San Joaquin Valley
Unified Air Pollution Control District

Best Performance Standard (BPS) x.x.xx

Date: 4/28/10

Class and Category	Oilfield Steam Generators
Best Performance Standard	[88% thermal efficiency (manufacturers rating) Or Horizontal convection section with at least 235 square feet of bare tube* surface area per MMBtu/hr of heat input (*or thermodynamically equivalent number of square feet of finned tube)] And [Variable frequency drive high efficiency electrical motors driving the blower and water pump]
Percentage Achieved GHG Emission Reduction Relative to Baseline Emissions	12.9%

District Project Number	C-1100391
Evaluating Engineer	Steve Roeder
Lead Engineer	Arnaud Marjollet
Initial Public Notice Date	April 28, 2010
Final Public Notice Date	May 21, 2010
Determination Effective Date	TBD

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I. Best Performance Standard (BPS) Determination Introduction

A. Purpose

To assist permit applicants, project proponents, and interested parties in assessing and reducing the impacts of project specific greenhouse gas emissions (GHG) on global climate change from stationary source projects, the San Joaquin Valley Air Pollution Control District (District) has adopted the polic*y: District Policy – Addressing GHG Emission Impacts for Stationary Source Projects Under CEQA When Serving as the Lead Agency.* This policy applies to projects for which the District has discretionary approval authority over the project and the District serves as the lead agency for CEQA purposes. Nonetheless, land use agencies can refer to it as guidance for projects that include stationary sources of emissions. The policy relies on the use of performance based standards, otherwise known as Best Performance Standards (BPS) to assess significance of project specific greenhouse gas emissions on global climate change during the environmental review process, as required by CEQA. Use of BPS is a method of streamlining the CEQA process of determining significance and is not a required emission reduction measure. Projects implementing BPS would be determined to have a less than cumulatively significant impact. Otherwise, demonstration of a 29 percent reduction in GHG emissions, from business-as-usual, is required to determine that a project would have a less than cumulatively significant impact.

B. Definitions

Best Performance Standard for Stationary Source Projects for a specific Class and Category is the most effective, District approved, Achieved-in-Practice means of reducing or limiting GHG emissions from a GHG emissions source, that is also economically feasible per the definition of Achieved-in-Practice. BPS includes equipment type, equipment design, and operational and maintenance practices for the identified service, operation, or emissions unit class and category.

Business-as-Usual is - the emissions for a type of equipment or operation within an identified class and category projected for the year 2020, assuming no change in GHG emissions per unit of activity as established for the baseline period, 2002-2004. To relate BAU to an emissions generating activity, the District proposes to establish emission factors per unit of activity, for each class and category, using the 2002-2004 baseline period as the reference.

Category is - a District approved subdivision within a “class” as identified by unique operational or technical aspects.

Class is - the broadest District approved division of stationary GHG sources based on fundamental type of equipment or industrial classification of the source operation.

C. Determining Project Significance Using BPS

Use of BPS is a method of determining significance of project specific GHG emission impacts using established specifications. BPS is not a required mitigation of project related impacts. Use of BPS would streamline the significance determination process by pre-quantifying the emission reductions that would be achieved by a specific GHG emission reduction measure and pre-approving the use of such a measure to reduce project-related GHG emissions.

GHG emissions can be directly emitted from stationary sources of air pollution requiring operating permits from the District, or they may be emitted indirectly, as a result of increased electrical power usage, for instance. For traditional stationary source projects, BPS includes equipment type, equipment design, and operational and maintenance practices for the identified service, operation, or emissions unit class and category.

II. Summary of BPS Determination Phases

The District has established Oilfield Steam Generators as a separate class and category which requires implementation of a Best Performance Standard (BPS) pursuant to the District's Climate Change Action Plan (CCAP). The District's determination of the BPS for this class and category has been made using the phased BPS development process established in the District's Final Staff Report, Addressing Greenhouse Gas Emissions under the California Environmental Quality Act. A summary of the specific implementation of the phased BPS development process for this specific determination is as follows:

BPS Development Process Phases for Oilfield Steam Generators			
Phase	**Description**	**Date**	**Comments**
1	Initial Public Process	2/9/10	The District's intent notice and a list of individuals receiving notification are attached as Appendix 1.
2	BPS Development	N/A	See Section III of this evaluation document.
3	Public Review	4/29/10	The District's BPS determination notice and a list of individuals receiving notification are attached as Appendix 2.
4	Public Comments	5/24/10	The public comment period ended on the date given. All public comments received and the District's responses are attached as Appendix 3.

