San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

2006 Area Source Emissions Inventory Methodology
330 - NATURAL GAS TRANSMISSION LOSSES

I. Purpose

This document describes the Area Source Methodology used to estimate fugitive emissions of volatile organic compounds (VOC) from natural gas transmission and distribution systems in the San Joaquin Valley Air Basin. It is based on methodologies developed by the EPA's *Emission Inventory Improvement Program* (EPA, 2004) and Sonoma Technology Inc. (STI, 2002). An area source category is a collection of similar emission units within a geographic area (ie., a County). An area source category collectively represents individual sources that are small and numerous, and that may not have not been inventoried as specific point, mobile, or biogenic sources. The California Air Resources Board (CARB) has grouped these individual sources with other like sources into area source categories. These source categories are grouped in such a way that they can be estimated collectively using one methodology.

II. Applicability

The emission calculations from this Area Source Methodology apply to the following Category of Emission Source (CES) code and Reconciliation Emission Inventory Code (REIC):

Table 1. Emission inventory codes.

CES	REIC	Description
58685	330-318-0110-0000	Natural Gas Distribution – Transmission losses

III. Point Source Reconciliation

Emissions from the area source inventory and point source inventory are reconciled against each other to prevent double counting. This is done using relationships created by the California Air Resources Board (ARB) between the area source REIC and the point sources' Standard Industry Classification (SIC) code and emissions process Source Category Code (SCC) combinations. The area source in this methodology is not represented within our point source inventory, so reconciliation is not necessary.

IV. Methodology Description

This methodology is used to estimate fugitive emissions of VOC from the transmission of natural gas from production fields through the distribution system to the consumers. Losses occur from leakage at valves, compressors, and fittings in the transmission and distribution lines. Gathering pipelines transport natural gas from production fields to transmission pipelines (gathering lines are included as part of the transmission pipelines). Transmission pipelines then transport natural gas to distribution centers, where the gas is moved within cities or towns through distribution lines and service connections. Compressor stations help to facilitate the flow of gas through the transmission lines by maintaining a constant pressure throughout the system.

Emissions are calculated by multiplying the number of compressor stations, number of storage stations, transmission pipeline mileage, distribution pipeline mileage, and number of service connections within each county by emission factors. Then, the fugitive natural gas emissions are summed and multiplied by the fraction VOC in natural gas to obtain VOC for each county.

V. Activity Data

In order to calculate the emissions from a transmission and distribution system, the following information is necessary:

<u>For Transmission Emissions:</u>

a. Number of miles of transmission pipeline;
b. Number of compressor stations along the transmission line;
c. Number of liquefied natural gas (LNG) storage stations along the transmission line;
d. Number of gas storage compressor stations along the transmission line;
e. Number of miles of gathering pipeline

<u>For Distribution Emissions:</u>

a. Number of miles of cast iron main pipeline;
b. Number of miles of unprotected steel main pipeline;
c. Number of miles of protected steel main pipeline;
d. Number of miles of plastic main pipeline;
e. Total number of services (the number of customer connections);
f. Total number of unprotected steel services;
g. Total number of protected steel services

Natural gas transmission pipeline mileage was obtained from the Office of Pipeline Safety within the U.S. Department of Transportation (OPS, 2007). The number of compressor stations and liquefied natural gas (LNG) storage stations were obtained by personal communication with Jim Tobin, Natural Gas Industry Analyst at the U.S. Department of Energy, Energy Information Administration. This data was reported at the county level and is presented in the following table.

Table 2. Natural gas transmission mileage for the counties in the SJVAPCD (2006).

County	Transmission Pipeline Mileage	Compressor Stations (No.)		LNC Storage Facilities (no.)
		Transmission	Storage	
Fresno	627	0	0	0
Kern[(1)]	1,465	1	1	0
Kings	235	1	0	0
Madera	121	0	0	0
Merced	156	0	0	0
San Joaquin	327	0	1	0
Stanislaus	200	0	0	0
Tulare	145	0	0	0
Total	3,276	2	2	0

(1) Includes both the Valley and non-Valley portions of Kern County.

Natural gas transmission mileage, distribution mileage by pipeline type, and service connection number by type was obtained from the Office of Pipeline Safety within the U.S. Department of Transportation. This data was only reported at the state level (U.S. Department of Transportation, OPS, 2007).

Table 3. California natural gas pipeline statistics (2006).

