San Joaquin Valley
Unified Air Pollution Control District

Best Available Control Technology (BACT) Guideline 1.5.13

Emission Unit: Biochar producing Pyrolysis reactors/Furnace

Industry Type: Agricultural /Commercial

Equipment Rating: 16.27 MMBtu/hr.

Last Update: 6/22/26

Pollutant	Achieved in Practice or contained in SIP	Technologically Feasible	Alternate Basic Equipment
NOx	Combustion of the produced syngas within the pyrolysis chamber under controlled temperature and oxygen conditions, and 30 ppmv @ 3% O2 or 0.036 lb./MMBtu	90% Control (catalytic reduction device (SCR) or equal)	

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 - Permit Specific BACT Determinations on Next Page(s)**

Top-Down Best Available Control Technology (BACT) Analysis for NOx Emissions from Biochar Pyrolysis Reactors

BACT is triggered for the NOx emissions produced from the from the Pyrolysis Reactors during the production of Biochar. The District's BACT clearinghouse does not currently contain a valid guideline applicable to pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates. Therefore, a project specific BACT analysis for this source category will be performed as part of this project.

1. **Step 1 - Identify all control technologies**

   The following BACT clearinghouse references were reviewed to determine whether any guidelines that could potentially apply biochar producing pyrolysis reactors, or pyrolysis furnaces have been required to employ controls:

   - EPA RACT/BACT/LAER clearinghouse
   - South Coast AQMD (SCAQMD) BACT clearinghouse
   - Bay Area Air District (BAAD) BACT clearinghouse
   - Sacramento Metro AQMD (SMAQMD) BACT clearinghouse
   - San Diego County APCD (SDCAPCD) BACT clearinghouse
   - San Joaquin Valley APCD (SJVAPCD) BACT clearinghouse
   - Santa Barbara County APCD (SBCAPCD) BACT clearinghouse
   - The CARB BACT clearinghouse does not include general guidelines, only individual determinations made by individual air districts.

   <u>Summary of BACT Guidelines</u>:

   Of the Air Districts reviewed, none of the Districts have a guideline that could be applicable to biochar producing pyrolysis reactors, or pyrolysis furnaces.

   Additionally, the rules and regulations from the following agencies were searched to identify if the agencies currently had any regulations that could be applied biochar producing pyrolysis reactors, or pyrolysis furnaces, that contained applicable emission limits.

   - San Luis Obispo County APCD (SLOCAPCD)
   - Santa Barbara County APCD (SBCAPCD)
   - Shasta County AQMD (SHCAQMD)
   - Antelope Valley AQMD (AVAQMD)
   - Great Basin Unified APCD(GBUAPCD)
   - South Coast AQMD (SCAQMD)
   - Bay Area Air District (BAAD)
   - Sacramento Metro AQMD (SMAQMD)

– San Diego County APCD (SDCAPCD)

Summary of Applicable Rules:

Rule	Agency	Emissions Requirement
Rule 405 - *Nitrogen Oxides Emission Standards, Limitations and Prohibitions*	SLOCAPCD	NOx: • *140 lb.-NOx/hr.*
Rule 309 - Specific Contaminants.	SBCAPCD	NOx: • *140 lb.-NOx/hr*.
Rule 3:2 - *Specific Air Contaminants*	SHCAQMD	NOx: • *300 ppm (Solid, liquid fuels) Sources constructed after 7/1/86*
Rule 419 - *NOx From Miscellaneous Combustion Unit*	SMAQMD	NOx: • *0.036 lb. NOx/MMBtu @3%O2. (furnaces, and kilns)* Note: Per definition 207, in Rule 419. A Furnace is defined as any unit with an enclosed chamber in which heat is produced by a combustion source, typically used for metallurgy, pyrolysis, ashing, calcining, sintering, and other high temperature processes.
Rule 474 - *Fuel Burning Equipment - Oxides of Nitrogen*	AVAQMD	NOx: Non-mobile fuel burning equipment rated more than 2,143 Btu/hr.: 125 ppm NOx (gas) 225 ppm NOx (liquid or solid)
Rule 416 - *Sulfur Compounds And Nitrogen Oxides*	GBUAPCD	NOx: • 140 lb.-NOx/hr..
Rule 1147 - *NOx Reductions from Miscellaneous Sources*	SCAQMD	NOx: • *30 ppmv @ 3% O2 or 0.036 lb./MMBtu (Gas-fired Furnace, and kilns operating at less than 1,200 F)*
Rule 68 - Fuel-Burning Equipment - Oxides of Nitrogen	SDCAPCD	NOx; Non-mobile fuel burning equipment rated more than 2,143 Btu/hr.: 125 ppm NOx (gas) 225 ppm NOx (liquid or solid)