III. Class and Category

In heavy oil production, steam generators are used to produce large quantities of steam. The steam is injected under great pressure into an oil production zone. The steam heats the crude oil, reducing its viscosity, making the oil easier to pump. The oil is pumped from the ground (as a produced fluid) and the oil contains a relatively large amount of water and dissolved gasses.

The water is separated from the oil in several stages, purified on-site, and used as feedwater for the steam generators.

Oilfield steam generators differ from typical boilers in several areas.

1. Steam generators produce large amounts of lower quality steam (in the area of 70%) under relatively high pressures (in the area of 1,000 psig).
2. The required temperature and pressure of the steam requirement varies depending upon the geological configuration of the wells that are being steamed.
3. Since the steam generator feedwater is generally water that has been produced from the oil wells, the temperature of the feedwater is relatively warm (above 115 degrees F), which limits overall thermal efficiency of the steam generator.
4. Steam generators typically operate constantly, year round, without stopping.
5. The useful output of the steam generated cannot be correlated to the obviously useful product of *barrels of oil produced*, because the amount of steam and it's impact on each oil well is difficult to determine on an individual basis, and varies considerably due to the geological characteristics of each oil deposit and each well. Therefore, the useful output of a steam generator must be described in terms of steam generator heat output (in MMBtu/hour) per unit of steam generator heat input (MMBtu/hour), (which is thermal efficiency).

Therefore, oilfield steam generators have been designated as a separate class and category of boiler.

IV. BPS Development

STEP 1. Establish Baseline Emissions Factor for Class and Category

The Baseline Emission Factor (BEF) is defined as the three-year average (2002-2004) of GHG emissions for a particular class and category of equipment in the San Joaquin Valley (SJV), expressed as annual GHG emissions per unit of activity. The Baseline Emission Factor is calculated by first defining an operation which is representative of the average population of units of this type in the SJV during the Baseline Period and then determining the specific emissions per unit throughput for the representative unit.

A. Representative Baseline Operation

For oilfield steam generators, the representative baseline operation has been determined to be a 77% thermally efficient steam generator with a vertical convection section, and standard (non variable frequency drive) electric drive motors for the blower and water pump. This determination is based on a survey of permitted steam generators and submissions from the oilfield industry.

The following analysis of baseline steam generator GHG emissions is based on actual physical measurements taken from baseline-era steam generator S-1114-16. This steam generator is considered to be a typical industry-wide example of baseline steam generator operation.

B. Basis and Assumptions

- All direct GHG emissions are the result of the combustion of natural gas in the steam generator.
- Maximum heat input rating of the steam generator is 62.4 MMBtu/hr
- Actual fuel consumption of the steam generator 56.4 MMBtu/hr
- Thermal efficiency is 77.0% (heat output ÷ heat input)
- Heat output for steam generator is (56.4 MMBtu/hr x 77%) = 43.4 MMBtu/hr
- The GHG emission factor for natural gas combustion is 117 lb-CO_2e/MMBtu (per CCAR document)*
- Indirect emissions are produced due to operation of the electric water pump and air blower motors
- Blower motor hp at 60 hertz is 130 hp
- Blower motor electrical efficiency is 94.5%
- Water Pump motor Input energy hp is 78.2 hp
- Water Pump motor output energy hp is 73.5 hp
- Indirect emissions from electric power consumption are calculated based on the current PG&E electric power generation factor of 0.524 lb-CO_2e per kWh
- Steam quality = 70%
- Steam temperature = 540 F
- Mass flowrate = 1,162,144 lb·water/day
- Stack temperature = 328 F
- Feedwater temperature = 132 F
- Convection surface area = 7,590 square feet

*EF CO_2e = 52.92 kg/MMBtu x 2.2046 kg/lb = 116.67 →117 lb·CO_2e/MMBtu

C. Unit of Activity

To relate Business-as-Usual to an emissions generating activity, it is necessary to establish an emission factor per unit of activity, for the established class and category, using the 2002-2004 baseline period as the reference.