Transmission Mileage	
Total State Transmission Mileage	12,252
Distribution Mileage	
Total Steel Unprotected Pipeline Mileage	9,250
Total Steel Protected Pipeline Mileage	43,091
Total Plastic Pipeline Mileage	48,043
Total Cast Iron Pipeline Mileage	212
Service Connections	
Total Services	8,410,894
Total Unprotected Steel Services	1,044,227
Total Protected Steel Services	2,319,801

Distribution pipeline mileage by type was disaggregated to the county level using the number of housing units per county as a surrogate (STI, 2002). The housing data was obtained from a California Department of Finance report (Sheya and Gage, 2007). For this, the total distribution pipeline mileage within the state was multiplied by the percent of total state housing units within each county. The following table illustrates the disaggregation of distribution pipeline within the District.

Table 4. Natural gas distribution pipeline disaggregated to counties within the District (2006)

County	Housing (no. units)	Housing (% of State total)	Mileage of Distribution Pipeline			
			Cast Iron	Unprotected Steel	Protected Steel	Plastic Main
Fresno	297,408	2.3%	4.9	212.8	991.1	1,105.0
Kern[(1)]	262,934	2.0%	4.2	185.0	861.8	960.9
Kings	40,596	0.3%	0.6	27.8	129.3	144.1
Madera	46,639	0.4%	0.8	37.0	172.4	192.2
Merced	80,136	0.6%	1.3	55.5	258.5	288.3
San Joaquin	219,707	1.7%	3.6	157.3	732.5	816.7
Stanislaus	171,719	1.3%	2.8	120.3	560.2	624.6
Tulare	132,469	1.0%	2.1	92.5	430.9	480.4
Total (District)	1,251,608	9.5%	20.1	878.8	4,093.6	4,564.1
Total (State)	13,140,388	100.0%	212.0	9,250.0	43,091.0	48,043.0

(1) Includes both the Valley and non-Valley portions of Kern County.

The number of services was also disaggregated to the county level using the number of housing units per county as a surrogate. The results are shown below.

Table 5. Natural gas services disaggregated to counties within the District (2006)

County	Housing (no. units)	Housing (% of State total)	Number of Services		
			Total	Unprotected Steel	Protected Steel
Fresno	297,408	2.2%	193,4501	24,017	53,355
Kern[(1)]	262,934	2.0%	168,218	20,885	46,396
Kings	40,596	0.3%	25,233	3,133	6,959
Madera	46,639	0.3%	33,644	4,177	9,279
Merced	80,136	0.6%	50,465	6,265	13,919
San Joaquin	219,707	1.7%	142,985	17,752	39,437
Stanislaus	171,719	1.3%	109,342	13,575	30,157
Tulare	132,469	1.0%	84,109	10,442	23,198
Total (District)	1,251,608	9.4%	799,035	99,202	220,381
Total (State)	13,140,388	100.0%	8,410,894	1,044,227	2,319,801

(1) Includes both the Valley and non-Valley portions of Kern County.

VI. Emission Factors

Emission factors for natural gas transmission and distribution systems were obtained from the EPA's Emission Inventory Improvement Program (2004).

Table 6. Natural gas transmission emission factors.

Emissions Source	Emission Factor (metric tons of methane)	Units (per year)
Transmission Pipeline		
Compressor Stations	975	Tons per station
Transmission Pipeline	0.61	Tons per mile
LNG Storage Stations	1041	Tons per station
Gas Storage Compressor Stations	955	Tons per station
Distribution Pipeline		
Cast Iron Pipeline	4.75	Tons per mile
Unprotected Steel Pipeline	2.25	Tons per mile
Protected Steel Pipeline	0.08	Tons per mile
Plastic Main Pipeline	0.54	Tons per mile
Distribution Services		
Total Services	0.014	Tons per service
Unprotected Steel Services	0.033	Tons per service
Protected Steel Services	0.0035	Tons per service

VII. Emissions Calculations

A. Sample Calculations

To calculate the total natural gas emissions (as methane) within Fresno County, it was necessary to know the number of compressor stations, number of storage stations, transmission pipeline mileage, distribution pipeline mileage, and number of service connections. Each component had the appropriate emission factors applied to it in order to obtain their emissions. These emissions were then summed and the VOC content calculated.

Given:

Fresno County Pipeline Statistics 2006

- Number of Compressor Stations = 0.0
- Number of LNG Storage Stations = 0.0
- Number of Gas Storage Compressor Stations = 0.0
- Miles of Transmission Pipeline = 637.4
- Miles of Cast Iron Distribution Pipeline = 5.4
- Miles of Unprotected Steel Distribution Pipeline = 206.3
- Miles of Protected Steel Distribution Pipeline = 948.0
- Miles of Plastic Main Distribution Pipeline = 1,002.5
- Total Number of Services = 178,770.3
- Total Number of Unprotected Steel Services = 1,787.1
- Total Number of Protected Steel Services = 70,675.6

Emissions Due to Compressor Stations (E_C)

$$E_C = Number\ of\ Compressor\ Stations \times Emission\ Factor$$

$$E_C = 0\ Compressor\ Stations \times \frac{975\ metric\ tons\ of\ methane}{station\text{ - }year} = \frac{0\ metric\ tons\ of\ methane}{year}$$

