# San Joaquin Valley
# Unified Air Pollution Control District

# Best Performance Standard (BPS) x.x.xx

Date: May 10, 2010

| | |
|---|---|
| **Class** | **Gasoline Dispensing Facilities (GDFs)** |
| **Category** | **GDFs with Underground Storage Tanks (USTs) and Phase II EVR Vapor Recovery System** |
| **Best Performance Standard** | **ARB-certified non-combustion based Phase II vapor recovery systems** |
| **Percentage Reduction in GHG Emissions Relative to Baseline Emissions** | **74.3%** |

| | |
|---|---|
| District Project Number | C-1100389 |
| Evaluating Engineer | Sajjad Ahmad |
| Lead Engineer | Jim Swaney, P.E. |
| Initial Public Notice Date | April 8, 2010 |
| Final Public Notice Date | April 30, 2010 |
| Determination Effective Date | May 12, 2010 |

# SAN JOAQUIN VALLEY
# AIR POLLUTION CONTROL DISTRICT

# Best Performance Standard (BPS) Evaluation

# GDFs with USTs and Phase II EVR

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# I. 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 (GHG) emissions 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 emissions 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 Gasoline Dispensing Facilities (GDFs) with Underground Storage Tanks (USTs) subject to California Air Resources Board's (ARB's) Phase II Enhanced Vapor Recovery (EVR) system requirements 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:

| Phase | Description | Date | Comments |
|---|---|---|---|
| | **Table 1** <br> **BPS Development Process Phases** <br> **for GDFs with USTs and Phase II EVR** | | |
| 1 | Initial Public Process | 3/04/10 | The District's intent notice is attached as Appendix D |
| 2 | BPS Development | 4/02/10 | See Section III of this evaluation document. |
| 3 | Public Review | 4/08/10 | The current draft proposed BPS will be posted on the District's website for public review. Any comments received during the public review process will be addressed before finalizing the BPS determination. |
| 4 | Public Comments | 5/06/10 | Public comments received during the public review process will be addressed before finalizing the BPS determination. |

## III. Class and Category

*Gasoline dispensing facilities (GDFs)* are recognized as a distinct class based on the following:

- GDFs represent a distinct operation (gasoline unloading, storage, and refueling) when compared to all other permit units currently regulated by the District.

- The District already considers this a distinct class with respect to Best Available Control Technology (BACT) for criteria pollutant emissions.

- This is a distinct class with respect to the District's prohibitory rules for criteria pollutant emissions (Rules 4621 and 4622).

- District's current prohibitory rules currently only allow ARB certified vapor recovery systems to control gasoline vapor emissions from GDFs. GDFs differ substantially from all other District classes in their basic function, operational components, and design requirements, and thus are considered to be a separate class.

*GDFs with Underground Storage Tanks (USTs) and with Phase II EVR* are recognized as a distinct category of GDFs based on the following:

- District has divided GDFs, in line with ARB classification, into two main categories: GDFs with underground storage tanks (USTs) and GDFs with aboveground storage tanks (AGTs). ARB has different vapor recovery certification procedures and enhanced vapor recovery (EVR) requirements for each category (see Appendix E for UST EVR timeline). Therefore, it is more appropriate to address GDFs with USTs under a separate BPS.

- There are certain GDFs with USTs that are not subject to EVR timeline as shown in Appendix E. These include GDFs with USTs with liquid condensate traps and GDFs at bulk plants where USTs also serve the bulk plant loading rack. Therefore, this BPS applies only to those GDFs that are subject to current EVR requirements.

- A Phase I vapor recovery system is always a balance system with no electrical requirements. Therefore, no Phase I vapor recovery system involves with direct or indirect GHG emissions and thus not evaluated in this BPS.

- Several of the Phase II EVR vapor recovery systems involve with a burner to control gasoline vapor emissions. Since the combustion of gasoline vapors results in direct GHG emissions, this document evaluates all current ARB certified Phase II EVR vapor recovery systems for GDFs with USTs.

## IV. BPS Development

### STEP 1. Establish Baseline Emission Factor (BEF)

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. BEF 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

Step 1: Number of GDFs with Various System Types:

For GDFs with USTs subject to ARB's EVR requirements, the representative baseline operation has been determined to be 59% of GDFs equipped with balance Phase II vapor recovery systems (predominately G-70-52-AM), 33% equipped with a vacuum assist system without a burner (with no combustion emissions) and 8% equipped with a vacuum assist system with a burner (with combustion emissions).

This determination is based on a review of the District's permit data base, which indicates that this was the most common configuration permitted by the District during the baseline period of 2002-2004. The following table summarizes the various system types during the baseline period:

| Table 2 Baseline Period (2002-04) GDF Representative Operations | | | | |
|---|---|---|---|---|
| # | Phase II Vapor Recovery System Type | | Number of GDFs | % of Number of GDFs |
| 1 | Balance Systems | | 739 | 59 % |
| 2 | Vacuum Assist Systems (no Combustion Emissions) | | 407 | 33 % |
| 3 | Vacuum Assist Systems (with Combustion Emissions) | Hirt VCS-200 (G-70-33) | 24 | 8 % |
| 4 | | Hirt VCS-400 (G-70-177) | 38 | |
| 5 | | Hasstech VCP-2/2A or 3A (G-70-7 or G-70-164) | 36 | |
| | | Total = | 1,244 | 100 % |

Step 2: Establishing Percentage of Gasoline Dispensed by Each System Type During Baseline Period:

District's Emissions Inventory (EI) database was reviewed to find the actual gasoline dispensed for each system type during the baseline emissions period. Since District's EI database was under development, the data for two years 2002 and 2003 was not complete. However, complete data was available for years 1999 and 2004 through 2008. The following table summarizes the EI data for each system type for years 1999 and 2002 through 2008:

| # | GDF Sub-Category | Emission Inventory Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1999 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| 1 | Balance Systems | 479,547 | 3,740 | 9,443 | 451,061 | 407,388 | 499,474 | 580,173 | 538,256 |
| 2 | Vaccum Assist without burner | 294,045 | 4,184 | 11,996 | 308,073 | 204,013 | 388,275 | 427,185 | 422,606 |
| 3 | Hirt VCS 200 (G-70-33) | 26,847 | | | 10,319 | 7,048 | 19,123 | 25,759 | 24,080 |
| 4 | Hirt VCS 400 (G-70-177) | 68,016 | | | 71,856 | 65,002 | 73,247 | 72,730 | 68,770 |
| 5 | Hasstech VCP-2/2A or 3A (G-70-7 or G-70-164) | 48,539 | | | 53,923 | 54,272 | 60,153 | 63,150 | 60,485 |
| | Grand Total = | 916,994 | 7,924 | 21,439 | 895,232 | 737,723 | 1,040,272 | 1,168,997 | 1,114,197 |

**Table 3**
**Total Gasoline Throughput (All numbers are in 1,000 gallons)**

As shown above, data for years 2002 and 2003 is not complete. Therefore, the data for all other years, in the above table, was used to calculate the percentage of total gasoline dispensed for each system type. This percentage is then assumed to be the representative of baseline period gasoline dispensed for each system type. The following table summarizes the calculations:

| Table 4 Percentage of Gasoline Dispensed (All numbers are in 1,000 gallons) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **#** | **GDF Sub-Category** | **Emission Inventory Year** | | | | | | **Total** | **%** |
| | | **1999** | **2004** | **2005** | **2006** | **2007** | **2008** | | |
| 1 | Balance Systems | 479,547 | 451,061 | 407,388 | 499,474 | 580,173 | 538,256 | 2,955,899 | **50%** |
| 2 | Vaccum Assist without burner | 294,045 | 308,073 | 204,013 | 388,275 | 427,185 | 422,606 | 2,044,196 | **35%** |
| 3 | Hirt VCS 200 (G-70-33) | 26,847 | 10,319 | 7,048 | 19,123 | 25,759 | 24,080 | 113,177 | |
| 4 | Hirt VCS 400 (G-70-177) | 68,016 | 71,856 | 65,002 | 73,247 | 72,730 | 68,770 | 419,622 | **15%** |
| 5 | Hasstech VCP-2/2A or 3A (G-70-7 or G-70-164) | 48,539 | 53,923 | 54,272 | 60,153 | 63,150 | 60,485 | 340,522 | |
| | **Grand Total =** | **916,995** | **895,234** | **737,722** | **1,040,271** | **1,168,997** | **1,114,197** | **5,873,416** | **100%** |

Therefore, the baseline emission factor will be calculated using representative baseline operation as 50% of gasoline dispensed at GDFs equipped with balance Phase II vapor recovery systems, 35% gasoline dispensed at GDFs equipped with a vacuum assist system without a burner (with no combustion emissions) and 15% of gasoline dispensed at GDFs equipped with a vacuum assist system with a burner (with combustion emissions).

## B. Basis and Assumptions

GHG emissions are stated as "$CO_2$ equivalents" ($CO_2e$) which includes the global warming potential of methane and nitrous oxide emissions associated with gaseous fuel combustion.

All other applicable basis and assumptions are stated in BEF calculations in Appendix A.

### 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.

Based on initial public review process and consistent with District and ARB practice of stating emission factors, the unit of activity for this class and category has been established as 1,000 gallon of gasoline dispensed.

### D. Calculations

Baseline Emission Factor (BEF) for this class and category is calculated as the sum of the direct GHG and indirect GHG emissions (on a per unit of activity basis), stated as lb-$CO_2$ equivalent per 1,000 gallon of gasoline dispensed (see Appendix A for detailed calculations):

**BEF = 3.435 lb-$CO_2$e/1,000 gallon**

### STEP 2. List Technologically Feasible GHG Emission Reduction Measures

The following findings or considerations are applicable to this class and category:

- The GDF must be equipped with ARB-certified Phase I and Phase II vapor recovery systems to comply with ARB's Enhanced Vapor Recovery (EVR) requirements for GDFs with underground gasoline storage tanks.

Vapor recovery systems are designed to control gasoline vapor emissions only during gasoline refueling. Gasoline vapors are not classified as GHG, instead they are considered Volatile Organic Compound (VOC) emissions. Therefore, the only GHG emissions resulting from GDFs are due to combustion of gasoline vapors in a burner associated with a Phase II system (direct GHG emissions) or a system electricity usage (indirect GHG emissions). Since none of the Phase II vapor recovery systems are designed to control or reduce GHG emissions, they cannot be directly classified as GHG reduction measures. However, all systems will be ranked on the basis of the amount of total GHG emissions (both direct and indirect GHG) and the systems resulting in least GHG emissions will be considered as GHG emissions reduction measures as compared to systems resulting in higher GHG emissions.

Thus Phase II EVR vapor recovery systems can be divided into two groups as follows:

1. <u>Phase II Vapor Recovery Systems with Combustion Emissions:</u> These types of vapor recovery systems use a burner to combust excess gasoline vapors to control system pressure. Therefore, in addition to gasoline vapor emissions during refueling, these systems involve with combustion emissions from burner. Currently there are three such ARB certified systems: VR-205, VR-207 and VR-208. They involve both direct GHG emissions due to combustion and indirect GHG emissions due to electric usage of various system components (see Appendix A for calculations of GHG emissions).

2. <u>Phase II Vapor Recovery Systems without Burner:</u> In addition to gasoline vapor emissions during refueling, these systems do not involve with combustion emissions. Currently there are five such ARB certified systems: VR-201, VR-202, VR-203, VR-204, and VR-209. They involve only indirect GHG emissions due to electric usage of various system components (see Appendix B for calculations of GHG emissions).