The resulting emission factor is a combination of direct emissions from fuel consumption and indirect emissions from electricity consumption.

The useful output of the steam generated cannot be correlated to *barrels of oil produced*, because the amount of steam and it's impact on each oil well is difficult to determine on an individual basis, and varies considerably due to the geological characteristics of each oil deposit and each well. Therefore, the useful output of a steam generator must be described in terms of steam generator heat output (in MMBtu/hour) per unit of steam generator heat input (MMBtu/hour), (which is thermal efficiency).

Unit of Activity = MMBtu of steam generator heat output

D. Calculations

1. Indirect GHG Emissions from blower motor

130 hp x .746 kW/hp x (1/94.5%) x 0.524 lb·CO_2e/kW·hr = 53.8 lb·CO_2e/hr
53.8 lb·CO_2e/hr ÷ 43.4 MMBtu = 1.24 lb·CO_2e/MMBtu (of heat output)

2. Indirect GHG emissions from the water pump

78.2 hp x 0.746 kW/hp x 0.524 lb·CO_2e/kW·hr = 30.6 lb·CO_2e/hr
30.6 lb·CO_2e/hr ÷ 43.4 MMBtu/hr = 0.705 lb·CO_2e/MMBtu (of heat output)

3. Direct GHG Emissions

56.4 MMBtu/hr (input) x 117 lb·CO_2e/MMBtu = 6,599 lb·CO_2e/hr
6,599 lb·CO_2e/hr ÷ 43.4 MMBtu/hr = 152 lb·CO_2e/hr

4. Total Baseline Emissions (Indirect + Direct emissions)

BE = (53.8 + 30.6 + 6599) lb·CO_2e/hr = 6,683 lb·CO_2e/hr
BE = 6,683 lb·CO_2e/hr ÷ 43.4 MMBtu/hr = 154 lb·CO_2e/MMBtu (of heat output)

BE = 6,683 lb/hr x 1 metric ton/2,205 lb = 3.03 metric tons·CO_2e/hour
BE = 154 lb·CO_2e/MMBtu x 1 metric ton/2,205 lb
= 0.0698 metric tons·CO_2e/MMBtu (heat output)

BEF = 0.0698 metric tons·CO_2e/**MMBtu of heat output**

STEP 2. List Technologically Feasible GHG Emission Control Measures

For oilfield steam generators, all technologically feasible GHG emissions reduction measures are listed, including equipment selection, design elements and best management practices that do not result in an increase in criteria pollutant emissions compared to the proposed equipment or operation.

Based on a review of available technology and with consideration of input from industry, manufacturers, and other members of the public, the following is determined to be the *technologically feasible* GHG emission reduction measures for oilfield steam generators. Please note that while these measures are technologically feasible, further analysis will follow which will conclude whether the listed technologically feasible measures can be considered candidates for the BPS.

Table 1
Technologically Feasible GHG Control Measures for Oilfield Steam Generators

Control Measure	Qualifications
1. High efficiency steam generator design	[88% thermal efficiency (manufacturers rating) Or Horizontal convection section with at least 235 square feet of bare tube* surface area per MMBtu/hr of heat input (*or thermodynamically equivalent number of square feet of finned tube)] And [Variable frequency drive high efficiency electrical motors driving the blower and water pump]
2. Additional economizer	Additional vertical heat exchange to further preheat water with exhaust gasses
3. Limiting the FGR controls	Reducing the recirculated flue gas air can reduce the amount of wasted heat which leads to thermal inefficiency
4. Ammonia Injection to Control NO_x	This would allow for even less recirculated flue gas and further improve the thermal efficiency
5. Variable frequency drive high efficiency electrical motors driving the blower and water pump	Ability to run the water pump no faster than it needs to be run, and ability to vary airflow through the steam generator without the need to use restrictive louvers

