0 MMBtu/hr or less

T-BACT

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

RULE REQUIREMENTS:

Reg IV, Rule 407 – Liquid and Gaseous Air contaminants (Last amended 4/2/1982)

A person shall not discharge into the atmosphere from any equipment:

1. Carbon Monoxide (CO) exceeding 2,000 ppm by volume measured on a dry basis, averaged over 15 consecutive minutes
2. Sulfur compounds which would exist as liquid or gas at standard conditions exceeding 500 ppm, calculated as sulfur dioxide (SO2) and averaged over 15 consecutive minutes

Reg IV, Rule 1147 – NOx Reductions from Miscellaneous Sources
(Last amended 7/7/2017)
This rule is to reduce NOx emissions from gaseous and liquid fuel fired combustion equipment. Per section (g)(2), this rule does not apply to charbroilers or food ovens. Therefore, this rule is not applicable to this BACT Determination.

Reg XI, Rule 1153.1 – Emissions of Oxides of Nitrogen from Commercial Food Ovens
(Last amended 11/7/2014)
This rule applies to **in-use** ovens, dryers, smokers, and dry roaster with NOx emissions from fuel combustion and are used to prepare food or products for making beverages for human consumption. This rule is not applicable to new units.

Any person owning or operating an in-use unit subject to this rule shall not operate the unit in a manner that exceeds CO emissions of 800 ppm by volume at 3% O2.

NOx Emission Limits PPM @ 3% O2, dry or pound/mmBTU heat input	
Process Temperature	
≤ 500°F	> 500°F
40 ppm or 0.042 lb/mmBTU	60 pm or 0.073 lb/mmBTU

(A) SCAQMD's does not require a permit for combustion equipment that has a rated maximum heat input capacity of 2.0 MMBtu/hr or less

San Diego County APCD

BACT
Source: NSR Requirements for BACT (June 2011)
There are no BACT standards published in the clearinghouse for this category

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

RULE REQUIREMENTS:
Regulation 4, Rule 68 – Fuel-Burning Equipment – Oxides of Nitrogen (9/20/1994)
This rule does not apply to fuel burning equipment which has a maximum input rating of < 50 mmBTU/hr.

Emissions of nitrogen oxides, from any non-vehicular fuel burning equipment subject to this rule, calculated as nitrogen dioxide at three percent oxygen on a dry basis, shall not exceed the following levels:

Type of Fuel	Nitrogen Oxides, Concentration	
	Volume (ppm)	Mass (mg/m3, at 20°C)
Gaseous	125	240
Liquid or Solid	225	430

When more than one type of fuel is used, the allowable NOx concentration shall be determined by proportioning the gross heat input for each fuel to its respective allowable concentration.

Regulation 4, Rule 53 – Specific Air Contaminants – (1/22/1997)
A shall not discharge into the atmosphere from any single source of emission equipment whatsoever:

1. Sulfur compounds calculated as sulfur dioxide: 0.05 percent, by volume, on a dry basis.
2. Combustion particulates: 0.1 grains per dry standard cubic foot of gas which is standardized to 12% of carbon dioxide by volume.

Bay Area AQMD

BACT
Source: BAAQMD BACT Guideline (5/22/2015)
There are no BACT standards published in the clearinghouse for this category.

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

RULE REQUIREMENTS:
Reg 8, Rule 2 – Organic Compounds from Miscellaneous Operations
Preparation of Food: Emissions from the preparation of food for human consumption provided best modern practices are used, are exempt from this Rule.

Reg 9, Rule 3 – Inorganic Gaseous Pollutants; NOx from Heat Transfer Operations §9-3-301
This rule does not apply to any new or modified heat transfer operation designed for a maximum heat input of less than 264 GJ (250 million BTU).

San Joaquin Valley Unified APCD

BACT
Source: SJVAPCD BACT Guideline 1.6.2 (6/23/2005)

Oven – Tortilla, ≤ 5 MMBtu/hr	
VOC	No Standard
NOx	Natural gas with optional LPG as backup fuel
SOx	No standard
PM10	No Standard
PM2.5	No standard
CO	No standard

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

RULE REQUIREMENTS:
Rule 4309 – Dryers, Dehydrators, and Ovens
This rule applies to any dryer, dehydrator, or oven that has a total rated heat input of ≥ 5.0 MMbtu/hr. Per Section 4.1.4 the requirements of this rule shall not apply to units used to bake or fry food for human consumption. Therefore, this rule does not apply.