Emissions Due to Liquefied Natural Gas (LNG) Storage Stations (E_{LNG})

$$E_{LNG} = Number\ of\ LNG\ Storage\ Stations \times Emission\ Factor$$

$$E_{LNG} = 0\ LNG\ Storage\ Stations \times \frac{1041\ metric\ tons\ of\ methane}{station - year} = \frac{0\ metric\ tons\ of\ methane}{year}$$

Emissions Due to Gas Storage Compressor Stations (E_{GSC})

$$E_{GSC} = Number\ of\ Gas\ Storage\ Compressor\ Stations \times Emission\ Factor$$

$$E_{GSC} = 0\ Gas\ Storage\ Compressor\ Stations \times \frac{955\ metric\ tons\ of\ methane}{station - year}$$

$$= \frac{0\ metric\ tons\ of\ methane}{year}$$

Emissions Due to Transmission Pipeline (E_T)

$$E_T = Miles\ of\ Transmission\ Pipeline \times Emission\ Factor$$

$$E_T = 627\ Miles\ of\ Transmission\ Pipeline \times \frac{0.61\ metric\ tons\ of\ methane}{mile\text{ - }year}$$

$$= \frac{382.5\ metric\ tons\ of\ methane}{year}$$

Emissions Due to Cast Iron Distribution Pipeline (E_{CID})

$$E_{CID} = Miles\ of\ Cast\ Iron\ Distribution\ Pipeline \times Emission\ Factor$$

$$E_{CID} = 4.9\ Miles\ of\ Cast\ Iron\ Distribution\ Pipeline \times \frac{4.75\ metric\ tons\ of\ methane}{mile\text{ - }year}$$

$$= \frac{23.3\ metric\ tons\ of\ methane}{year}$$

Emissions Due to Unprotected Steel Distribution Pipeline (E_{USD})

$$E_{USD} = Miles\ \ of\ \ Unprotected\ Steel\ Distribution\ Pipeline \times Emission\ \ Factor$$

$$E_{USD} = 213\ Miles\ of\ Unprotected\ Steel\ Distribution\ Pipeline \times \frac{2.25\ metric\ tons\ of\ \ methane}{mile\ -\ year}$$

$$= \frac{479.3\ \ metric\ tons\ of\ \ methane}{year}$$

Emissions Due to Protected Steel Distribution Pipeline (E_{PSD})

$$E_{PSD} = Miles\ \ of\ \ Protected\ \ Steel\ \ Distribution\ Pipeline \times Emission\ Factor$$

$$E_{PSD} = 991\ Miles\ of\ \ Protected\ Steel\ Distribution\ Pipeline \times \frac{0.08\ metric\ tons\ of\ \ methane}{mile\ -\ year}$$

$$= \frac{79.3\ metric\ tons\ of\ \ methane}{year}$$

Emissions Due to Plastic Main Distribution Pipeline (E_{PMD})

$$E_{PMD} = Miles\ of\ \ Plastic\ \ Main\ Distribution\ Pipeline \times Emission\ \ Factor$$

$$E_{PMD} = 1{,}105\ Miles\ of\ \ Plastic\ Main\ Distribution\ Pipeline \times \frac{0.54\ metric\ tons\ of\ \ methane}{mile\ -\ year}$$

$$= \frac{596.7\ metric\ tons\ of\ \ methane}{year}$$

Emissions Due to Total Number of Services (E_S)

$$E_S = Total\ \ Number\ of\ \ \ Services \times Emission\ Factor$$

$$E_S = 193{,}451\ Services \times \frac{0.014\ metric\ tons\ of\ \ methane}{mile\ -\ year} = \frac{2708.3\ metric\ tons\ of\ \ methane}{year}$$

Emissions Due to Unprotected Steel Services (E_{US})

$$E_{US} = Total\ \ Number\ of\ \ \ Unprotected\ Steel\ Services \times Emission\ Factor$$

$$E_{US} = 24{,}017\ Unprotected\ Steel\ Services \times \frac{0.033\ metric\ tons\ of\ methane}{mile\ -\ year}$$

$$= \frac{792.6\ metric\ tons\ of\ methane}{year}$$

Emissions Due to Protected Steel Services (E_{PS})

$$E_{PS} = Total\ \ Number\ of\ \ Protected\ \ Steel\ \ Services \times Emission\ Factor$$

$$E_{PS} = 53{,}355\ Protected\ Steel\ Services \times \frac{0.0035\ metric\ tons\ of\ methane}{mile\ -\ year}$$

$$= \frac{186.7\ metric\ tons\ of\ methane}{year}$$

Total Methane Emissions for Fresno County (E_{TOTAL})

$$E_{TOTAL} = E_C + E_{LNG} + E_{GSC} + E_T + E_{CID} + E_{USD} + E_{PSD} + E_{PMD} + E_S + E_{US} + E_{PS}$$

The emissions from each source are summarized below:

Table 7. Summary of fugitive emissions of methane from the transmission of natural gas in Fresno county (2006).