Discussion of Each Technologically Feasible Item

1. High efficiency steam generator design using a horizontal convection section to achieve at least 88% thermal efficiency

Prior to the baseline period, hundreds of oilfield steam generators existed. Many oilfield steam generators burned crude oil to produce steam. One design criteria was that the stack temperature needed to remain relatively high to avoid the SO_x from condensing in the stack. This would corrode the convection section and give rise to visible emissions. The minimal convection section (heat transfer section) was of the vertical or pyramid style, and known to be only efficient enough to support the goal of maintaining a high exhaust temperature. Economically, these units were built on a small foot print, and a vertical heat transfer section seemed like a reasonable design for the efficiency required at the time.

During the phase-out of crude oil and high-sulfur gaseous fuels, the use of sulfur scrubbers was required along with the use of other equipment that would lower SO_x emissions to District standards. At the same time, low-NO_x emissions were promulgated by the District.

In many cases, existing steam generators, many of them of the crude oil-fire design, were simply retrofit with low-NO_x burners and FGR to meet the lower NO_x standards. While these retrofitted units proved to meet the NO_x objective, they were not particularly thermally efficient. At the time, it was more cost-effective (up front) to retrofit an old steam generator with new burners than to erect a whole new modern steam generator, and as such, the typical "retrofit" steam generator made up the bulk of baseline-era steam generators.

With the District's lower sulfur emissions standards, the combusted sulfur is less likely to condense in the stack and thus stack temperatures can be lowered considerably. This allowed steam generator designers to get more overall thermal efficiency out of steam generators.

One key feature of this re-design for modern-era steam generators was the *horizontal convection section*. On a modern-era steam generator (not a retrofit), the heat transfer section is laid down on the ground (on a long slab), since there is no shortage of space at oilfields. This allows for a massive increase in convection surface area, which is where most of the actual heat transfer takes place between the burning fuel and the steam. While a vertical or pyramid convection section could have a convection surface area of 7,590 feet, a new horizontal convection section can be designed to easily accommodate a much larger convection section of over 20,000 square feet. The additional heat transfer would take advantage of the lower stack temperature (lowering the stack temperature by about 100 deg F, to approximately 229 deg F) and reclaim a lot of otherwise wasted heat for steam production, increasing the overall thermal efficiency of the steam generator.

As clarified in the "BPS Emission Factor" below, an achieved-in-practice steam generator with a horizontal convection section allows for a thermal efficiency of at least 88%. This increase in thermal efficiency results in a *decrease in GHG emissions of 12.9% from baseline.*

The horizontal convection section with more convection surface has been achieved-in-practice, and will be a candidate for the oilfield steam generator BPS.

In order to specify the BPS, one important question must be answered.

> How much convection surface area is required to product the acceptable thermal efficiency of steam generators of different heat input ratings?

Heat transfer in steam generators is based on the formula Q = U·S·DT, where
Q = heat transfer (in MMBtu/hour),
U = overall heat transfer coefficient,
S = surface area, and
DT = log of mean temperature difference

From the governing formula, it is clear that the relationship between the Q and S is linear, and intuitively it is clear that S limits Q. The higher the S for a given load, the more Q may be transferred to the steam.

The preponderance of oilfield examples indicate that the modern high efficiency convection section for an 85 MMBtu/hr steam generator, operating at 88% thermal efficiency, has a ratio (R) of 20,000 square feet of convection surface area per 85 MMBtu/hour.

In order to accommodate other heat input ratings, and allowing S to vary linearly with Q, the ratio needed to produce the target 88% thermal efficiency is:

$$R = \frac{20{,}000\ ft^2}{85\frac{MMBtu}{hour}} = 235\frac{ft^2}{\frac{MMBtu}{hr}}$$

This ratio will be part of the equipment option in the BPS.

To complete the analysis, two other assumptions are made.