The following table summarizes the current ARB certified Phase II vapor recovery systems that are applicable to this class and category:

| Table 5 ARB Certified Phase II EVR Vapor Recovery Systems | | | | |
|---|---|---|---|---|
| # | ARB Executive Order | System | Most Prominent System Component | System Type |
| 1 | VR-201 and VR-202 | Healy | Healy Clean Air Separator | Vacuum Assist |
| 2 | VR-203 and VR-204 | VST | VST Membrane Processor Or Veeder-Root Vapor Polisher | Balance |
| 3 | VR-205 | VST | Hirt VCS 100 Thermal Oxidizer | Balance |
| 4 | VR-207 and VR-208 | Emco Wheaton | Hirt VCS 100 Thermal Oxidizer | Balance |
| 5 | VR-209 | VST | Healy Clean Air Separator | Balance |

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 this class and category:

| Table 6 Technologically Feasible GHG Reduction Measures | |
| --- | --- |
| **Reduction Measure** | **Qualifications** |
| ARB-certified non-combustion based Phase II vapor recovery systems | Use of non-combustion based systems eliminates the direct GHG emissions involved with combustion based systems. |
| ARB-certified combustion based Phase II vapor recovery systems | These systems have no control over direct GHG emissions, however, they will be ranked along with other systems based on the amount of total GHG emissions reductions as a percentage of baseline emissions. |

All of the reduction measures identified above are equipped with control equipment for VOC emissions which meets current regulatory requirements and criteria for Best Available Control Technology.  None of the identified control measures would result in an increase in emissions of criteria pollutants.


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

For all technologically feasible GHG emission reduction measures, all GHG reduction measures determined to be Achieved-in-Practice are identified.  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.

The following findings or considerations are applicable to this class and category:

- GDFs with ARB-certified non-combustion Phase II EVR vapor recovery systems have been demonstrated commercially available and are thus Achieved-in-Practice

- GDFs with ARB-certified combustion based Phase II EVR vapor recovery systems have been demonstrated commercially available and thus are Achieved-in-Practice

All of the reduction measures identified above are equipped with control equipment for VOC emissions which meets current regulatory requirements and criteria for Best Available Control Technology. None of the identified control measures would result in an increase in emissions of criteria pollutants.

## STEP 4. Quantify Potential GHG Emission and Percent Reduction

For each Achieved-in-Practice GHG emission reduction measure identified in Step 3 above:

a. Quantify the potential GHG emission reduction, as compared to the Baseline Emission Factor (BEF) per unit of activity ($G_a$).

b. Express the potential GHG emission reduction as a percent ($G_b$) of BEF per unit of activity as follows:

$$\% \ Reduction \ in \ GHG \ emissions \ (G_b) = \frac{BEF - (proposed \ project \ emissions \ factor)}{BEF} \times 100$$

Please see Appendices B and C for detailed calculations of both direct and indirect GHG emissions from each of the currently ARB certified Phase II EVR vapor recovery systems.

**STEP 5. Rank All Achieved-in-Practice GHG Emission Reduction Measures**

Based on calculations presented in Appendices B and C, the Achieved-in Practice GHG emission reduction measures are ranked by order of percentage GHG emissions reduction in the table below:

| | Table 7 Ranking of Achieved-in-Practice GHG Emission Control Measures | | |
|---|---|---|---|
| **Rank** | **Control Measure** | **Potential GHG Emission Reduction per Unit of Activity ($G_a$)** <br><br> **lb-$CO_2$e/1,000 gallon** | **Potential GHG Emission Reduction as a Percentage of the Baseline Emission Factor ($G_p$)** |
| 1 | VST with Healy Clean Air Separator (VR-209) | 3.421 | **99.58 %** |
| 2 | VST with Veeder-Root Vapor Polisher (VR-203 or VR-204) | 3.409 | **99.25 %** |
| 3 | Healy with Healy Clean Air Separator (VR-201 or VR-202) | 3.240 | **94.32 %** |
| 3 | VST with VST Membrane Processor (VR-203 or VR-204) | 2.553 | **74.31 %** |
| 5 | VST/Emco Wheaton with Hirt VCS 100 Thermal oxidizer (VR-205, VR-207 or VR-208) | -1.618 | **-47.11 %** |

**STEP 6. Establish 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 the Table 7 above from Section II.5, Best Performance Standard (BPS) for this class and category is determined as:

***Best Performance Standard for GDFs with Underground Storage Tanks and Phase II EVR Vapor Recovery System***

***ARB-certified non-combustion based Phase II vapor recovery systems.***

**STEP 7. Eliminate All Other Achieved-in-Practice Options**

The following Achieved-in-Practice GHG emissions control measures, identified in Section II.4 and ranked in Table 7 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:

*Eliminated Achieved-in-Practice Control Measures for GDFs with Underground Storage Tanks and Phase II EVR Vapor Recovery System:*

- *ARB-certified combustion based Phase II vapor recovery systems.*

# V. Appendices

# APPENDIX A

# Calculations for Baseline Emission Factor (BEF)

# Calculations for Baseline Emissions Factor (BEF)

As discussed in Section III.1.A of this document, there were three GDF classes during the baseline period of 2002-2004.  Baseline emission factor for GHG emissions is calculated below for each GDF class and then combined to give an overall BEF.  The following table summarizes the percentage of gasoline dispensed used to calculate baseline emission factor:

| Percentage of Gasoline Dispensed (All numbers are in 1,000 gallons) | | | |
|---|---|---|---|
| # | GDF Sub-Category | Total | % |
| 1 | Balance Systems | 2,955,899 | **50 %** |
| 2 | Vaccum Assist without burner | 2,044,196 | **35 %** |
| 3 | Hirt VCS 200 (G-70-33) | 113,177 | **2 %** |
| 4 | Hirt VCS 400 (G-70-177) | 419,622 | **7 %** |
| 5 | Hasstech VCP-2/2A or 3A (G-70-7 or G-70-164) | 340,522 | **6 %** |
| | Grand Total = | 5,873,416 | 100 % |

BEF for each of these five sub-categories is calculated below:

## a) GDFs equipped with a balance Phase II vapor recovery system:

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions**

- The direct GHG emissions from this class are methane emissions included in the gasoline vapors.  As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2$e/1,000 gallon gasoline dispensed.

- Indirect GHG emissions are zero since balance systems do not use any electric motor-driven vacuum pump to draw vapors.

**Calculations**

Total GHG emissions = Direct GHG + Indirect GHG
= (0.0143 lb-$CO_2$e/1,000 gallon) + 0
= 0.0143 lb-$CO_2$e/1,000 gallon

Thus the Baseline Emission Factor for this sub-category is:

$$\textbf{BEF}_a \;=\; 0.0143 \;\frac{lb-CO2e}{1,000\; gallon}$$

## b) GDFs equipped with a vacuum assist Phase II vapor recovery system WITHOUT a burner:

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions**

- The direct GHG emissions from this class are methane emissions included in the gasoline vapors. As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2$e/1,000 gallon gasoline dispensed.

- Indirect GHG emissions are due to operation of a ½ bhp electric motor-driven vacuum pump associated with the Phase II vapor recovery system.

- The vacuum pump at each fueling point (FP) is estimated to operate 8 hours/FP-day.

- Nozzles pump at 10 gal/min (from ARB Executive Orders).

- Stations are designated to handle peak gasoline dispensing periods, so an estimated use factor of 50% is considered conservative.

- If the time that a vehicle spends at a fueling point (FP) is 8 minutes, only about 2 minutes of that time is actually spent dispensing fuel (20 gallon @ 10 gal/min). Therefore, a utilization factor of 0.25 will be used for calculations.

- Based on above assumptions, maximum time that a vacuum pump operates is calculated as: 24 hour/day × 0.25 × 0.5 = 3 hour/FP-day.

- Based on above assumptions, maximum gasoline dispensed by each nozzle is calculated as: 10 gal/min × 1,440 min/day × 0.25 × 0.5 = 1,800 gallon/day per nozzle.

- Since only one vehicle can be refueled at one fueling point (FP) at a time, the maximum gasoline dispensed at a fueling point = 1,800 gallon/FP-day.

- Indirect emissions from electric power consumptions are calculated based on the current PG&E electric power generation factor of 0.524 lb- $CO_2$e per kWh.

- Electric motor efficiency is 90%

**Calculations**

Direct GHG emissions:

Direct GHG emissions = 0.0143 lb-$CO_2$e/1,000 gallon

Indirect GHG Emissions:

Indirect GHG emissions are calculated as follows:

Specific electricity consumption for the vacuum pump, calculated in units of kWh/1,000 gallon, is:

$$\frac{0.5\,bhp}{0.90} \times \frac{0.7457\,kW}{1\,bhp} \times \frac{3\,hours}{FP-day} \times \frac{1\,FP-day}{1,800\,gallon} \times \frac{1,000\,gallon}{1,000\,gallon} = 0.690\,\frac{kW-hr}{1,000\,gallon}$$

Indirect GHG Emissions are:

$$\frac{0.690\,kW-hr}{1,000\,gallon} \times \frac{0.524\,lb-CO2e}{1\,kW-hr} = 0.362\,\frac{lb-CO2e}{1,000\,gallon}$$

Total GHG Emissions:

Total GHG emissions = Direct GHG + Indirect GHG
= (0.0143 lb-$CO_2$e/1,000 gallon) + 0.362 lb-$CO_2$e/1,000 gallon
= 0.3763 lb-$CO_2$e/1,000 gallon

Thus the Baseline Emission Factor for this sub-category is:

$$\textbf{BEF}_\textbf{b} = 0.3763\,\frac{lb-CO2e}{1,000\,gallon}$$

### c) GDFs equipped with a vacuum assist Phase II vapor recovery system WITH a burner:

Under this category, it was further found that about 2% of the total gasoline dispensed during baseline period was from GDFs equipped with Hirt VCS-200 thermal oxidizer, whereas 7% gasoline was dispensed from GDFs equipped with Hirt VCS-400 thermal oxidizer and 6% gasoline was dispensed from GDFs equipped with Hasstech VCP-2/2A thermal oxidizer. Thus BEF each of these sub categories is evaluated below:

## c-1) GDFs equipped with a vacuum assist Phase II vapor recovery system WITH a Hirt VCS-200 thermal oxidizer:

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions**

- There are two sources of direct GHG emissions from this class:
  - $CO_2$ emissions from combustion of gasoline vapors in the thermal oxidizer.
  - $CH_4$ emissions included in the gasoline vapors. As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2$e/1,000 gallon gasoline dispensed.

- Maximum $CO_2$ emissions from combustion of gasoline vapors in the Hirt thermal oxidizer are 29.8 lb-$CO_2$/hr (based on ARB determination for Hirt VCS-100 thermal oxidizer emissions of 14.9 lb-$CO_2$/hr and the fact that VCS-200 thermal oxidizer design flowrate is double that of VCS-100).

- The Hirt thermal oxidizer and the vacuum pump associated with thermal oxidizer are estimated to operate 30 minutes-each per 1,000 gallon of gasoline dispensed (worst case).

- Indirect emissions are produced due to operation of a ½ bhp electric motor-driven vacuum pump associated with the Phase II vapor recovery system.

- Indirect emissions from electric power consumptions are calculated based on the current PG&E electric power generation factor of 0.524 lb-$CO_2$e per kWh.