Survey of Permit Requirements for Biochar producing Pyrolysis Reactors, or Pyrolysis Furnaces

In order to evaluate what NOx controls are currently being achieved by biochar producing pyrolysis reactors, or pyrolysis furnaces, permitted in the SJVAPCD, all permitted sources within the District were searched. The District has issued multiple pyrolysis furnaces as seen below; the permitted NOx controls are similar to what is being proposed in the present project. However, none of the more stringent NOx emissions controls permitted within the SJVAPCD were specifically for pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates. The following permits were the most stringent comparable operations.

N-1318-6-0: ONE NATURAL GAS-FIRED POLLUTION CONTROL PRODUCTS MODEL PTR27F CONTROLLED PYROLYSIS CLEANING FURNACE WITH 0.135 MMBTU/HR PRIMARY BURNER MODEL SK225 AND 0.190 MMBTU/HR AFTERBURNER MODEL J83

- *The NOx emissions from the pyrolysis furnace associated with this permit are restricted to 0.0271 lb.-NOx/hr. However, the pyrolysis furnace associated with this permit is utilized as an alternative cleaning method to abrasive sand blasting. The unit is operated as a burnout furnace for the preparation of metal parts prior to being powder coated. Therefore, the emissions from this unit do not represent the expected emissions from a pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates.*

N-4054-10-0: ONE 0.8 MMBTU/HR POLLUTION CONTROL PRODUCTS MODEL PRC 300 CONTROLLED PYROLYSIS CLEANING FURNACE SERVED BY AN AFTERBURNER

- *The NOx emissions from the Pyrolysis furnace associated with this permit are restricted to 0.0271 lb.-NOx/hr. However, the pyrolysis furnace is utilized as an alternative cleaning method to abrasive sand blasting. The unit is operated as a burnout furnace for the preparation of metal parts prior to being powder coated. Therefore, the emissions from this unit do not represent the expected emissions from a pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates.*

N-4338-11-1: CONTROLLED PYROLYSIS CLEANING FURNACE (#11) WITH A 0.24 MMBTU/HR PRIMARY BURNER AND A 0.24 MMBTU/HR SECONDARY BURNER

- *The NOx emissions from the Controlled Pyrolysis cleaning furnace associated with this permit, are restricted to 0.03 lb.-NOx/hr. However, the pyrolysis furnace is utilized as an alternative cleaning method to abrasive sand blasting. The unit is operated as a burnout furnace for the preparation of metal parts prior to being powder coated. Therefore, the emissions from this unit do not represent the expected emissions from a pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates.*

N-9729-1-1: BIOCHAR AND BIO-DISTILLATES PRODUCTION OPERATION CONSISTING OF A PYROLYSIS REACTOR, A BIO-DISTILLATES SEPARATION SYSTEM CONSISTING OF A STRIPPING UNIT WITH THREE CONDENSATION TOWERS, A 1.5 MMBTU/HR PYROVAC (FRANBEC CDA LTD) MODEL FRC 1.2M FLARE FOR BIOGAS DISPOSAL, ASSOCIATED FEEDER, AUGERS, AND ASSOCIATED CONVEYORS

- *The NOx emissions from the flare serving the PYROLYSIS REACTOR, associated with permit N-9729-1, are restricted to 0.269 lb.-NOx/MMBtu. However, the pyrolysis reactor is used for the production of both bio distillates and biochar. In the process associated with permit N-9729-1, the syngas produced from the pyrolysis reaction is collected, and condensed in the condensation towers, before the non-condensable VOC are transferred to a flare for disposal. This differs from the pyrolysis operation associated with this project; where the bio distillates are not separated or collected, and are completely consumed during the combustion of the syngas. Therefore, the emissions from this unit do not represent the expected emissions from a pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates.*

C-954-4-9: POWDER COATING OPERATION CONSISTING OF POWDER COATING BOOTH, 1.8 MMBTU/HR DRY-OFF OVEN, 3.3 MMBTU/HR BAKE OVEN, AND 0.34 MMBTU/HR CONTROLLED PYROLYSIS FURNACE WITH INTEGRAL AFTERBURNER FOR PARTS HANGER CLEANING