Rule 4801 – Sulfur Compounds (Amended 12/17/1992)
A person shall not discharge into the atmosphere sulfur compounds, which would exist as a liquid or gas at standard conditions, exceeding in the concentration at the point of discharge: two-tenths (0.2) percent by volume calculated as sulfur dioxide, on a dry basis averaged over 15 consecuitve minutes.

Ventura County APCD

BACT
Source: CARB BACT Clearingouse (Category searched: "Dryer or Oven, Direct or Indirect)
There are no BACT standards published in the clearinghouse for this category.

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

RULE REQUIREMENTS:
Reg 4, Rule 74.34 – NOx Reductions from Miscellaneous Sources
This rule reduces the emissions of NOx and CO, and applies to dryers, furnaces, heaters, incinerators, kilns, ovens, and duct burners. This rule applies to any unit where the total heat input for the unit is 5 MMBtu/hr or greater.

NOx Emission Limits PPM @ 3% O2, dry or pound/mmBTU heat input	
Process Temperature	
< 1,200°F	≥ 1,200°F
30 ppm or 0.036 lb/mmBTU	60 pm or 0.072 lb/mmBTU

Carbon monoxide emissions from units subject to this rule shall not exceed 400 ppm (0.30 lb/MMBtu heat input) at 3% O_2.

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

SUMMARY OF ACHIEVED IN PRACTICE CONTROL TECHNOLOGIES	
VOC	No Standard – [SMAQMD, SCAQMD, SDCAPCD, BAAQMD, SJVAPCD]
NOx	<u>For Ribbon Burners ≤ 500°F</u> 1. 30 ppmvd @ 3% O_2 [SCAQMD, VCAPCD] 2. Natural gas with optional LPG as backup fuel [SJVAPCD] 3. Gaseous fuel: 125 ppm and 240 mg/m3 at 20°C, Liquid or Solid fuel: 225 ppm and 430 mg/m3 at 20°C. [SDAPCD] 4. No Standard – [EPA, ARB, SMAQMD, SDCAPCD, BAAQMD] <u>Other Direct Fired Burner</u> 1. 30 ppmvd @ 3% O_2 [SCAQMD, VCAPCD] 2. Natural gas with optional LPG as backup fuel [SJVAPCD] 3. Gaseous fuel: 125 ppm and 240 mg/m3 at 20°C, Liquid or Solid fuel: 225 ppm and 430 mg/m3 at 20°C. [SDAPCD] 4. No Standard – [EPA, ARB, SMAQMD, SDCAPCD, BAAQMD] <u>Infrared Burner</u> 1. 30 ppmvd @ 3% O_2 [SCAQMD, VCAPCD] 2. Natural gas with optional LPG as backup fuel [SJVAPCD] 3. Gaseous fuel: 125 ppm and 240 mg/m3 at 20°C, Liquid or Solid fuel: 225 ppm and 430 mg/m3 at 20°C. [SDAPCD] 4. No Standard – [EPA, ARB, SMAQMD, SDCAPCD, BAAQMD]
SOx	1. Natural Gas and 500 ppmvd @ 3% O_2 [SCAQMD] 2. 0.5% by volume [SDAPCD] 3. 0.2% by volume [SMAQMD, BAAQMD] 4. No Standard – [EPA, ARB, SDCAPCD, BAAQMD, SJVAPCD]
PM10	1. Natural Gas [SCAQMD] 2. 0.1 grains per dry standard cubic foot at 12% carbon dioxide by volume [SMAQMD, SDAPCD] 3. No Standard – [EPA, ARB, BAAQMD, SJVAPCD]
PM2.5	No Standard – [EPA, ARB, SMAQMD, SCAQMD, SDCAPCD, BAAQMD, SJVAPCD]
CO	1. 400 ppm @ 3% O_2 or 0.3 lb/MMBtu [VCAPCD] 2. 800 ppm @ 3% O_2 [SCAQMD] 3. No Standard – [EPA, ARB, SMAQMD, SDCAPCD, BAAQMD, SJVAPCD]
Organic HAP/VHAP (T-BACT)	No Standard – [EPA, ARB, SMAQMD, SCAQMD, SDCAPCD, BAAQMD, SJVAPCD]