- Electric motor efficiency is 90%

**Calculations**

Direct GHG emissions:

$CO_2$ emissions = 29.8 lb-$CO_2$e/hr x 30 min/1,000 gallon x 1 hr/60 min
$\quad\quad\quad\quad$ = 14.9 lb-$CO_2$e/1,000 gallon

$CH_4$ emissions = 0.0143 lb-$CO_2$e/1,000 gallon

Total direct GHG emissions $\;$ = $CO_2$ emissions + $CH_4$ emissions
$\quad\quad\quad\quad\quad\quad$ = (14.9 lb-$CO_2$e/1,000 gallon) + 0.0143 lb-$CO_2$e/1,000 gallon
$\quad\quad\quad\quad\quad\quad$ = 14.9143 lb-$CO_2$e/1,000 gallon

Indirect GHG Emissions:

Specific electricity consumption for the vacuum pump is:

0.5 bhp x (1/90%) x 0.7457 kW/bhp x 30 min/1,000 gallon x 1 hr/60 min
= 0.207 kWh/1,000 gallon

Based on PG&E electric power generation factor, indirect GHG emissions are:

0.207 kWh/1,000 gallon x 0.524 lb-$CO_2$e/kWh
= 0.108 lb-$CO_2$e/1,000 gallon

Total GHG Emissions:

Therefore, total GHG emissions from Phase II vapor recovery system with Hirt thermal oxidizer are:

Total GHG emissions = Direct GHG + Indirect GHG
       = (14.9143 lb-$CO_2$e/1,000 gallon) + 0.108 lb-$CO_2$e/1,000 gallon
       = 15.0223 lb-$CO_2$e/1,000 gallon

Thus the Baseline Emission Factor for this sub-category is:

**$BEF_{c-1}$ = 15.0223 lb-$CO_2$e/1,000 gallon**

**c-2) GDF equipped with a vacuum assist Phase II vapor recovery system WITH a Hirt VCS-400 thermal oxidizer:**

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions**

- There are two sources of direct GHG emissions from this class:
  - $CO_2$ emissions from combustion of gasoline vapors in the thermal oxidizer.
  - $CH_4$ emissions included in the gasoline vapors. As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2$e/1,000 gallon gasoline dispensed.

- Maximum $CO_2$ emissions from combustion of gasoline vapors in the Hirt thermal oxidizer are 59.6 lb-$CO_2$/hr (based on ARB determination for Hirt VCS-100 thermal oxidizer emissions of 14.9 lb-$CO_2$/hr and the fact that VCS-400 thermal oxidizer design flowrate is four times that of VCS-100).

- The Hirt thermal oxidizer and the vacuum pump associated with thermal oxidizer are estimated to operate 30 minutes-each per 1,000 gallon of gasoline dispensed (worst case).

- Indirect emissions are produced due to operation of a ½ bhp electric motor-driven vacuum pump associated with the Phase II vapor recovery system.

- Indirect emissions from electric power consumptions are calculated based on the current PG&E electric power generation factor of 0.524 lb-$CO_2$e per kWh.

- Electric motor efficiency is 90%

**Calculations**

Direct GHG Emissions:

$CO_2$ emissions = 59.6 lb-$CO_2$e/hr x 30 min/1,000 gallon x 1 hr/60 min
          = 29.8 lb- $CO_2$e/1,000 gallon

$CH_4$ emissions = 0.0143 lb-$CO_2$e/1,000 gallon

Total direct GHG emissions  = $CO_2$ emissions + $CH_4$ emissions
            = (29.8 lb-$CO_2$e/1,000 gallon) + 0.0143 lb-$CO_2$e/1,000 gallon
            = 29.814 lb-$CO_2$e/1,000 gallon

Indirect GHG Emissions:

Specific electricity consumption for the vacuum pump is:

0.5 bhp x (1/90%) x 0.7457 kW/bhp x 30 min/1,000 gallon x 1 hr/60 min
= 0.207 kWh/1,000 gallon

Based on PG&E electric power generation factor, indirect GHG emissions are:

0.207 kWh/1,000 gallon x 0.524 lb-$CO_2$e/kWh
= 0.108 lb-$CO_2$e/1,000 gallon

Total GHG Emissions:

Therefore, the total GHG emissions from Phase II vapor recovery system with Hirt thermal oxidizer are:

Total GHG from Hirt thermal oxidizer = 29.814 + 0.108
$$= 29.922 \text{ lb-CO}_2\text{e/1,000 gallon}$$
Thus the Baseline Emission Factor for this sub-category is:

**$BEF_{c-2}$ = 29.922 lb-CO$_2$e/1,000 gallon**

**c-3) GDFs equipped with a vacuum assist Phase II vapor recovery system WITH a Hasstech VCP-2/2A or VCP-3A thermal oxidizers:**

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions**

- Currently no data is available for Hasstech VCP-2/2A or VCP-3A thermal oxidizers. Therefore, it will be assumed that each of the Hasstech VCP-2/2A or VCP-3A thermal oxidizers have $CO_2$ emissions similar to a Hirt VCS-200 thermal oxidizer. Thus maximum $CO_2$ emissions from combustion of gasoline vapors in the Hasstech thermal oxidizers are 29.8 lb-$CO_2$/hr.

- Since Hasstech VCP-2/2A and 3A have identical thermal oxidizers, GHG emissions from Hasstech will be calculated once.

- There are two sources of direct GHG emissions from this class:

  ➢ $CO_2$ emissions from combustion of gasoline vapors in the thermal oxidizer.

  ➢ $CH_4$ emissions included in the gasoline vapors. As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2$e/1,000 gallon gasoline dispensed.

- The Hasstech thermal oxidizer and the vacuum pump associated with thermal oxidizer are estimated to operate 30 minutes-each per 1,000 gallon of gasoline dispensed (worst case).

- Indirect emissions are produced due to operation of a ½ bhp electric motor-driven vacuum pump associated with the Phase II vapor recovery system.

- Indirect emissions from electric power consumptions are calculated based on the current PG&E electric power generation factor of 0.524 lb-$CO_2$e per kWh.

- Electric motor efficiency is 90%

**Calculations**

Direct GHG Emissions:

$CO_2$ emissions = 29.8 lb-$CO_2$e/hr x 30 min/1,000 gallon x 1 hr/60 min
                 = 14.9 lb-$CO_2$e/1,000 gallon

$CH_4$ emissions = 0.0143 lb-$CO_2$e/1,000 gallon

Total direct GHG emissions  = $CO_2$ emissions + $CH_4$ emissions
                            = (14.9 lb-$CO_2$e/1,000 gallon) + 0.0143 lb-$CO_2$e/1,000 gallon
                            = 14.9143 lb-$CO_2$e/1,000 gallon

Indirect GHG Emissions:

Specific electricity consumption for the vacuum pump is:

0.5 bhp x (1/90%) x 0.7457 kW/bhp x 30 min/1,000 gallon x 1 hr/60 min
= 0.207 kWh/1,000 gallon

Based on PG&E electric power generation factor, indirect GHG emissions are:

0.207 kWh/1,000 gallon x 0.524 lb-$CO_2$e/kWh
= 0.108 lb-$CO_2$e/1,000 gallon

Total GHG Emissions:

Therefore, total GHG emissions from Phase II vapor recovery system with Hasstech thermal oxidizer are:

Total GHG emissions = Direct GHG + Indirect GHG
                    = (14.9143  lb-$CO_2$e/1,000 gallon) + 0.108 lb-$CO_2$e/1,000 gallon
                    = 15.0223 lb-$CO_2$e/1,000 gallon

Thus the Baseline Emission Factor for this sub-category is:

**$BEF_{c-3}$ = 15.0223 lb-$CO_2$e/1,000 gallon**

## D) Calculations of Overall Baseline Emissions Factor:

The overall Baseline Emission Factor (BEF) is calculated as follows:

$$BEF = (0.50 \times BEF_a) + (0.35 \times BEF_b) + (0.02 \times BEF_{c-1}) + (0.07 \times BEF_{c-2}) + (0.06 \times BEF_{c-3})$$

$$= \left(0.50 \times \frac{0.01431 \, lb - CO_2}{1,000 \, gallon}\right) + \left(0.35 \times \frac{0.37631 \, lb - CO_2}{1,000 \, gallon}\right) + \left(0.02 \times \frac{150223 \, lb - CO_2}{1,000 \, gallon}\right) + \left(0.07 \times \frac{29922 \, lb - CO_2}{1,000 \, gallon}\right) + \left(0.06 \times \frac{150223 \, lb - CO_2}{1,000 \, gallon}\right)$$

$$= \left(\frac{0.007 \, lb - CO_2}{1,000 \, gallon}\right) + \left(\frac{0.132 \, lb - CO_2}{1,000 \, gallon}\right) + \left(\frac{0.300 \, lb - CO_2}{1,000 \, gallon}\right) + \left(\frac{2.095 \, lb - CO_2}{1,000 \, gallon}\right) + \left(\frac{0.901 \, lb - CO_2}{1,000 \, gallon}\right)$$

$$BEF = \frac{3.435 \, lb - CO_{2e}}{1,000 \, gallon}$$

# APPENDIX B

# Calculations for GHG Emissions from Hirt Thermal oxidizer
# (with Combustion Emissions)

**Determination of GHG Emissions from Hirt Thermal oxidizer**

ARB has currently certified several Phase II EVR vapor recovery systems for GDFs subject to ARB EVR timeline. Currently three balance systems (under ARB executive orders VR-205, VR-207, and VR-208) involve with Hirt VCS 100 thermal oxidizer. Under normal conditions, these balance systems do not involve in any vacuum pump to draw gasoline vapors and Hirt thermal oxidizer typically does not operate during that time. However, when pressure in the ullage space rises above the allowable limit, Hirt thermal oxidizer activates and starts drawing excess vapor with a turbine and incinerates until pressure in the ullage is within the allowable range. The ullage pressurization occurs mostly during periods of less activity, e.g. station being shut down overnight, winter fuels present, etc. ARB has determined that a typical Hirt thermal oxidizer operates only a maximum of 20 minutes a day.

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions:**

- There are two sources of direct GHG emissions from this class:

  ➢ $CO_2$ emissions from combustion of gasoline vapors in the thermal oxidizer.

  ➢ $CH_4$ emissions included in the gasoline vapors. As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2$e/1,000 gallon gasoline dispensed.

- Maximum $CO_2$ emissions from combustion of gasoline vapors in the Hirt thermal oxidizer are 14.9 lb-$CO_2$/hr (ARB determination).

- The Hirt thermal oxidizer and the vacuum pump associated with thermal oxidizer are estimated to operate 20 minutes-each per 1,000 gallon of gasoline dispensed (worst case).

- Indirect emissions are produced due to operation of a ½ bhp electric motor-driven vacuum pump associated with the Phase II vapor recovery system.

- Indirect emissions from electric power consumptions are calculated based on the current PG&E electric power generation factor of 0.524 lb-$CO_2$e per kWh.

- Electric motor efficiency is 90%

**Calculations:**

Direct GHG Emissions:

$CO_2$ emissions = 14.9 lb-$CO_2$e/hr x 20 min/1,000 gallon x 1 hr/60 min
            = 4.967 lb-$CO_2$e/1,000 gallon

$CH_4$ emissions = 0.0143 lb-$CO_2$e/1,000 gallon

Total direct GHG emissions  = $CO_2$ emissions + $CH_4$ emissions
                    = (4.967 lb-$CO_2$e/1,000 gallon) + 0.0143 lb-
                       $CO_2$e/1,000 gallon
                    = 4.981 lb-$CO_2$e/1,000 gallon

Indirect GHG Emissions:

Specific electricity consumption for the vacuum pump is:

0.5 bhp x (1/90%) x 0.7457 kW/bhp x 20 min/1,000 gallon x 1 hr/60 min
= 0.1381 kWh/1,000 gallon

Based on PG&E electric power generation factor, indirect GHG emissions are:

0.1381 kWh/1,000 gallon x 0.524 lb-$CO_2$e/kWh
= 0.0724 lb-$CO_2$e/1,000 gallon

Total GHG Emissions:

Therefore, the total GHG emissions from Phase II vapor recovery system with Hirt thermal oxidizer are:

Total GHG emissions = Direct GHG + Indirect GHG
                    = (4.981 lb-$CO_2$e/1,000 gallon) + 0.0724 lb-
                       $CO_2$e/1,000 gallon
                    = 5.0534 lb-$CO_2$e/1,000 gallon

Potential GHG emission reduction as compared to BEF per unit of activity ($G_a$) is calculated as:

$G_a$ = BEF - Total GHG emissions
    = 3.435 - 5.0534
    = -1.618 lb-$CO_2$e/1,000 gallon

Potential GHG emission reduction as a percentage of the BEF per unit of activity ($G_p$) is calculated as:

$$G_p = G_a / BEF = -1.618 / 3.435 \times 100 = -47.11 \%$$

Negative sign means that the emissions are actually increasing by 47.11%.