1. The surface area given is "Bare Tube" S (not fin surface area)
2. All steam generator tubes are made of a similar metallic composition

While the heat transfer capacity of one linear foot of bare tube is lower than the heat transfer capacity of one linear foot of an otherwise similar "finned" tube, the heat transfer capacity of 1 square unit of surface area of bare-tube is higher than the heat transfer capacity of 1 square unit of surface area of "finned" tube, because the fin itself adds a slight barrier to heat transfer. 235 square feet of “fin” will have a lower thermal transfer capacity than 235 square feet of bare tube.

There are many variations in fin design. Fins can be extruded, embedded, L-based, helically cut, etc., made of different materials, and some fins have serrations cut into them to increase turbulence and enhance heat transfer. While it is clear that fin design is paramount to heat transfer, the fin design itself is beyond the scope of BPS. While the District will require 235 square feet of bare tube surface area per MMBtu/hr, BPS may be granted to various designs of finned convection sections. This means that the manufacturer must demonstrate that the finned design is thermodynamically equivalent to the 235 square feet of bare tube per MMBtu/hr.

Therefore, the BPS requirement will be written as such:

> 88% thermal efficiency (manufacturers rating)
> or
> Horizontal convection section with at least 235 square feet of bare tube* surface area per MMBtu/hr of heat input (*or thermodynamically equivalent number of square feet of finned tube)

Finally, since the metallic composition of the steam generator tubes are all designed for the same basic working environment, their synthesis (corrosion resistant steel) should remain somewhat consistent between various steam generators. For this reason, a detailed thermodynamic analysis of the heat transfer capacity of the tubes themselves isn't necessary.

2. Additional Economizer

Extra heat can be transferred from the exhaust gasses to the steam by installing an extra economizer, further increasing the thermal efficiency of the steam generator.

It is important to note that economizers are useful in processes where high quality lower volume steam is required. With purified de-ionized highly filtered water, high quality steam is possible and often necessary to serve a particular industry.

Since an oilfield steam generator can have a relatively large horizontal convection section that can bring down the stack temperature to the area of 230 degrees F, the practicality of an extra and vertical economizer comes into question. In the oilfield, the need for this equipment is diminished.

Finally, in order to be considered BPS, the technology must be actually achieved-in-practice. Since new oilfield steam generators do not have added vertical economizers this technology is not achieved-in-practice in the oilfield, and therefore this technology is precluded from being a candidate for oilfield steam generator BPS.

3. and 4. Limiting the FGR Controls and the Use of Ammonia Injection

Flue gas recirculation recirculates a portion of the exhaust gas back into the combustion chamber of the steam generator to mix with the oxygen-rich incoming air. This exhaust is heated up with the other products of combustion, absorbing heat from the combustion process. This reduces the peak combustion temperature, which primarily lowers NO_x production, and also reduces the thermal efficiency of the steam generator.

It is clear that increasing the recirculated air can lower NO_x to a certain point, beyond which the flame may become unstable. For years, FGR has been used by steam generator manufacturers and operators to meet the District's standards for low NO_x emissions.

The achievement of criteria emission standards (NO_x levels) takes precedence over achieving CO_2e standards, one must realize that reducing the FGR on a steam generator will lead to an increase in NO_x emissions. This increase in NO_x emissions must be mitigated somehow in order to maintain compliance with NO_x rules.

One option that would make a reduction in FGR rate feasible would be to supplement the FGR technology with ammonia injection in the stack (Selective Catalytic Reduction (SCR)) to control NO_x emissions. The SCR would reduce the NO_x emissions without the need for such extensive FGR. The result would be increased thermal efficiency of the steam generator, and a corresponding decrease in GHG emissions per unit of useful heat output.

While this technology is promising, in order to be a BPS, this technology would have to be achieved-in-practice. To date, no oilfield steam generators are equipped with ammonia injection. Therefore, this technology can not be considered achieved-in-practice, and thus this technology is precluded from being a candidate for oilfield steam generator BPS.