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

BEST CONTROL TECHNOLOGIES ACHIEVED		
Pollutant	**Standard**	**Source**
VOC	No Standard	EPA, ARB, SMAQMD, SCAQMD, SDCAPCD, BAAQMD, SJVAPCD
NOx	<u>For Ribbon Burners ≤ 500°F</u> 1. 30 ppmvd @ 3% O_2 2. Natural gas with optional LPG as backup fuel <u>Other Direct Fired Burner</u> 1. 30 ppmvd @ 3% O_2 2. Natural gas with optional LPG as backup fuel <u>Infrared Burner</u> 1. 30 ppmvd @ 3% O_2 2. Natural gas with optional LPG as backup fuel	SCAQMD, SJVAPCD, VCAPCD
SOx	1. Natural Gas and 500 ppmvd @ 3% O_2	SCAQMD
PM10	1. Natural Gas	SCAQMD
PM2.5	No Standard	EPA, ARB, SMAQMD, SCAQMD, SDCAPCD, BAAQMD, SJVAPCD
CO	1. 400 ppmvd @ 3% O_2	VCAPCD
Organic HAP/VHAP (T-BACT)	No Standard	EPA, ARB, SMAQMD, SCAQMD, SDCAPCD, BAAQMD, SJVAPCD

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.

Pollutant	Technologically Feasible Alternatives
VOC	Natural gas fuel or equivalent
NOx	SCR
SOx	No other technologically feasible option identified
PM10	No other technologically feasible option identified
PM2.5	Natural gas fuel or equivalent
CO	Natural gas fuel or equivalent
Organic HAP/VHAP (T-BACT)	Natural gas fuel or equivalent

Berber Food Manufacturing dba Mi Rancho is proposing to use natural gas to fire their tortilla oven. Therefore, natural gas or an equivalent fuel will be considered technologically feasible for VOC, PM2.5, CO, and Organic HAP/VHAP.

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)
VOC	17,500
NO_X	24,500
PM10	11,400
SO_X	18,300
CO	TBD if BACT triggered

Cost Effectiveness Analysis Summary

Selective Catalytic Reduction (SCR):
For tortilla ovens that operate at 270 to 380 ^{0}F, the NOx removal efficiency is around 50% because the SCR would be operating below the optimum temperature range of 480 to 800 ^{0}F per EPA's SCR Cost manual. A cost effective analysis for SCRs were performed below.

As shown in Attachment B, the cost effectiveness for the add on SCR system to control NOx to a 15 ppm level was calculated to be **$58,966/ton** for a 1 MMBtu/hr oven and **$24,501/ton** for a 19 MMBtu/hr boiler (see attached Oven Cost Effectiveness Analysis).

For a 1 MMBtu/hr oven:

NOx Control Level = 20 ppmv (50% Control)

NOx Baseline Level = 40 ppmv

Oven Rating = 1 MMBtu/hr

Equipment Life = 20 years

Direct Cost = $46,118

Direct Annual Cost = $1,498 per year

Indirect Annual Cost = $4,778 per year

Total Annual Cost = $6,276 per year

NOx Removed = 0.11 tons per year

Cost of NOx Removal = $58,966 per ton reduced

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

For a 19 MMBtu/hr oven:

NOx Control Level = 20 ppmv (50% Control)

NOx Baseline Level = 40 ppmv

Boiler Rating = 19 MMBtu/hr

Equipment Life = 20 years

Direct Cost = $317,271

Direct Annual Cost = $16,666 per year

Indirect Annual Cost = $32,881 per year

Total Annual Cost = $49,546 per year

NOx Removed = 2.02 tons per year

Cost of NOx Removal = $24,501 per ton reduced

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

C. SELECTION OF BACT/T-BACT:

Based on the review of EPA, ARB, SMAQMD, SCAQMD, SDCAPCD, BAAQMD, and SJVAPCD BACT Clearinghouses and cost effectiveness determinations for Technologically Feasable Controls, BACT for VOC, NOx, SOx, PM10, and PM2.5 will be the following:

BACT For Tortilla Ovens ≤ 500 °F and < 19 MMBtu/hr		
Pollutant	**Standard**	**Source**
VOC	Natural gas fuel or equivalent	Technologically feasible
NOx	1. 30 ppmvd @ 3% O_2 2. Natural gas with optional LPG as backup fuel	SCAQMD, VCAPCD, SJVAPCD
SOx	1. Natural Gas 2. 500 ppmvd @ 3% O_2	SCAQMD
PM10	Natural gas fuel or equivalent	SCAQMD
PM2.5	Natural gas fuel or equivalent	Technologically feasible
CO	1. 400 ppmvd @ 3% O_2 2. Natural gas fuel or equivalent	VCAPCD, Technologically feasible

T-BACT For Tortilla Ovens ≤ 500 °F and < 19 MMBtu/hr		
Pollutant	**Standard**	**Source**
Organic HAP/VHAP (T-BACT)	Natural gas fuel or equivalent	Technologically feasible

REVIEWED BY: _____ **DATE:** _____

APPROVED BY: _____ **DATE:** 11/16/18

Attachment A

BACT Determinations Published by SCAQMD and SJVAPCD

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
Best Available Control Technology (BACT) Guidelines for Non-Major Polluting Facilities*

2-2-2018 Rev. 0

Equipment or Process: Food Oven

		Criteria Pollutants					
Subcategory[1]	**Rating/ Size**	**VOC**	**NOx**	**SOx**	**CO**	**PM10**	**Inorganic**
Ribbon Burner	> 500°F		60 ppmvd @ 3% O_2 (2-2-2018)	Natural Gas (2-2-2018)	Compliance with applicable SCAQMD Rules 407 or 1153.1(2-2-2018)	Natural Gas (2-2-2018)	
	≤ 500°F		30 ppmvd @ 3% O_2 (2-2-2018)	Same as above	Same as above	Same as above	
Other Direct Fired Burner			30 ppmvd @ 3% O_2 (2-2-2018)				
Infrared Burner			30 ppmvd @ 3% O_2 (2-2-2018)				
Add-on Control for Bakery Oven processing yeast leavened products with emissions ≥ 30 lb VOC/day		Catalytic oxidizer with 95% overall control efficiency (mass basis); catalyst inlet temperature ≥ 600°F; ceramic prefilter (2-2-2018)	Compliance with SCAQMD Rule 1147 at the time of applicability (2-2-2018)				

(Continued on next page)

[1]Indirect Fired units may be subject to Rules 1146 and 1146.1 and BACT for Process Heater

* Means those facilities that are not major polluting facilities as defined by Rule 1302 - Definitions

SJVAPCD BACT

Best Available Control Technology (BACT) Guideline 1.6.2
Last Update: 6/23/2005

Oven - Tortilla, <= 5 MMBtu/hr

Pollutant	Achieved in Practice or in the SIP	Technologically Feasible	Alternate Basic Equipment
NOx	natural gas fired with optional LPG as backup fuel		

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 s a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is requried 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. For background information, see Permit Specific BACT Determinations on Details Page.

Attachment B

Cost Effectiveness Determination for SCR

1 MMBtu/hr OVEN 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 = $ 58,965.76 $/ton

Equipment

Oven rating	1	mmBTU/hr
Oven Operating hours	8760	hours
Oven capacity factor	1	
SCR Operating Days	365	days
Total Capacity Factor	1	
Baseline NOx (40 ppm)	0.0486	lb/mmBTU
SCR NOx (50% Control)	0.0243	lb/mmBTU
Ammonia Slip	10	ppm
Ammonia Stochiometric Ratio	1.05	
Stored Ammonia Conc	29	%
Amonnia Storage days	90	days
Sulfur Content	0.005	%
Pressure drop for SCR Ductwork	3	inches W.G.
Pressure drop for each Catalyst Layer	1	inche W.G.
Temperature at SCR Inlet	650	degrees F
Equipment Life	20	years
Annual interest Rate	4	%
Catalyst cost, Initial	240	$/ft2
Catalyst cost, replacement	290	$/ft2
Electrical Power cost	0.138	$/KWh
Ammonia Cost	0.101	$/lb
Catalyst Life	24000	hr
Catalyst Layers	2 full, 1 empty	

Boiler Calculations

Q_B	1	mmBTU/hr
$q_{flue\ gas}$	356.3273976	acfm
N_{NOx}	0.5	

SCR Reactor Calculations

$Vol_{Catalyst}$	1.574920155	ft3
$A_{Catalyst}$	0.371174372	ft2
A_{SCR}	0.426850528	ft2
l=w=	0.653337989	ft
n_{layer}	1	
h_{layer}	5.243073531	
n_{total}	2	
h_{SCR}	33.48614706	ft