# APPENDIX C

## Calculations for GHG Emissions from Technologically Feasible Options

## 1. Healy with Clean Air Separator (VR-201 or VR-202):

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions:**

- The direct GHG emissions from this class are methane emissions included in the gasoline vapors. As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2e$/1,000 gallon gasoline dispensed.

- Indirect GHG emissions are due to operation of a ¼ bhp electric motor-driven Healy Vacuum Pump VP1000 installed in each dispenser.

- The vacuum pump operates at two speeds: low speed when one fueling point being activated, and high speed when both fueling points are activated simultaneously. For worst case scenario, it is assumed that pump operates 100 % load at high speed only.

- Nozzles pump at 10 gal/min (from ARB Executive Orders).

- Stations are designated to handle peak gasoline dispensing periods, so an estimated use factor of 50% is considered conservative.

- If the time that a vehicle spends at a fueling point (FP) is 8 minutes, only about 2 minutes of that time is actually spent dispensing fuel (20 gallon @ 10 gal/min). Therefore, a utilization factor of 0.25 will be used for calculations.

- Based on above assumptions, maximum time that a vacuum pump operates is calculated as: 24 hour/day × 0.25 × 0.5 = 3 hour/FP-day.

- Based on above assumptions, maximum gasoline dispensed by each nozzle is calculated as: 10 gal/min × 1,440 min/day × 0.25 × 0.5 = 1,800 gallon/day per nozzle.

- Since only one vehicle can be refueled at one fueling point (FP) at a time, the maximum gasoline dispensed at a fueling point = 1,800 gallon/FP-day.

- Indirect emissions from electric power consumptions are calculated based on the current PG&E electric power generation factor of 0.524 lb- $CO_2e$ per kWh.

- Electric motor efficiency is 90%

**Calculations:**

Direct GHG Emissions:

Direct GHG emissions = 0.0143 lb-$CO_2$e/1,000 gallon

Indirect GHG Emissions:

Total electricity consumption for each vacuum pump per 1,000 gallon of gasoline dispensed is:

1/4 bhp x (1/90%) x 0.7457 kW/bhp x 3 hours/FP-day x 1 FP-day/1,800 gallon x 1,000 gallon/1,000 gallon = 0.3452 kWh/1,000 gallon

Based on PG&E electric power generation factor, indirect GHG emissions are:

0.3452 kWh/1,000 gallon x 0.524 lb-$CO_2$e/kWh
= 0.1809 lb-$CO_2$e/1,000 gallon

Total GHG Emissions:

Therefore, total GHG emissions from Phase II vapor recovery system with Healy system (VR-201 or VR-202) are:

Total GHG emissions = Direct GHG + Indirect GHG
$\qquad$ = (0.0143 lb-$CO_2$e/1,000 gallon) + 0.1809 lb-$CO_2$e/1,000 gallon
$\qquad$ = 0.1952 lb-$CO_2$e/1,000 gallon

Potential GHG emission reduction as compared to BEF per unit of activity ($G_a$) is calculated as:

$G_a$ = BEF - Total GHG emissions
$\qquad$ = 3.435 – 0.1952
$\qquad$ = 3.240 lb-$CO_2$e/1,000 gallon

Potential GHG emission reduction as a percentage of the BEF per unit of activity ($G_p$) is calculated as:

$G_p$ = $G_a$ / BEF = 3.240 / 3.435 x 100 = 94.32 %

## 2. VST with VST Membrane Processor (VR-203 or VR-204):

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions:**

- The direct GHG emissions from this class are methane emissions included in the gasoline vapors.  As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2$e/1,000 gallon gasoline dispensed.

- VST Membrane Processor is equipped with two vacuum pumps each with a 1/2 bhp electrical motor.

- Each vacuum pump associated with the membrane processor operates 2 hours per 1,000 gallon of gasoline dispensed (worst case).

- Indirect emissions from electric power consumptions are calculated based on the current PG&E electric power generation factor of 0.524 lb- $CO_2$e per kWh.

- Electric motor efficiency is 90%

**Calculations:**

Direct GHG Emissions:

Direct GHG emissions = 0.0143 lb-$CO_2$e/1,000 gallon

Indirect GHG Emissions:

Total electricity consumption for two vacuum pumps per 1,000 gallon of gasoline dispensed is:

2 pumps x 1/2 bhp x (1/90%) x 0.7457 kW/bhp x 2 hr/1,000 gallon
= 1.657 kWh/1,000 gallon

Based on PG&E electric power generation factor, indirect GHG emissions are:

1.657 kWh/1,000 gallon x 0.524 lb-$CO_2$e/kWh
= 0.868 lb-$CO_2$e/1,000 gallon

Total GHG Emissions:

Therefore, total GHG emissions from Phase II vapor recovery system with VST Membrane Processor (VR-203 or VR-204) are:

Total GHG emissions = Direct GHG + Indirect GHG
$$= (0.0143 \text{ lb-}CO_2\text{e}/1,000 \text{ gallon}) + 0.868 \text{ lb-}CO_2\text{e}/1,000 \text{ gallon}$$
$$= 0.8823 \text{ lb-}CO_2\text{e}/1,000 \text{ gallon}$$

Potential GHG emission reduction as compared to BEF per unit of activity ($G_a$) is calculated as:

$G_a$ = BEF - Total GHG emissions
$$= 3.435 - 0.8823$$
$$= 2.553 \text{ lb-}CO_2\text{e}/1,000 \text{ gallon}$$

Potential GHG emission reduction as a percentage of the BEF per unit of activity ($G_p$) is calculated as:

$G_p = G_a$ / BEF = 2.553 / 3.435  x 100 = 74.31 %

### 3. VST with Veeder-Root Vapor Polisher (VR-203 or VR-204):

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions:**

- The direct GHG emissions from this class are methane emissions included in the gasoline vapors. As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2$e/1,000 gallon gasoline dispensed.

- The electrical component with VST Veeder-Root Vapor Polisher is the pressure sensor switch and solenoid that activates with pressure increase to allow gasoline vapors to flow to the carbon canister.

- All electrical components operate on direct-current only at an electric voltage of 110 volts.

- Total electricity consumed by all electrical components is 100 milli-Amperes (m-Amp) at 110 volts.

- Total operating time for all electrical components is 2 hours per 1,000 gallon gasoline dispensed.

**Calculations:**

Direct GHG Emissions:

Direct GHG emissions = 0.0143 lb-$CO_2$e/1,000 gallon

Indirect GHG Emissions:

Total electricity consumption for all system components is calculating using the following formula:
$P = I \times V$

Where,
P = electrical power (watts)
I = electrical current (amperes)
V = electrical voltage (volts)

Thus,

P = (100 milli-Amp x 1 Amp/1,000 milli-Amp) x 110 volts

= 0.1 Amp x 110 volts

=11 watts x 1 kilo-watt (kW)/1,000 watts

= 0.011 kW

Based on assumption that these electrical components operate for 2 hours per 1,000 gallon gasoline dispensed, the total system electrical power consumption is calculated as:

P = 0.011 kW x 2 hours/1,000 gallon

= 0.022 kWh/1,000 gallon

Based on PG&E electric power generation factor, indirect GHG emissions are:

0.022 kWh/1,000 gallon x 0.524 lb-$CO_2$e/kWh = 0.0115 lb-$CO_2$e/1,000 gallon

Total GHG Emissions:

Therefore, total GHG emissions from Phase II vapor recovery system with VST Vapor Polisher (VR-203 or VR-204) are:

Total GHG emissions = Direct GHG + Indirect GHG
= (0.0143 lb-$CO_2$e/1,000 gallon) + 0.0115 lb-$CO_2$e/1,000 gallon
= 0.0258 lb-$CO_2$e/1,000 gallon

Potential GHG emission reduction as compared to BEF per unit of activity ($G_a$) is calculated as:

$G_a$ = BEF - Total GHG emissions
= 3.435 - 0.0258
= 3.409 lb-$CO_2$e/1,000 gallon

Potential GHG emission reduction as a percentage of the BEF per unit of activity ($G_p$) is calculated as:

$G_p$ = $G_a$ / BEF = 3.409 / 3.435 x 100 = 99.25 %

Appendix C-7

#### 4. VST with Healy Clean Air Separator (VR-209):

**Basis:**

1,000 gallons of gasoline dispensed.

**Assumptions:**

- The direct GHG emissions from this class are methane emissions included in the gasoline vapors. As calculated in Appendix I, methane emissions in terms of $CO_2$ equivalent emissions are 0.0143 lb-$CO_2$e/1,000 gallon gasoline dispensed.

- Indirect GHG emissions are zero since balance systems do not use any electric motor-driven vacuum pump to draw vapors.

**Calculations:**

Total GHG emissions = Direct GHG + Indirect GHG
$$= (0.0143 \text{ lb-}CO_2\text{e/1,000 gallon}) + 0$$
$$= 0.0143 \text{ lb-}CO_2\text{e/1,000 gallon}$$

Potential GHG emission reduction as compared to BEF per unit of activity ($G_a$) is calculated as:

$G_a$ = BEF - Total GHG emissions
$$= 3.435 - 0.0143$$
$$= 3.421 \text{ lb-}CO_2\text{e/1,000 gallon}$$

Potential GHG emission reduction as a percentage of the BEF per unit of activity ($G_p$) is calculated as:

$G_p = G_a / \text{BEF} = 3.421 / 3.435 \ \times 100 = 99.58 \%$

# APPENDIX D

## Initial Public Process

## Notice Of Development Of
# Best Performance Standards

NOTICE IS HEREBY GIVEN that the San Joaquin Valley Air Pollution Control District solicits public comment on development of Best Performance Standards for the following Stationary Source class and category of greenhouse gas emissions:

## GASOLINE DISPENSING FACILITIES
### Subject to District Permitting Requirements

The District is soliciting public input on the following topics for the subject Class and Category of greenhouse gas emission source:

- Recommendations regarding the scope of the proposed Class and Category (Stationary GHG sources group based on fundamental type of equipment or industrial classification of the source operation),
- Recommendations regarding processes or operational activities the District should consider when establishing Baseline Emissions for the subject Class and Category,
- Recommendations regarding processes or operational activities the District should consider when converting Baseline Emissions into emissions per unit of activity, and
- Recommendations regarding technologies to be evaluated by the District, when establishing Best Performance Standards for the subject Class and Category.

Information regarding development of Best Performance Standard for the subject Class and Category of greenhouse gas emission source can be obtained from the District's website at http://www.valleyair.org/Programs/CCAP/CCAP_idx.htm.

To facilitate public comment, the District has prepared a draft Best Performance Standards document for the subject stationary source class and category of greenhouse gas emissions. This document can be downloaded from the District's website at http://www.valleyair.org/Programs/CCAP/CCAP_idx.htm.

Written comments regarding the subject Best Performance Standard should be addressed to Sajjad Ahmad by email, Sajjad.Ahmad@valleyair.org, or by mail at SJVUAPCD, 1990 East Gettysburg Avenue, Fresno, CA 93726 and must be received by **February 23, 2010**. For additional information, please contact Sajjad Ahmad by e-mail or by phone at (559) 230-5903.