5. Variable frequency drive high efficiency electrical motors driving the blower and water pump

According to the analysis that follows, the electric motors that drive the blowers and water pumps associated with oilfield steam generators contribute to indirect GHG emissions. In the example that follows, high efficiency electric motors coupled with high efficiency variable frequency drives result in electricity savings. This reduces the indirect GHG emissions for the steam generator.

This equipment can save nearly 150,000 kW·hr/year on a typical oilfield steam generator. At an indirect emission factor of 0.524 lb·CO_2e/kW·hr, this amounts to a savings of 78,600 lb·CO_2e per year.

While this technology may result in only a 0.11% decrease in overall CO_2e as compared to the entire steam generator project, it does reduce GHG and it is achieved-in-practice. Therefore, this technology is a candidate for oilfield steam generator BPS.

STEP 3. Identify all Achieved-in-Practice GHG Emission Control Measures

Achieved-in-Practice is defined as any equipment, technology, practice or operation available in the United States that has been installed and operated or used at a commercial or stationary source site for a reasonable period of time sufficient to demonstrate that the equipment, the technology, the practice or the operation is reliable when operated in a manner that is typical for the process. In determining whether equipment, technology, practice or operation is Achieved-in-Practice, the District will consider the extent to which grants, incentives or other financial subsidies influence the economic feasibility of its use.

Pursuant to the discussion above for each technologically feasible item listed, those technologies that are achieved-in-practice have been identified as such and will be brought forward as Achieved-in-Practice GHG control measures, as indicated in the following table.

Table 2
Achieved-in-Practice GHG Control Measures for Oilfield Steam Generators

Control Measure	Achieved-Qualifications
High thermal efficiency steam generator	[88% thermal efficiency (manufacturers rating) Or Horizontal convection section with at least 235 square feet of bare tube* surface area per MMBtu/hr of heat input (*or thermodynamically equivalent number of square feet of finned tube)] And [Variable frequency drive high efficiency electrical motors driving the blower and water pump]
Variable frequency drive high efficiency electrical blower and water pump motors	95% NEMA efficiency

STEP 4. Quantify the Potential GHG Emission and Percent Reduction for Each Identified Achieved-in-Practice GHG Emission Control Measure

For each Achieved-in-Practice GHG emission, the following are identified:

a. Quantify the potential GHG emissions per unit of activity (G_a)
b. Express the potential GHG emission reduction as a percent (G_p) of Baseline GHG emissions factor per unit of activity (BEF)

This section will analyze the high thermal efficiency steam generator (88% thermal efficiency or horizontal convection section with at least 20,000 square feet of convection area) with variable frequency drive high efficiency electrical blower and water pump motors.

The following analysis of BPS steam generator GHG emissions is based on actual physical measurements taken from modern-era steam generator S-1114-111. This unit is considered to be a typical industry-wide example of BPS steam generator operation.

A. Basis and Assumptions

- All direct GHG emissions are the result of the combustion of natural gas in the steam generator.
- Maximum heat input rating of the steam generator is 85 MMBtu/hr
- Actual fuel consumption for the steam generator is 72.5 MMBtu/hr
- Heat output at 88.1% thermal efficiency = 63.9 MMBtu/hr
- The GHG emission factor for natural gas combustion is 117 lb-CO_2e/MMBtu (per CCAR document, see earlier assumptions)
- Air blower motor mechanical output when operated at 40.3 Hz is 110 hp
- Water pump motor mechanical output when operated at 56.1 Hz is 77.3 hp
- High efficiency electric motor efficiency = 95.8% (NEMA)
- Indirect emissions from electric power consumption are calculated based on the current PG&E electric power generation factor of 0.524 lb-CO_2e per kWh
- Steam quality = 70%
- Steam temperature = 524 F
- Mass flowrate = 1,683,234 lb·water/day
- Feedwater temperature = 115 F
- Convection surface area = 20,245 square feet

B. Calculation of Potential GHG Emissions per Unit of Activity (G_a)

1. Indirect GHG Emissions from Blower

Specific electricity consumption and GHG for the high efficiency blower motor

110 hp x 0.746 kW/hp x (1/95.8%) x 0.524 lb·CO_2e/kW·hr = 44.9 lb·CO_2e/hr
44.9 lb·CO_2e/hr ÷ 63.9 MMBtu/hr = 0.703 lb·CO_2e/MMBtu (of heat output)