Reagent Calculations

$m_{reagent}$	0.018888087	lb/hr
m_{sol}	0.065131336	lb/hr
q_{sol}	0.008700849	gph
Tank Volume	18.79383302	gal

Cost Estimation

Direct Costs

DC	$46,118.04

Indirect Costs

General Facilites	$2,305.90
Engineering and home office fees	$4,611.80
Process Contingency	$2,305.90
Total Indirect Installation Costs	$9,223.61
Project Contingency	$8,301.25
Total Plant Cost	$63,642.89
Preproduction Cost	$1,272.86
Inventory Capital	$14.21
Total Capital Investment	$64,929.96

Direct Annual Costs

Maintenance Costs	$973.95	per yr
Power	0.2650515	KW
Annual Electricity	$320.42	per yr
Reagent Solution Cost	$57.63	per yr

Catalyst Replacement

FWF	0.320348539	
Annual Catalyst Replacement	$146.31	per yr

Total Variable Direct Cost	$524.35	per yr
Total Direct Annual Cost	$1,498.30	per yr
CRF	0.07358175	
Indirect Annual Cost	$4,777.66	per yr
Total annual Cost	$6,275.96	per yr
NOx Removed	0.11	tons
Cost of NOx removal	$58,965.76	per ton

19 MMBtu/hr OVEN 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 = $ 24,500.66 $/ton

Equipment

Oven rating	19	mmBTU/hr
Oven Operating hours	8760	hours
Oven capacity factor	1	
SCR Operating Days	365	days
Total Capacity Factor	1	
Baseline NOx (40 ppm)	0.0486	lb/mmBTU
SCR NOx (50% Control)	0.0243	lb/mmBTU
Ammonia Slip	10	ppm
Ammonia Stochiometric Ratio	1.05	
Stored Ammonia Conc	29	%
Amonnia Storage days	90	days
Sulfur Content	0.005	%
Pressure drop for SCR Ductwork	3	inches W.G.
Pressure drop for each Catalyst Layer	1	inche W.G.
Temperature at SCR Inlet	650	degrees F
Equipment Life	20	years
Annual interest Rate	4	%
Catalyst cost, Initial	240	$/ft2
Catalyst cost, replacement	290	$/ft2
Electrical Power cost	0.138	$/KWh
Ammonia Cost	0.101	$/lb
Catalyst Life	24000	hr
Catalyst Layers	2 full, 1 empty	

Boiler Calculations

Q_B	19	mmBTU/hr
$q_{flue\ gas}$	6770.220554	acfm
N_{NOx}	0.5	

SCR Reactor Calculations

$Vol_{Catalyst}$	29.92348295	ft3
$A_{Catalyst}$	7.052313077	ft2
A_{SCR}	8.110160039	ft2
l=w=	2.847834272	ft
n_{layer}	1	
h_{layer}	5.243073531	
n_{total}	2	
h_{SCR}	33.48614706	ft

Reagent Calculations

$m_{reagent}$	0.35887366	lb/hr
m_{sol}	1.23749538	lb/hr
q_{sol}	0.165316124	gph
Tank Volume	357.0828275	gal

Cost Estimation

Direct Costs

DC	$317,270.76

Indirect Costs

General Facilites	$15,863.54
Engineering and home office fees	$31,727.08
Process Contingency	$15,863.54
Total Indirect Installation Costs	$63,454.15
Project Contingency	$57,108.74
Total Plant Cost	$437,833.65
Preproduction Cost	$8,756.67
Inventory Capital	$269.97
Total Capital Investment	$446,860.30

Direct Annual Costs

Maintenance Costs	$6,702.90	per yr
Power	5.0359785	KW
Annual Electricity	$6,087.89	per yr
Reagent Solution Cost	$1,094.89	per yr

Catalyst Replacement

FWF	0.320348539	
Annual Catalyst Replacement	$2,779.92	per yr

Total Variable Direct Cost	$9,962.70	per yr
Total Direct Annual Cost	$16,665.61	per yr
CRF	0.07358175	
Indirect Annual Cost	$32,880.76	per yr
Total annual Cost	$49,546.37	per yr
NOx Removed	2.02	tons
Cost of NOx removal	$24,500.66	per ton