Information regarding the District's Climate Action Plan and how to address GHG emissions impacts under CEQA, can be obtained from the District's website by clicking on http://www.valleyair.org/Programs/CCAP/CCAP_idx.htm.

| From: | Sajjad Ahmad | | Sent: Fri 2/19/2010 4:52 PM |
|---|---|---|---|

**To:** HirtVCS@aol.com; demmington@veeder.com; kreid@veeder.com; walker@vsthose.com; brown@vsthose.com; nelson@franklinfueling.com; trondson@franklinfueling.com; walsh@franklinfueling.com; rbenscoter@husky.com; wburnett@husky.com; jlaschke@husky.com; JERodriguezSD@aol.com; jgrubb@barghausen.com; ainigues@barghausen.com; richardw@franzen-hill.com; john_moore@banks-co.com; lctesting@yahoo.com; cyork@rrmsc.com; charleiyork@gmail.com; anthony@tritonsc.com; zmann100@hotmail.com; mike.eliason@vpps.net

**Cc:** Jim Swaney; Arnaud Marjollet; Resa Garcia; Patia Siong; Sajjad Ahmad; Sheraz Gill

**Subject:** Notice of Development of Best Performance Standards (BPS)

The San Joaquin Valley Air Pollution Control District is soliciting public input on the development of Best Performance Standards. The Notice of Development for Gasoline Dispensing Facilities is available here.

Written comments regarding the subject Best Performance Standard should be addressed to Sajjad Ahmad by email, Sajjad Ahmad@valleyair.org, or by mail at SJVUAPCD, 1990 East Gettysburg Avenue, Fresno, CA 93726 and must be received by **February 23, 2010**. For additional information, please contact Sajjad Ahmad by e-mail or by phone at (559) 230-5903.

The San Joaquin Valley Air Pollution Control District created several list serves for stakeholders and other interested parties to register in order to receive e-mail notifications regarding the establishment of Best Performance Standards (BPS) for stationary sources and characterization of emission reduction measures for land-use development projects.

To participate in the development of BPS for gasoline dispensing operation, please sign up by clicking on the following link below :

**Gasoline Dispensing Facilities BPS :** Please click here to register.

Appendix D-3

From:    gasoline_dispensing_facilities_bps@lists.valleyair.org        Sent:  Thu 2/25/2010 11:49 AM

To:    Sajjad Ahmad

Cc:

Subject:  [Gasoline_Dispensing_Facilities_BPS] (no subject)

Attachments:  📄 ATT2090529.txt (786 B)

## Dear Interested Parties:

The San Joaquin Valley Air Pollution Control District is soliciting public input on the development of Best Performance Standards.  The Notice of Development for Gasoline Dispensing Facilities is available <u>here</u>.

The information requested below will be used when establishing Best Performance Standards for the subject Class and Category:

- Total electricity usage of various ARB certified Phase II EVR vapor recovery systems for underground gasoline storage tanks.  This information is required to determine indirect greenhouse gas emissions for a specific system.
- For ARB certified Phase II EVR systems involved with combustion emissions, the data is required to calculate both direct and indirect greenhouse gas (GHG) emissions.  Direct GHG emissions would be calculated based on combustion process and indirect GHG emissions would be calculated based on total electricity usage.
- Any other suggestions to better evaluate BPS.

## *Extension of Initial Commenting Period:*

The District is **extending** the initial commenting period regarding development of Best Performance Standards (BPS) for Gasoline Dispensing Facilities.

Written comments regarding the subject Best Performance Standard should be addressed to Sajjad Ahmad by email, <u>Sajjad.Ahmad@valleyair.org</u>, or by mail at SJVUAPCD, 1990 East Gettysburg Avenue, Fresno, CA 93726 and must be received by **March 4, 2010**.  For additional information, please contact Sajjad Ahmad by e-mail or by phone at (559) 230-5903.

Thank you for your cooperation in this matter.

# APPENDIX E

## ARB's EVR Timeline

EVR Timeline    (updated June 2006)

Phase I EVR System

Phase II EVR Standards & Specifications

Unihose Dispenser

ORVR (>2.0 mil gal/yr)

ORVR (>1.0 mil gal/yr)

ORVR (<1.0 mil gal/yr)

Liquid Retention - 350 ml

Liquid Retention - 100 ml

Nozzle Spitting

Spillage

Dripless Nozzle

ISD (>1.8 million gal/yr)

ISD (> 600,000 gal/yr)

Dotted box: time between start of 4-year clock and operative date

Start of solid bar: date required for new or modified facilities (operative date)

End of solid bar: date required for existing facilities (installed before start of bar)

Not required for dispensers installed before April 2003

# APPENDIX F

## Public Comments Received and District Responses

# Public Comments and District's Response

Comments received and District responses are stated below:

**1) Dedek**  *(From Dave Deckman, Director of Air Quality Services, Dudek.
Received on March 1, 2010 via email.)*

**Comment:**

I noticed in the draft BPS for gasoline dispensing facilities that the District is
evaluating carbon monoxide as a greenhouse gas, apparently because it would
oxidize to carbon dioxide (a designated greenhouse gas under AB 32) in the
atmosphere. I am curious about this approach because I have not seen any air
quality agency or environmental group suggest that carbon monoxide emissions
from a CEQA project should be included in the greenhouse gas analysis. As you
many know, carbon monoxide emissions from development projects (i.e.,
residential/commercial development) can be substantial for large projects.

Nonetheless, these emissions, from personal experience, have not been
questioned as greenhouse gases or precursors. Furthermore, your analysis
shows that carbon monoxide emissions are less than 0.1 percent of the carbon
dioxide emissions. This is certainly with the margin of error for estimating carbon
dioxide emissions, which are typically based on the assumed percentage of
carbon in a fuel that is oxidized to carbon dioxide, along with other assumptions
you have made to calculate the Baseline Emission Factor.

**Response:**

The District concurs that carbon monoxide is not currently designated as GHG
and carbon monoxide calculations were included as GHG in error.  Therefore,
GHG emission calculations have been revised to exclude carbon monoxide
emissions.

## 2) <u>Vapor Systems Technologies, Inc. (VST)</u>

*From Glenn Walker, President, Vapor Systems Technologies, Inc. (VST).
Received on March 8, 2010 via email and via mail on March 9, 2010.*

**Comment #1:** (*Received on March 8, 2010*)

Pg. 4 III. Step 1. A. Representative Baseline Operation – Current CARB data shows that the penetration of assist systems statewide is approximately 70%, with the rest of the GDFs having balance systems – this is of course statewide not San Joaquin Valley but should a baseline be established with data from 2002-2004 or with more current data?

**Response:**

As discussed in Section IV, Step 1 of this document (page 6), the data for years 1999, and 2004 through 2008 was used to establish baseline emission factor (BEF) for 2002-04. As shown in Table 3 (page 6) of this document, the data show a fairly constant gasoline throughput distribution among various systems. Therefore, there would be no significant difference in BEF calculations in using data from 2002-04 or most recent years.

Further it was determined that during baseline period of 2002-04 only 33% of GDFs, within the District, were equipped with vacuum assist systems with only 35% of total gasoline dispensed. Since District can only use data within its own jurisdiction, no state wide data will be used to establish BEF.

**Comment #2:** (*Received on March 8, 2010*)

For the calculations for the GHG Emissions – VST would propose considering:
   a. GHG associated with producing vapor pumps
   b. GHG associated with installing and maintaining the equipment—in addition to the capital cost there is a replacement cost including equipment, labor, travel, disposal of the equipment etc

**Response to VST Comments #2a and 2b:**

Production of vapor pumps, and installation and maintenance of the equipment are short term activities when compared to long term project operation over the life of the project. GHG emissions associated with these activities are classified as 'project life cycle emissions' pursuant to District's 'Final Staff Report – Climate Change Action Plan; Addressing GHG Emissions Impacts under CEQA'. The report describes the project life cycle emissions as: emissions generated during the entire life cycle of the project: ranging from mining of raw materials,

processing those materials into steel, manufacturing of equipment, to shipment and installation of equipment at the project site, etc.

The Final Staff Report further discusses quantifying project life cycles emissions as: "While use of raw materials for construction and operation is an indirect consequence of a project, the emissions and potential environmental impacts associated with the production and transportation of raw materials is unknown and estimation of said emissions is highly speculative. The quantification of emissions associated with raw material usage is likely to be double-counted when developing emission inventories for industrial sources. The source of the raw materials and/or manufacturing processes associated with raw material usage may occur outside the state and is not included in the emissions inventory for the state and therefore should not be included in the emissions inventory for the project for the purposes of CEQA.

Substantial research would be required to minimize the speculative nature of trying to characterize indirect emissions for each project. Project proponents would have to determine the origin of the materials used during the construction and/or operation of the project. Additional research would be necessary to gather emission rates for the international vehicles (ship, aircraft, trains, trucks, etc.), global energy production, global industrial processes, and other GHG emitting processes. Even if this information is compiled, the resulting estimates represent an insignificant percentage, as compared to direct project emission."

Therefore, GHG associated with these categories will not be considered at this time.

**Comment #2c:** (*Received on March 8, 2010*)

For the calculations for the GHG Emissions – VST would propose considering:
   c. Regulatory compliance cost – reduction of over pressurization caused by active systems versus passive. VST has two test sites in operation that have demonstrated zero regulation issues as well as zero downtime.

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**Response to VST Comment #2c:**

When determining that a particular GHG reduction measure has been Achieved-in-Practice, the District considers the extent to which grants or other financial subsidies influence economic feasibility of a specific technology or GHG reduction measure. 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.

The regulatory issues along with associated downtime are highly unpredictable. In addition, all currently ARB certified Phase II EVR vapor recovery systems have already been shown to be Achieved-in-Practice, there is no need to include the regulatory costs associated with each system.

**Comments #3 through 8:** (*Received on March 8, 2010)*

Corrections to Content:

3. Pg. 6 Table 2 #4 is incorrect in the Phase II Vapor Recovery System - it should read VST instead of EMCO Wheaton for VR-209
4. Pg. 8 Table 4 #2 is incorrect in the Control Measure – it should read VST with Healy Clean Air Separator for VR-209
5. Appendix 6 – #1 pg. 2 in the sentence – "Therefore, the total GHG from Phase II vapor recovery system with Hirt Burner are:" It should read "…with Clean Air Separator…"
6. Appendix 6 - #2 pg 2 in the sentence - "Therefore, the total GHG from Phase II vapor recovery system with Hirt Burner are:" It should read "…with VST Membrane Processor…"
7. Appendix 6 - #2 pg 3 in the sentence - "Total GHG from Healy (VR-201, VR-202)" It should read "…from VST (VR-203, VR-204)…"
8. Appendix 6 - #4 pg. 3 the title reads – "EMCO Wheaton with Healy Clean Air Separator" – it should read "VST with Healy Clean Air Separator"

**Response to VST Comments #3 through 8:** The comments to correct the names of various Phase II vapor recovery systems throughout the first draft BPS evaluation have been incorporated as suggested.

## 3) <u>Hirt Combustion Engineers, Inc.</u>

*From Thomas J. Smith, Chief Engineer, Hirt Combustion Engineers, Inc.*

<u>Comment #1:</u> (*Received on February 26, 2010*)

The Hirt VCS 100 processor is a thermal oxidizer, not a burner. A burner is used in a backyard barbecue. The thermal oxidizer is a very sophisticated device used to reduce emissions to a few ppm.

<u>Response:</u>

The word 'burner' has been replaced by 'thermal oxidizer' for all Hirt and Hasstech processors in the BPS evaluation.

<u>Comment #2:</u> (*Received on February 26, 2010*)

There has been a significant omission made for the analysis of greenhouse gases for the EVR systems, especially the systems defined by VR 201, 202, 203, 204, and 209. Such systems just barely met the 95% control standard. They emit lots of hydrocarbons, such as methane. Methane and other vaporous hydrocarbons are much more effective greenhouse gases than $CO_2$. If the concern is truly greenhouse gas emissions, then such gases need to be evaluated. In fact, there was a study regarding methane emissions from cows for that same reason. Certainly, if indirect $CO_2$ emissions are getting evaluated, then the hydrocarbon emissions should be considered.