- *The NOx emissions from the Controlled Pyrolysis burn-off furnace associated with this permit, are restricted to 0.0271 lb.-NOx/hr. However, the pyrolysis furnace is utilized as an alternative cleaning method to abrasive sand blasting. The unit is operated as a burnout furnace for the preparation of metal parts prior to being powder coated. Therefore, the emissions from this unit do not represent the expected emissions from a pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates.*

C-1057-4-1: PYROLYSIS MODEL PTR-260 NATURAL GAS-FIRED FURNACE EQUIPPED WITH TWO 195,000 BTU/HR INCINOMITE MODEL #J-82-DS BURNERS

- *The NOx emissions from the PYROLYSIS FURNACE associated with this permit, are restricted to 0.0271 lb.-NOx/hr. However, the pyrolysis furnace is utilized as an alternative cleaning method to abrasive sand blasting. The unit is operated as a burnout furnace for the preparation of metal parts prior to being powder coated. Therefore, the emissions from this unit do not represent the expected emissions from a pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates.*

S-866-4-0: 0.380 MMBTU/HR POLLUTION CONTROL PRODUCTS MODEL PTR-27F CONTROLLED PYROLYSIS FURNACE INCLUDING A PRIMARY BURNER AND AN AFTERBURNER

- *The NOx emissions from the Controlled Pyrolysis cleaning furnace associated with this permit, are restricted to 0.0271 lb.-NOx/hr. However, the pyrolysis furnace is utilized as an alternative cleaning method to abrasive sand blasting. The unit is operated as a burnout furnace for the preparation of metal parts prior to being powder coated. Therefore, the emissions from this unit do not represent the expected emissions from a pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates.*

S-2607-4-0: 475,000 BTU/HR POLLUTION CONTROL PRODUCTS MODEL VPI-150 CONTROLLED PYROLYSIS ELECTRIC MOTOR BURNOUT FURNACE INCLUDING 185,000 BTU/HR PRIMARY BURNER AND 290,000 BTU/HR AFTERBURNER

- *The NOx emissions from the Controlled Pyrolysis cleaning furnace associated with this permit, are restricted to 0.03 lb.-NOx/hr. However, the pyrolysis furnace is utilized as an alternative cleaning method to abrasive sand blasting. The unit is operated as a burnout furnace for the preparation of metal parts prior to being powder coated. Therefore, the emissions from this unit do not represent the expected emissions from a pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates.*

Alternative Technologies

The District has determined that there are no alternative Technologies available that can be used in place of the proposed pyrolysis reactor for the production of biochar.

Conclusion:

There are multiple Air District Rules, that can be used to establish the Achieved In Practice BACT standards for pyrolysis reactors/pyrolysis furnaces. The District will rely on a combination of Air District Rules, and the proposed control measures to establish the applicable BACT requirements.

There are multiple permitted Pyrolysis Furnaces within the District. However, none of the units permitted at this time, can be used to establish BACT for Pyrolysis Reactors/Furnaces used for the production of biochar. The following are the most stringent control technologies identified for reducing the NOx emissions from the pyrolysis reactors during the production of biochar:

1. Rout the flue gases exiting the proposed PM10 wet scrubber to a selective catalytic reduction device (SCR). (*Technologically feasible*).

2. Combustion of the produced syngas within the pyrolysis chamber under controlled temperature and oxygen conditions (*Achieved in Practice – Proposed by applicant*)

3. NOx emissions are limited to *30 ppmv @ 3% O2 or 0.036 lb./MMBtu* (*Achieved in Practice for Furnaces operating at less than 1200 F, SMAQMD Rule 419 - NOx From Miscellaneous Combustion Unit, and SCAQMD Rule 1147 - NOx Reductions from Miscellaneous Sources*)

Step 2 - Eliminate Technologically Infeasible Options

There are no technologically infeasible options associated with this project.

Step 3 - Rank Remaining Control Technologies by Control Effectiveness

NOx:

1. Rout the flue gases exiting the proposed wet scrubber to a selective catalytic reduction device (SCR). (*Technologically feasible*).