2. Indirect GHG Emissions from Water Pump

Electrical Consumption for the high efficiency water pump motor

77.3 hp x 0.746 kW/hp x 1/95.8% x 0.524 lb·CO_2e/kW·hr = 31.5 lb·CO_2e/hr
31.5 lb·CO_2e/hr ÷ 63.9 MMBtu/hr = 0.493 lb·CO_2e/MMBtu (of heat output)

3. Direct GHG Emissions

72.5 MMBtu/hr (heat input) x 117 lb·CO_2e/MMBtu = 8,483 lb·CO_2e/hr
8,483 lb·CO_2e/hr ÷ 63.9 MMBtu/hr = 132.8 lb·CO_2e/MMBtu (of heat output)

4. Total BPS GHG Emissions (indirect emissions + direct emissions)

G_a = (44.9 + 31.5 + 8,483) lb·CO_2e/hr = 8,559 lb·CO_2e/hour
G_a = (0.703 + 0.493 + 132.8) lb·CO_2e/MMBtu =
= 134.0 lb·CO_2e/MMBtu (heat output)

G_a = 134 lb·CO_2e/MMBtu x 1 metric ton/2,205 lb =
= 0.0608 metric tons·CO_2e/MMBtu (heat output)

G_a = 0.0608 metric tons·CO_2e/MMBtu

C. Calculation of Potential GHG Emission Reduction as a Percentage of the Baseline Emission Factor (G_p)

G_p = (BEF - G_a) / BEF metric tons/MMBtu
= (0.0698 - 0.0608)/0.0698 = .1289
G_p = 12.9%

STEP 5. Rank all Achieved-in-Practice GHG emission reduction measures by order of % GHG emissions reduction

Based on the calculations presented in Section II.4 above, the Achieved-in Practice GHG emission reduction measures are ranked in Table 3 below:

Table 3 **Ranking of Achieved-in-Practice GHG Emission Control Measures**			
Rank	Control Measure	Potential GHG Emission per Unit of Activity (G_a) (Metric Ton-CO_2e/MMBtu)	Potential GHG Emission Reduction as a Percentage of the Baseline Emission Factor (G_p)
1	[88% thermal efficiency (manufacturers rating) Or Horizontal convection section with at least 235 square feet of bare tube* surface area per MMBtu/hr of heat input (*or thermodynamically equivalent number of square feet of finned tube)] And [Variable frequency drive high efficiency electrical motors driving the blower and water pump]	0.0608	12.9%

STEP 6. Establish the Best Performance Standard (BPS) for this Class and Category

For Stationary Source Projects for which the District must issue permits, Best Performance Standard is – "For a specific Class and Category, the most effective, District approved, Achieved-In-Practice means of reducing or limiting GHG emissions from a GHG emissions source, that is also economically feasible per the definition of achieved-in-practice. BPS includes equipment type, equipment design, and operational and maintenance practices for the identified service, operation, or emissions unit class and category".

Based on the definition above and the ranking given in Table 3 from Section II.5, Best Performance Standard (BPS) for this class and category is determined as:

<u>Best Performance Standard for Oilfield Steam Generators</u>

[88% thermal efficiency (manufacturers rating)
Or
Horizontal convection section with at least 235 square feet of bare tube* surface area per MMBtu/hr of heat input (*or thermodynamically equivalent number of square feet of finned tube)]
And
[Variable frequency drive high efficiency electrical motors driving the blower and water pump]

STEP 7. Eliminate All Other Achieved-in-Practice Options from Consideration as Best Performance Standard

The following Achieved-in-Practice GHG control measures, identified in Section II.4 and ranked in Table 3 of Section II.5 are specifically eliminated from consideration as Best Performance Standard since they have GHG control efficiencies which are less than that of the selected Best Performance Standard as stated in Section II.6.

No other Achieved-in-Practice options were identified.