<u>Response:</u>

The District staff worked with ARB staff in ARB's Climate Change Division and concurred that methane is the only hydrocarbon in petroleum fractions that is currently designated as GHG. None of the other higher hydrocarbons are designated as GHG. ARB staff at ARB's Fuel Division provided fuel data (see Appendix G) indicating that no methane is present in gasoline. However, ARB's staff in Monitoring and Laboratory Division indicated that although no methane is present in the liquid gasoline, significant concentration of methane is detected in gasoline vapors. This was detected during Hirt VCS 100 system certification process at two test sites in Sacramento and Stockton (see Appendix H). However, no justification was provided about the source of methane in the gasoline vapors. As a conservative measure, the District has decided to add methane emissions in GHG calculations, based on ARB's report. Thus GHG calculations have been revised to include methane emissions from all systems (see Appendix I for methane emission calculations).

**Comment #3:** (*Received on April 9, 2010*)

I believe your numbers don't reflect the hydrocarbons, such as methane, emitted from the various EVR Stage II systems.  The CARB requirement for efficiency is 95%.  Many systems, just barely met the standard.  Also, the system in widespread use has shown to have storage tank overpressure problems that are marked by the ISD systems.  In other word, Fugitive Emissions.  However, the Hirt VCS 100 processor with Emco Wheaton/Goodyear hanging hardware showed an efficiency over 99%.  When the throughput of the various sites is factored in, this difference of about 4 % becomes substantial.  With over a billion gallons of gasoline dispensed every month in California, that is a lot of methane.  If I remember my chemistry, methane that is 8x more effective as a greenhouse gas than $CO_2$!

**Response:**

As described under response to comment #2 above, the District has revised the GHG calculations to include methane emissions from all systems (see Appendix I for methane emission calculations).  However, since all ARB certified Phase II EVR vapor recovery systems are required to achieve a minimum vapor control efficiency of 95%, the District is using this required efficiency.

**Comment #4:** (*Received on May 4, 2010*)

If all systems are equal at 95%, then the logical discussion is as follows:

Clearly, our system emits $CO_2$ when the thermal oxidizer is on operation.  However, the other systems must emit the same $CO_2$.  If a system uses more electricity than our system, an indirect emission will be from a distant electrical power plant, perhaps consuming a fossil fuel.  (Probably a minor difference.)  But, that is only a small part of the story.

What do the other systems, like the Healy bladder tank and Veeder Root carbon canister do? The vapor goes in their "processor", and then goes out of their "processor", without any real processing occurring.  If all systems operate at about 95% then something is missing.

The part nobody is looking at is the automobile.  The "extra vapor" is collected by the vehicle's ORVR system.  Then, when the vehicle takes off down the road, the ORVR system sends that vapor into the engine - where it is converted (processed?) into $CO_2$ and sent out the exhaust pipe.  This $CO_2$ emission needs to be accounted for and included with the Stage II vapor recovery system's total.  Such $CO_2$ is certainly significant compared to a VCS 100 and should level the discussion.  In other words, it seems rather hypocritical to say "burners are bad, they emit greenhouse gases - especially that Hirt VCS 100" and then jump in a mobile burner with wheels and drive down the road.

And what does the Hirt processor do when an ORVR equipped vehicle is refueled?  Nothing. It sits idle emitting nothing.

## Response:

As described under response to comment #3 above, since all ARB certified Phase II EVR vapor recovery systems are required to achieve a minimum vapor control efficiency of 95%, the District is using this required efficiency.  With regard to $CO_2$ emitted by motor vehicles, the GHG emissions associated with the operation of motor vehicles are independent of GHG emitted by the GDF operation addressing excess gasoline vapors.

# APPENDIX G

## Gasoline Fuel Analysis

# CRC Report No. E-65-3

# FUEL PERMEATION FROM AUTOMOTIVE SYSTEMS: E0, E6, E10, E20 AND E85

## Final Report

## December, 2006

**COORDINATING RESEARCH COUNCIL, INC.**

3650 MANSELL ROAD·SUITE 140·ALPHARETTA, GA 30022

# FUEL PERMEATION FROM AUTOMOTIVE SYSTEMS: E0, E6, E10, E20 and E85

**Final Report**
**CRC Project No. E-65-3**

December, 2006

Prepared by:

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Milford, Michigan

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**Automotive Testing Laboratories, Inc.**
Mesa, Arizona

### III. The Project and Procedures

#### Fuels

Six test fuels were blended for the CRC E-65-3 follow-up project. All of the low-level ethanol blends (i.e., E0-E20) were made from California blending components and were targeted at California summer fuel characteristics with vapor pressures targeted at 7.0 psi. The gasoline used to blend the E85 fuel was a high vapor pressure conventional gasoline, but butane still had to be added to the blend to approach the target 7.0 psi vapor pressure. These fuels were:

| Tag | Description |
|-----|-------------|
| E0 | Non-oxygenated base fuel |
| E6 | 5.7 Volume% ethanol fuel (2 Weight% oxygen) |
| E6Hi | 5.7 Volume% ethanol fuel with increased aromatics content |
| E10 | 10 Volume% ethanol fuel |
| E20 | 20 Volume% ethanol fuel |
| E85 | 85 Volume% ethanol fuel |

The basic inspections of the six test fuels are shown in Table 3.

Table 3
Test Fuel Inspections

| Inspection | Units | E0 | E6 | E6Hi | E10 | E20 | E85 |
|------------|-------|------|------|------|------|------|------|
| API Gravity | °API | 61.4 | 58.8 | 52.3 | 58.3 | 55.4 | 48.6 |
| Relative Density | 60/60°F | 0.7334 | 0.7434 | 0.7699 | 0.7455 | 0.7572 | 0.7855 |
| DVPE | psi | 7.00 | 7.25 | 7.19 | 7.17 | 7.06 | 6.80 |
| Oxygenates--D 4815 | | | | | | | |
| MTBE | vol % | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ETBE | vol % | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 |
| EtOH | vol % | 0.00 | 6.02 | 6.28 | 10.29 | 19.82 | 84.69 |
| MeOH | vol % | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.83 |
| O2 | wt % | 0.00 | 2.23 | 2.25 | 3.81 | 7.23 | 29.73 |
| FIAM Corrected--D 1319 | | | | | | | |
| Aromatics | vol% | 22.57 | 26.79 | 41.47 | 26.03 | 26.18 | 3.86 |
| Olefins | vol% | 10.70 | 4.91 | 3.32 | 4.77 | 4.85 | 1.57 |
| Saturates | vol% | 66.73 | 62.24 | 50.45 | 58.83 | 49.23 | 9.82 |
| Oxygenates | vol% | 0.00 | 6.02 | 6.28 | 10.31 | 19.94 | 85.21 |
| Aromatics--D 5580 | | | | | | | |
| Benzene | vol% | 0.41 | 0.55 | 0.43 | 0.51 | 0.70 | 0.17 |
| Toluene | vol% | 5.26 | 6.84 | 5.25 | 6.50 | 8.31 | 0.67 |
| Ethylbenzene | vol% | 1.08 | 1.46 | 1.13 | 1.39 | 1.71 | 0.15 |
| p/m-Xylene | vol% | 4.67 | 5.38 | 4.21 | 5.13 | 6.01 | 0.59 |
| o-Xylene | vol% | 1.67 | 1.98 | 1.81 | 1.89 | 2.14 | 0.22 |
| C9+ | vol% | 8.86 | 10.01 | 25.71 | 9.52 | 7.55 | 2.02 |
| Total | vol% | 21.96 | 26.22 | 38.55 | 24.93 | 26.42 | 3.82 |

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Table 3 (Continued)
**Test Fuel Inspections**

| Inspection | Units | E0 | E6 | E6Hi | E10 | E20 | E85 |
|---|---|---|---|---|---|---|---|
| D 86 Distillation | | | | | | | |
| IBP | °F | 101.1 | 108.9 | 98.0 | 107.7 | 112.1 | 116.8 |
| 5% Evaporated | °F | 123.2 | 125.8 | 124.8 | 127.2 | 130.6 | 153.5 |
| 10% Evaporated | °F | 134.5 | 130.7 | 132.1 | 132.1 | 135.8 | 164.0 |
| 20% Evaporated | °F | 148.5 | 136.8 | 142.4 | 138.2 | 143.4 | 168.7 |
| 30% Evaporated | °F | 165.0 | 144.8 | 159.0 | 144.7 | 149.7 | 170.4 |
| 40% Evaporated | °F | 186.2 | 175.8 | 206.3 | 150.8 | 155.1 | 171.2 |
| 50% Evaporated | °F | 209.5 | 202.0 | 241.9 | 182.6 | 159.6 | 171.5 |
| 60% Evaporated | °F | 231.1 | 225.6 | 274.0 | 221.8 | 165.9 | 171.8 |
| 70% Evaporated | °F | 251.2 | 249.3 | 302.8 | 246.0 | 234.6 | 172.0 |
| 80% Evaporated | °F | 273.4 | 275.7 | 324.5 | 273.3 | 257.9 | 172.4 |
| 90% Evaporated | °F | 305.6 | 309.9 | 345.3 | 309.4 | 291.1 | 173.1 |
| 95% Evaporated | °F | 330.6 | 335.9 | 363.2 | 335.7 | 312.4 | 174.1 |
| EP | °F | 389.9 | 380.4 | 411.4 | 378.3 | 352.0 | 297.4 |
| Recovery | vol % | 97.7 | 97.6 | 97.2 | 98.0 | 97.3 | 97.1 |
| Residue | vol % | 1.0 | 1.0 | 1.2 | 1.1 | 1.0 | 1.9 |
| Loss | vol % | 1.3 | 1.4 | 1.5 | 0.8 | 1.7 | 1.0 |
| | | | | | | | |
| Karl Fischer Water | wt % | - | - | - | - | - | 0.42 |

**Additional Inspections**

| Fuel | | Units | E0 | E6 | E6Hi | E10 | E20 | E85 |
|---|---|---|---|---|---|---|---|---|
| Gum | | | | | | | | |
| | Unwashed | mg/100ml | 20 | 16 | 18 | 17 | 19 | 9 |
| | Washed | mg/100ml | 1 | 1 | 0 | 0 | 0 | 0 |
| | | | | | | | | |
| Peroxide Number | | ppm | <1 | <1 | <1 | 1.0 | <1 | 4.4 |
| | | | | | | | | |
| Induction Period | | Hr | 24 | 24 | 24 | 24 | 24 | 24 |
| | | | | | | | | |
| Potential Gum | | | | | | | | |
| | Unwashed | mg/100ml | 22 | 22 | 24 | 20 | 19 | 7 |
| | Washed | mg/100ml | 0 | 0 | 0 | 0 | 0 | 2 |
| | | | | | | | | |
| Research ON | | | 90.5 | 92.1 | 96.2 | 94.5 | 98.7 | 105.8 |
| | | | | | | | | |
| Motor ON | | | 83.2 | 84.2 | 86.2 | 86.4 | 86.6 | 89.2 |
| | | | | | | | | |
| (R+M)/2 | | | 86.9 | 88.2 | 91.2 | 90.5 | 92.7 | 97.5 |

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Complete speciation analyses of the fuels were also furnished, and the files are available with the following names:

| Tag | File Name |
|-----|-----------|
| E0 | E0-FR41677-LDR |
| E6 | E6-FR41678-LDR |
| E6Hi | E6High-FR41785-LDR |
| E10 | E10-FR41681-LDR |
| E20 | E20-FR43560-LD |
| E85 | E85-FR42011-LDR |

Compositions of the E0 and low level ethanol blends are presented by hydrocarbon type and carbon number in Tables 4, 5 and 6 below.