2. NOx emissions are limited to *30 ppmv @ 3% O2 or 0.036 lb./MMBtu* (*Achieved in Practice for Furnaces operating at less than 1200 F, SMAQMD Rule 419 - NOx From Miscellaneous Combustion Unit, and SCAQMD Rule 1147 - NOx Reductions from Miscellaneous Sources*)

3. Combustion of the produced syngas within the pyrolysis chamber under controlled temperature and oxygen conditions (*Achieved in Practice – Proposed by applicant*)

Step 4 - Cost Effectiveness Analysis

Control Options 2 and 3, listed in the previous step, are considered Achieved in Practice for the purpose of this BACT determination. Per District BACT Policy, a cost effectiveness analysis is not required for Achieved in Practice controls.

The cost analysis for control option 1, listed in the previous step utilizes the EPA Air Pollution Cost Control Manual Section 6 Chapter 4.2 as updated January 2002 (NOx Post-Combustion Selective Catalytic Reduction, https://www.epa.gov/sites/default/files/2020-07/documents/c_allchs.pdf). The manual allows users to estimate the capital and annualized costs for installing and operating a Selective Catalytic Reduction device.

Total Capital Investment:
The facility has supplied a capital investment of $877,676 based on a project quote the facility received in 2016. Since the estimated capital cost was based on 2016 dollars, the rates for which inflation must be accounted for are from December 2016 to August 2026. The consumer price index (CPI) for 2026 is 330.21 points, per the US Bureau of Labor Statistics. The CPI for 2016 was 240.007 points, per the US Bureau of Labor Statistics.

Therefore, the 2026 value of the capital investment of $877,676 in 2016 is calculated as follows:

$$\begin{aligned}\text{Capital Investment}_{2026} &= (\text{CPI}_{2026}/\text{CPI}_{2016}) \times \text{Capital Investment}_{2016} \\ &= (330.21/240.007) \times \$877{,}676 \\ &= (1.3758) \times \$877{,}676 \\ &= \$1{,}207{,}537.25\end{aligned}$$

The Capital Investment$_{2026}$ cost will be annualized pursuant to current District policy. The annualized capital investment cost, amortizing over 10 years at 6%, is calculated as follows:

Annualized Capital Investment = P x ((i x(1+i)^n)/ (1+i)^n-1)

Where,

P = Combined Capital Cost $_{2026}$
= $1,207,537.25
I = Interest Rate (Decimal)
=0.06
N = Equipment life (yrs.)
= 10

Annualized Capital Investment = $1,207,537.25 x ((0.06 x(1+0.06)^{10})/ (1+0.06)^{10}-1)
= $164,065.59 / yr.
= $164,066 / yr.

Total Annual Costs:

In order to properly estimate the Annual capital cost of the SCR system, it is necessary to determine direct and indirect costs associated with purchasing and installing SCR equipment. The total Annual Cost is calculated as follows:

Total Annual Cost = Direct Annual Cost + Indirect Annual Cost

Annual Direct Cost:

Direct capital costs include purchased equipment costs such as SCR system equipment, instrumentation, sales tax and freight. This includes costs associated with field measurements, numerical modeling and system design. It also includes direct installation costs such as auxiliary equipment (e.g., ductwork, fans, compressor), foundations and supports, handling and erection, electrical, piping, insulation, and painting. The following direct annual costs have been provided by the applicant in 2016 dollars:

Annual Maintenance Cost $_{2016}$	=	$4,388
Annual Reagent Cost $_{2016}$	=	$207
Annual Electricity Cost $_{2016}$	=	$13,823
Annual Catalyst Replacement Cost $_{2016}$	=	$12,150
Total Annual Direct Cost $_{2016}$	=	$30,568

The 2026 Annual Direct Cost are calculated as follows:

Total Annual Direct Cost $_{2026}$ = *(CPI_{2026}/CPI_{2016}) x Total Annual Direct Cost $_{2016}$*
= (1.3758) x \$30,568
= \$42,055.45
= \$42,055

Annual Indirect Cost:

Annual Indirect costs are those associated with installing and erecting the control system equipment but do not contribute directly to the physical capital of the installation. This generally includes general facilities and engineering costs such as construction and contractor fees, preproduction costs such as startup and testing, inventory capital and any process and project contingency costs. The following Indirect annual costs were provided by the applicant, in 2016 dollars, and Annualized Capital Investment cost calculated above.