Table 4
**Test Fuel Composition Comparison - Paraffins**

| | Paraffins by Volume % | | | | | | | | | |
|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| Fuel | C3- | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12+ |
| E0 | | 0.419 | 18.789 | 10.322 | 6.783 | 14.017 | 4.341 | 1.618 | 0.502 | 0.068 |
| E6 | | 0.163 | 14.938 | 17.492 | 8.016 | 9.732 | 3.613 | 0.919 | 0.442 | 0.031 |
| E6Hi | | 1.609 | 10.58 | 13.061 | 6.091 | 7.394 | 2.808 | 1.343 | 0.424 | 0.126 |
| E10 | | 0.150 | 14.22 | 16.649 | 7.753 | 9.15 | 3.412 | 0.865 | 0.417 | 0.027 |
| E20 | | 0.876 | 9.202 | 12.752 | 8.295 | 9.066 | 1.585 | 0.446 | 0.049 | 0.007 |

Table 5
**Test Fuel Composition Comparison - Olefins**

| | Olefins by Volume % | | | | | | | | | |
|------|-------|-------|-------|-------|-------|-------|-------|-----|-----|------|
| Fuel | C3- | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12+ |
| E0 | 0.029 | 0.101 | 2.025 | 5.126 | 0.579 | 0.514 | 0.013 | | | |
| E6 | | 0.013 | 0.914 | 1.613 | 0.771 | 0.347 | 0.007 | | | |
| E6Hi | | 0.008 | 0.66 | 1.197 | 0.595 | 0.273 | 0.007 | | | |
| E10 | | 0.011 | 0.876 | 1.509 | 0.727 | 0.324 | 0.007 | | | |
| E20 | 0.016 | 0.004 | 0.669 | 2.040 | 0.873 | 0.448 | | | | |

Appendix G-6

Table 9

| Rig: | 01E0 | | | | | |
|---|---|---|---|---|---|---|
| Test#: | 6389 | | | | | |

Detailed Hydrocarbon Speciation Results

| | | | MIR | 24-Hour Net mass | % total | Predicted |
|---|---|---|---|---|---|---|
| Elution No. | Species Name | CAS # | g O₃/g HC | (mg) | mass | Ozone mg |
| 81 | Toluene | 00108-88-3 | 3.97 | 14.321 | 17% | 56.85 |
| 18 | 2-Methylbutane (Isopentane) | 00078-78-4 | 1.67 | 10.787 | 13% | 18.01 |
| 111.1 | m-Xylene | 00108-38-3 | 10.61 | 8.835 | 10% | 93.74 |
| 21 | n-Pentane | 00109-66-0 | 1.53 | 3.666 | 4% | 5.61 |
| 117 | ortho-Xylene | 00095-47-6 | 7.48 | 2.951 | 3% | 22.08 |
| 111.2 | p-Xylene | 00106-42-3 | 4.24 | 2.591 | 3% | 10.99 |
| 36.1 | 2-MePentane | 00107-83-5 | 1.78 | 2.289 | 3% | 4.08 |
| 135.1 | 1,2,4-TriMeBenz | 00095-63-6 | 7.18 | 2.131 | 2% | 15.30 |
| 109 | Ethylbenzene | 00100-41-4 | 2.79 | 2.066 | 2% | 5.77 |
| 53 | Benzene | 00071-43-2 | 0.81 | 1.952 | 2% | 1.58 |
| 34 | 2,3-Dimethylbutane | 00079-29-8 | 1.13 | 1.514 | 2% | 1.71 |
| 128 | 1-Methyl-3-Ethylbenzene | 00620-14-4 | 9.37 | 1.501 | 2% | 14.06 |
| 40 | n-Hexane | 00110-54-3 | 1.43 | 1.475 | 2% | 2.11 |
| 63 | 2,2,4-TriMePentane (IsoOctane) | 00540-84-1 | 1.43 | 1.437 | 2% | 2.05 |
| 26 | 2-Methyl-2-butene | 00513-35-9 | 14.44 | 1.298 | 2% | 18.75 |
| | Ethanol | 00064-17-5 | 1.69 | 1.260 | 1% | 2.13 |
| 49 | Methylcyclopentane | 00096-37-7 | 2.40 | 1.244 | 1% | 2.99 |
| 56 | Cyclohexane | 00110-82-7 | 1.44 | 1.130 | 1% | 1.63 |
| 79 | 2,3,4-Trimethylpentane | 00565-75-3 | 1.22 | 0.986 | 1% | 1.20 |
| 74 | Methylcyclohexane | 00108-87-2 | 1.97 | 0.955 | 1% | 1.88 |
| 130 | 1,3,5-Trimethylbenzene | 00108-67-8 | 11.22 | 0.953 | 1% | 10.69 |
| 23 | t-2-Pentene | 00646-04-8 | 10.23 | 0.910 | 1% | 9.31 |
| 38 | 3-Methylpentane | 00096-14-0 | 2.06 | 0.905 | 1% | 1.87 |
| 9 | 2-Methylpropane | 00075-28-5 | 1.34 | 0.892 | 1% | 1.20 |
| 12 | n-Butane | 00106-97-8 | 1.32 | 0.874 | 1% | 1.15 |
| 86 | 3-Methylheptane | 00589-81-1 | 1.33 | 0.832 | 1% | 1.11 |
| 57 | 2-Methylhexane | 00591-76-4 | 1.36 | 0.809 | 1% | 1.10 |
| 42 | t-2-Hexene | 04050-45-7 | 8.35 | 0.754 | 1% | 6.30 |
| 59.2 | 3-Methylhexane | 00589-34-4 | 1.84 | 0.722 | 1% | 1.33 |
| 129 | 1-Methyl-4-Ethylbenzene | 00622-96-8 | 3.75 | 0.705 | 1% | 2.64 |
| 127 | n-Propylbenzene | 00103-65-1 | 2.20 | 0.661 | 1% | 1.45 |
| 136 | n-Decane | 00124-18-5 | 0.81 | 0.608 | 1% | 0.49 |
| 90 | 2,2,5-Trimethylhexane | 03522-94-9 | 1.31 | 0.541 | 1% | 0.71 |
| 96 | n-Octane | 00111-65-9 | 1.09 | 0.532 | 1% | 0.58 |
| 45.1 | c-2-Hexene | 07688-21-3 | 8.35 | 0.520 | 1% | 4.34 |
| 83 | 2-Methylheptane | 00592-27-8 | 1.18 | 0.500 | 1% | 0.59 |
| 66 | n-Heptane | 00142-82-5 | 1.26 | 0.495 | 1% | 0.62 |
| 77 | 2,4-Dimethylhexane | 00589-43-5 | 1.79 | 0.476 | 1% | 0.85 |
| 29 | 2,2-Dimethylbutane | 00075-83-2 | 1.33 | 0.465 | 1% | 0.62 |
| 50 | 2,4-Dimethylpentane | 00108-08-7 | 1.63 | 0.447 | 1% | 0.73 |
| 58 | 2,3-Dimethylpentane | 00565-59-3 | 1.53 | 0.376 | 0% | 0.58 |

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Table 9 (continued)

| Detailed Hydrocarbon Speciation Results | | | | 24-Hour | | |
|---|---|---|---|---|---|---|
| Elution No. | Species Name | CAS # | MIR g O₃/g HC | Net mass (mg) | % total mass | Predicted Ozone mg |
| 133 | 1-Ethyl-2-Methylbenzene | 00611-14-3 | 6.61 | 0.365 | 0% | 2.41 |
| 25 | c-2-Pentene | 00627-20-3 | 10.23 | 0.361 | 0% | 3.69 |
| 115 | Styrene | 00100-42-5 | 1.94 | 0.346 | 0% | 0.67 |
| 14 | t-2-Butene | 00624-64-6 | 13.90 | 0.331 | 0% | 4.60 |
| 84.2 | 4-MeHeptane | 00589-53-7 | 1.46 | 0.321 | 0% | 0.47 |
| 113 | 3-Methyloctane | 02216-33-3 | 1.42 | 0.257 | 0% | 0.36 |
| 140 | 1,2,3-Trimethylbenzene | 00526-73-8 | 11.25 | 0.239 | 0% | 2.69 |
| 39.1 | 2-Methyl-1-pentene | 00763-29-1 | 5.15 | 0.235 | 0% | 1.21 |
| 48 | 2,2-Dimethylpentane | 00590-35-2 | 1.21 | 0.199 | 0% | 0.24 |
| 16 | c-2-Butene | 00590-18-1 | 13.22 | 0.184 | 0% | 2.44 |
| 20 | 2-Methyl-1-butene | 00563-46-2 | 6.47 | 0.179 | 0% | 1.16 |
| 1 | Methane | 00074-82-8 | 0.01 | 0.124 | 0% | 0.00 |
| 76.1 | 2,5-DiMeHexane | 00592-13-2 | 1.66 | 0.121 | 0% | 0.20 |
| 30 | Cyclopentene | 00142-29-0 | 7.32 | 0.099 | 0% | 0.72 |
| 19.1 | 1-Pentene | 00109-67-1 | 7.73 | 0.096 | 0% | 0.74 |
| 76.2 | EtCyPentane | 01640-89-7 | 2.25 | 0.062 | 0% | 0.14 |
| 39.2 | 1-Hexene | 00592-41-6 | 6.12 | 0.033 | 0% | 0.20 |
| | | | Mass w/MIR Values | 81.9 | 95.7% | 352.7 |
| | | | | Specific Reactivity | | 4.31 |
| 43 | 3-Methyl-t-2-pentene | 00616-12-6 | | 1.196 | 1% | |
| 47 | Unknown #16 | | | 0.686 | 1% | |
| 61 | 3-Methyl-c-2-pentene | 00922-62-3 | | 0.534 | 1% | |
| 82.2 | c-1,3-Dimethylcyclopentane | 02532-58-3 | | 0.330 | 0% | |
| 88 | 2-Me-3-Et-pentane | 00609-26-7 | | 0.316 | 0% | |
| 36.2 | c-1,3-Dimethylcyclohexane | 00638-04-0 | | 0.288 | 0% | |
| 62 | 4-Me-c-2-Pentene | 00691-38-3 | | 0.140 | 0% | |
| 45.2 | t-1,2-Dimethylcyclopentane | 00822-50-4 | | 0.130 | 0% | |
| 123 | 3-MeCyclopentene | 01120-62-3 | | 0.069 | 0% | |
| | | | Mass w/o MIR Values | 3.69 | 4.3% | |
| 4 | Ethane | 00074-84-0 | | 0.000 | 0% | |
| 2 | Ethylene | 00074-85-1 | | 0.000 | 0% | |
| 3 | Acetylene (Ethyne) | 00074-86-2 | | 0.000 | 0% | |

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# APPENDIX H

## ARB Source Test Report ST-09-10

# Air Resources Board

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TO: Pat Bennett, Manager
Vapor Recovery Certification Section
Monitoring and Laboratory Division

FROM: Angus MacPherson, Manager
Testing and Certification Section
Monitoring and Laboratory Division

DATE: August 10, 2009

SUBJECT: $NO_x$, $CO_2$ and CO EMISSIONS, HIRT MODEL VCS-100

Enclosed please find a copy of the Air Resources Board report titled: "$NO_x$, $CO_2$ and CO EMISSIONS FROM TWO HIRT MODEL VCS-100 PHASE II EVR GASOLINE VAPOR PROCESSORS." The processors are located at the Emco Wheaton phase II EVR certification site in Sacramento, California and ARCO phase II EVR certification site in Stockton, California. Testing and Certification Section staff collected $NO_x$, $CO_2$ and CO emissions data in support of formaldehyde testing for the two Hirt processors November 3, 2008 and December 3, 2008.

The final report presents $NO_x$, $CO_2$ and CO emissions data for the two Hirt VCS-100 processors and describes the sampling methodology employed in collecting the emissions data. Questions regarding the report may be directed to me at (916) 445-4686 or amacpher@arb.ca.gov.

Enclosure

California Environmental Protection Agency

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California Environmental Protection Agency

# Air Resources Board

MONITORING AND LABORATORY DIVISION

SOURCE TEST REPORT NUMBER ST-09-10

$NO_X$, $CO_2$ and CO EMISSIONS FROM TWO HIRT MODEL VCS – 100
PHASE II EVR GASOLINE VAPOR PROCESSORS

TEST DATES: November 3rd, 2008
December 3rd, 2008

REPORT DATE: August 10th, 2009

Prepared by:

Angus S. MacPherson, P.E.
Testing and Certification Section
Monitoring and Laboratory Division

This report has been reviewed by the staff of the California Air Resources Board and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

## SUMMARY

The Air Resources Board (ARB) Monitoring and Laboratory Division (MLD) determined nitrogen oxides ($NO_x$), carbon dioxide ($CO_2$) and carbon monoxide (CO) emissions from the exhausts of two Hirt model VCS-100 phase II enhanced vapor recovery (EVR) thermal processors. The processors are located at the Hirt/Emco Wheaton EVR certification gasoline dispensing facility (GDF) in Sacramento, California and the Hirt/VST EVR certification GDF in Stockton, California. Testing was performed November 3, 2008 in Sacramento and December 3, 2008 in Stockton.

The results presented in this report were compiled from tests intended to determine aldehyde emissions from the two Hirt VCS–100 processors, as required by ARB Certification Procedures for Vapor Recovery Systems of Gasoline Dispensing Facilities. $NO_x$ emissions were measured, using ARB Method 100, for quality assurance reasons. $NO_x$ is an ozone precursor, and $NO_2$ is a potential interference to aldehyde analysis[1]. $CO_2$ and CO concentrations were measured, using USEPA Method 2B, for use as intermediate values in calculating processor exhaust flow rate and aldehyde mass emission rates. The $NO_x$, $CO_2$ and CO emissions measured during the aldehyde emissions tests are presented to provide interested parties with the information available regarding emissions from these processors.

$NO_x$, $CO_2$ and CO emission rates determined in triplicate for the Hirt model VCS–100 vapor processor at the Sacramento certification site are summarized in Table S-1. $NO_x$ emissions averaged 10 parts per million (ppm) and 0.0049 pounds per hour (lb/hr). $CO_2$ emissions averaged 1.6 percent (%) and 7.5 lb/hr. CO emissions averaged 12 ppm and 0.0036 lb/hr. The average processor run time and exhaust flow rate were 1137 seconds and 68.5 dry standard cubic feet per minute (dscfm). The average non-methane hydrocarbon (NMHC) and methane concentrations in the vapor metered to the processor were 33.0% and 1.3%, respectively.

$NO_x$, $CO_2$ and CO emission rates determined in triplicate for the Hirt model VCS–100 vapor processor at the Stockton certification site are summarized in Table S-2. $NO_x$ emissions averaged 21 ppm and 0.0013 lb/hr. $CO_2$ emissions averaged 2.41 % and 14.9 lb/hr. CO emissions averaged 1 ppm and 0.0005 lb/hr. The average processor run time and exhaust flow rate were 1197 seconds and 90.3 dscfm. The average NMHC and methane concentrations in the vapor metered to the processor were 52.4% and 3.0%, respectively.

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[1] Formaldehyde measurements by the DNPH methods: A review by the testing and monitoring workgroup July 8, 1997
http://www.epa.gov/ttn/atw/iccr/dirss/formald1.pdf

**Summary Table S-1**
**NOx, CO2 and CO Emissions Profile**
**Hirt Model VCS - 100 Phase II EVR Thermal Processor Unit**
**Hirt / Emco Wheaton EVR Certification Site, Sacramento, California**
**November 3, 2008**

| Date | Time | Processor Inlet | | | Processor Run Time | Exhaust Flow Rate | Processor Exhaust Emissions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $C_3H_8$ (%) | $CH_4$ (%) | Vol (scf) | (sec) | (dscfm) | $NO_x$ (ppm) | (lb/hr) | $CO_2$ (%) | (lb/hr) | CO (ppm) | (lb/hr) |
| 3-Nov-08 | 1200-1250 | 33.5 | 1.3 | 22.3 | 1260 | 67.3 | 9.5 | 0.0046 | 1.6 | 7.5 | 9.9 | 0.0029 |
| 3-Nov-08 | 1300-1340 | 32.5 | 1.3 | 17.2 | 979 | 67.9 | 10 | 0.0050 | 1.6 | 7.4 | 11 | 0.0034 |
| 3-Nov-08 | 1350-1430 | 33.1 | 1.2 | 20.6 | 1172 | 70.3 | 10 | 0.0051 | 1.5 | 7.4 | 14 | 0.0044 |
| **Average:** | | **33.0** | **1.3** | **20.1** | **1137** | **68.5** | **10** | **0.0049** | **1.6** | **7.5** | **12** | **0.0036** |

Notes:

$NO_x$ – Oxides of nitrogen, reported as $NO_2$, molecular weight = 46.
$CO_2$ – Carbon dioxide, molecular weight = 44.
CO – Carbon monoxide, molecular weight = 28.
lb/hr – Pounds per hour.
ppm – Parts per million by volume.
dscfm – Dry standard cubic feet per minute.
$C_3H_8$ – Processor inlet hydrocarbon concentration, as propane.
$CH_4$ – Processor inlet methane concentration.
scf – Standard cubic feet.

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Summary Table S-2

NOx, CO2 and CO Emissions Profile
Hirt Model VCS - 100 Phase II EVR Thermal Processor Unit
Hirt / VST EVR Certification Site, Stockton, California
December 3, 2008

| Date | Time | Processor Inlet | | | Processor Run Time | Exhaust Flow Rate | Processor Exhaust Emissions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $C_3H_8$ (%) | $CH_4$ (%) | Vol (scf) | (sec) | (dscfm) | $NO_x$ (ppm) | (lb/hr) | $CO_2$ (%) | (lb/hr) | CO (ppm) | (lb/hr) |
| 3-Dec-08 | 1140-1215 | 52.4 | 3.0 | 23.7 | 1260 | 81.7 | 20 | 0.012 | 2.35 | 13.2 | 2.1 | 7.5E-04 |
| 3-Dec-08 | 1230-1300 | 58.8 | 3.3 | 20.5 | 1086 | 101 | 21 | 0.015 | 2.41 | 16.7 | 1.1 | 4.6E-04 |
| 3-Dec-08 | 1320-1350 | 58.8 | 3.2 | 23.4 | 1244 | 88.4 | 21 | 0.013 | 2.47 | 14.9 | 0.45 | 1.7E-04 |
| Average: | | 56.7 | 3.2 | 22.5 | 1197 | 90.3 | 21 | 0.013 | 2.41 | 14.9 | 1.2 | 4.6E-04 |

Notes:

$NO_x$ – Oxides of nitrogen, reported as $NO_2$, molecular weight = 46.
$CO_2$ – Carbon dioxide, molecular weight = 44.
CO – Carbon monoxide, molecular weight = 28.
lb/hr – Pounds per hour.
ppm – Parts per million by volume.
dscfm – Dry standard cubic feet per minute.
$C_3H_8$ – Processor inlet hydrocarbon concentration, as propane.
$CH_4$ – Processor inlet methane concentration.
scf – Standard cubic feet.

S-3

# APPENDIX I

## Methane Emission Calculations

# <u>Methane Emission Calculations</u>

<u>Basis:</u>

1,000 gallons of gasoline dispensed.

<u>Assumptions</u>

- Maximum amount of VOC emissions from Phase II vapor recovery system are 0.38 pounds of hydrocarbons (HC) per 1,000 gallons of gasoline transferred (equivalent to a minimum vapor control efficiency of 95%) (per CARB certification requirements and executive orders).

- Maximum methane ($CH_4$) concentration in the gasoline vapors is 3.2% by volume, whereas maximum concentration of non-methane hydrocarbons (in terms of propane) in the gasoline vapors is 56.7%. Thus total hydrocarbon concentration in gasoline vapors is 59.9% by volume [1].

- Density of methane is 662 grams per cubic meter or 0.005525 lb/gal[2].

- Molecular weight of $CH_4$ and $CO_2$ are 16.03 and 44.0 lb/lb-mol, respectively at 32ºF and 1 atmosphere (Chemical Engineer's Handbook by Robert H. Perry, 5th edition, Table 3-31).

- Density of gasoline vapor is not readily available. Therefore, density of pure butane gas will be used as proxy for gasoline vapor density. Density of pure butane gas at 32ºF and 1 atmosphere is 0.1623 lb/ft$^3$ or 0.021696 lb/gallon (Chemical Engineer's Handbook by Robert H. Perry, 5th edition, Table 3-31).

<u>Calculations:</u>

Based on ARB requirements of Phase II EVR vapor recovery systems, achieving a minimum of 95% control efficiency, the maximum allowable VOC emissions are:

$$Maximum\ VOC\ emissions = \frac{0.38\ lb - HC}{1,000\ gallon\ gasoline\ dispensed}$$

Since maximum methane concentration in gasoline vapors is 3.2% by volume and total hydrocarbon concentration is 59.9% by volume, methane concentration can be stated as follows:

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[1] Pursuant to Summary Table S-2 of ARB Monitoring and Laboratory Division's 'Source Test Report #ST-09-10', dated August 10, 2009, for NOx, CO2, and CO Emissions from two Hirt Model VCS-100 Phase II EVR Gasoline Vapor Processors.

[2]Taken from ARB's Documentation of California's Greenhouse Gas Inventory (version 2 – Last updated on 03/13/2009) at website:
http://www.arb.ca.gov/cc/inventory/doc/docs3/3a2ai_livestockpopulation_dairycows_ch4_2006.htm

$$Methane\ Emissions = \frac{3.2\ gallon\ CH_4}{59.9\ gallon\ \ HC}$$

Using methane and butane densities, methane concentration by weight is calculated as:

$$Methane\ Emissions = \frac{3.2\ gallon\ CH_4}{59.9\ gallon\ \ HC} \times \frac{0.005525\ lb - CH_4}{gallon - CH_4} \times \frac{gallon - HC}{0.021696\ lb - HC} \times 100$$

$$= \frac{1.36\ lb - CH_4}{100\ lb - HC}\ \text{or 1.36 \% CH}_4\text{ by weight}$$

Thus the methane emissions are calculated as follows:

$$Methane\ Emissions = \frac{0.38\ lb - HC}{1,000\ gallon\ gasoline\ dispensed} \times \frac{1.36\ lb - CH_4}{100\ lb - HC}$$

$$= \frac{0.0052\ lb - CH_4}{1,000\ gallon\ gasoline\ dispensed}$$

To convert $CH_4$ emissions in terms of equivalent $CO_2$ emissions, the following chemical reaction is used:

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$
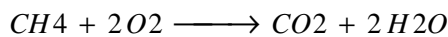
Thus,

$$1\ lb - mol\ of\ CO_2 = 1\ lb - mol\ of\ \ CH_4$$

or

$$\frac{x\ \ lb - CO_2}{Mol\ Wt - CO_2} = \frac{y\ \ lb - CH_4}{Mol\ Wt - CH_4}$$

or

$$x\ lb - CO_2\ = \frac{y\ \ lb - CH_4}{Mol\ Wt - CH_4} \times Mol\ Wt - CO_2$$

or

$$Methane\ Emissions = 0.0052\ lb - CH_4 \times \frac{lb - mol}{16.03\ lb - CH_4} \times \frac{44.00\ lb - CO_2}{lb - mol}$$

or

$$Methane\ Emissions = 0.0143\ \frac{lb - CO_2(e)}{1,000\ gallon}$$

Appendix I-3