Administrative Charges $_{2016}$ = \$2,681
Administrative Charges $_{2026}$ = (CPI_{2026}/CPI_{2016}) x Administrative Charges $_{2016}$
= 1.3758 x \$2,681
= \$3,936

Annualized Capital Investment $_{2026}$ = \$164,066

Total Indirect Annual Costs $_{2026}$ = Annualized Capital Investment $_{2026}$ + Administrative Charges $_{2026}$
= \$3,936 + \$164,066
= \$168,002

Based on the provided direct and indirect annual cost, the total annual cost for the SCR system is as follows:

Total Annual Cost = *Direct Annual Cost* $_{2026}$ + *Indirect Annual Cost*$_{2026}$
= \$42,055 + \$168,002
= *\$210,057/yr*.

District Standard Emissions:

Pursuant to District Policy 1305 - *Best Available Control Technology (BACT),* the District Standard Emissions (DSE) value for units S-10463-3, ’-4 and ‘-5, being new emissions units, are equal to the emissions level allowed by the applicable SJVAPCD rule once the final compliance date for the rule has passed. However, there are no applicable District Rules that apply to Biochar Producing Pyrolysis Reactors. Therefore, emissions shall be set equal to commercially available emissions levels for similar units. However, these emission factors are not available for similar units. Furthermore, there are no emission factors available in the Compilation of Air Pollutant Emission Factors (AP-42). Therefore, the DSE shall be estimated based on the most stringent of the available Air District Rule Surveyed. Of the Air district Rules surveyed the SMAQMD Rule 419 - *NOx From Miscellaneous Combustion Unit*, and SCAQMD Rule 1147 - *NOx Reductions from Miscellaneous Sources* were the most stringent. Both Air District Rules restricted Gas-fired Furnaces, and kilns operating at less than 1,200 F to a NOx limit of 30 ppmv @ 3% O2 or 0.036 lb./MMBtu. Per definition 207, in SMAQMD Rule 419. A Furnace is defined as any unit with an enclosed chamber in which heat is produced by a combustion source, typically used for metallurgy, pyrolysis, ashing, calcining, sintering, and other high temperature processes. Therefore, the DSE is calculated as follows:

DSE = *EF (lb./MMBtu) x Max Heat Rating $_{\textit{Pyrolysis Reactor}}$ (MMBtu/hr.) x 8,000 (hr./yr.) x (1 ton/2,000 lb.)*
= (0.036 lb.-NOx/MMBtu) x (16.27 MMBtu/hr.) x (8,000 hr./yr.) x (1 ton/ 2,000 lb.)
= 4,685 lb.-NOx /yr. x (1 ton/ 2,000 lb.)
= 2.3 ton - NOx /yr.

<u>Emission Reductions:</u>
The SCR system for NOx control is considered to provide 90% control. The emission reduction is calculated by taking the DSE values minus the same DSE values with the tech feasible BACT applied. This is shown below as follows:

Emission Reduction = *DSE – DSE w/ Tech Feasible BACT*
= 2.3 ton-NOx /yr. – ((2.3 ton-NOx /yr.) x (1- 0.90))
= 7.3 ton-NOx /yr. – 0.73 ton-NOx /yr.
= 2.1 ton-NOx /yr.

The Cost efficiency per reactor served by a SCR system is calculated as follows:

Cost efficiency ($/ton) = *Total Annual Cost $_{\textit{2026}}$ ($/yr.)/ Amount Emission Reductions (ton/yr.)*
= *$210,057/yr.* / 2.1 ton-NOx
= $99,636.2/ ton-NOx

As shown above the capital costs operation and maintenance cost associated with the SRC system exceeds the District's cost-effective threshold of $37,800/ton-NOx. Therefore, this option is not cost-effective and will not be required for this project.

<u>Note</u>: The ATC project associated with this BACT update (S-1254248), was deemed complete on 12/18/25. Therefore, a cost-effective threshold of $37,800/ton NOx was used, rather than the $39,000/ton NOx cost-effective threshold indicated in APR 1305 - Best Available Control Technology (BACT), for projects deemed complete after 6/1/26.

Step 5 - Select BACT

BACT for pyrolysis reactor/furnaces utilized in Biochar production operations not associated with the production of Bio distillates, is the combustion of the produced biomass derived syngas within the pyrolysis chamber, in addition to limiting the NOx emissions to 30 ppmv @ 3% O2 or 0.036 lb. Therefore, BACT for NOx is satisfied.