Source of Emissions	Metric Tons of Methane (per year)
E_C, Emissions from Compressor Stations	0.0
E_{LNG}, Emissions from LNG Storage Stations	0.0
E_{GSC}, Emissions from Gas Storage Compressor Stations	0.0
E_T, Emission from Transmission Pipeline	382.5
E_{CID}, Emissions from Cast Iron Distribution Pipeline	23.3
E_{USD}, Emissions from Unprotected Steel Distribution Pipeline	478.8
E_{PSD}, Emissions from Protected Steel Distribution Pipeline	79.3
E_{PMD}, Emissions from Plastic Main Distribution Pipeline	596.7
E_S, Emissions from Total Number of Services	2,708.3
E_{US}, Emissions from Unprotected Steel Services	792.6
E_{PS}, Emissions from Protected Steel Services	186.7
E_{TOTAL}, Total Emissions from Transmission and Distribution Systems	5,248.2

Total TOG Emissions in Fresno County

To obtain the TOG (total organic gases) emissions, divide the total methane emissions by it's organic fraction within composite natural gas as seen below. The fraction of methane in composite natural gas as given by ARB is 0.937.

$$TOG\ Emissions = \frac{Total\ Methane\ Emissions}{Fraction\ of\ \ Methane\ \ in\ \ Composite\ Natural\ Gas}$$

$$TOG\ Emissions = \frac{\left(\frac{5{,}248\ metric\ tons\ of\ methane}{year}\right)}{\left(\frac{0.937\ metric\ tons\ of\ methane}{1\ ton\ of\ TOG}\right)} = \frac{5{,}601\ metric\ tons\ of\ TOG}{year}$$

Total VOC Emissions in Fresno County

In order to obtain VOC emissions, TOG emissions are multiplied by the ARB's fraction VOC in composite natural gas and then converted from metric tons (1,000 kg) to regular tons (2,000 lbs).

$$Total\ VOC\ Emissions = TOG\ Emissions \times Fraction\ VOC \times \left(\frac{2{,}205\ lbs}{metric\ ton}\right) \times \left(\frac{1\ ton}{2{,}000\ lbs}\right)$$

$$Total\ VOC\ Emissions = \frac{5{,}601\ metric\ tons\ \ TOG}{year} \times \frac{0.012\ \ metric\ tons\ \ VOC}{metric\ ton\ TOG} \times \frac{2{,}205\ lbs}{metric\ ton} \times \frac{1\ ton}{2{,}000 lbs}$$

$$= \frac{74.1\ tons\ of\ VOC}{year}$$

Therefore, there are 74.1 tons of fugitive VOC emissions every year from the transmission and distribution of natural gas in Fresno County.

VIII. Temporal Variation

Since the utilities need to maintain constant pressure within their distribution system; the daily, weekly and monthly rates of loss are considered uniform.

A. Daily

ARB Code 24 (24 hours per day - uniform activity during the day)

B. Weekly

ARB Code 7 (7 days per week - uniform activity every day of the week)

C. Monthly

8.33% of yearly activity each month (Uniform monthly activity)

IX. Spatial Variation

Emissions from this category can be distributed in each county using housing population as a surrogate.

X. Growth Factor

Growth factors are developed by either the District's Planning Department or CARB for each EIC. These factors are used to estimate emissions in future years. The growth factors associated with this emissions category may be obtained from the Air Quality Analysis Section of the District's Planning Department.

XI. Control Level

Control levels are developed by either the District's Planning Department or CARB for each EIC. Control levels are used to estimate emissions reductions in future years due to implementation of District rules. These control levels take into account the effect of control technology, compliance and exemptions at full implementation of the rules.

Natural gas transmission systems are not subject to District rules. Control levels associated with this emissions category may be obtained from the Air Quality Analysis Section of the District's Planning Department.

XII. ARB Chemical Speciation

CARB has developed organic gas profiles in order to calculate reactive organic gasses (ROG), volatile organic compounds (VOC) or total organic gas (TOG) given any one of the three values. For each speciation profile, the fraction of TOG that is ROG and VOC is given. The organic gas profile codes can also be used to lookup associated toxics. ARB's speciation profile for natural gas is presented in Table 8.

Table 8. CARB organic gas speciation profile for fugitive emissions of natural gas.

Profile Description	ARB Organic Gas Profile#	Fractions	
		ROG	VOC
Composite Natural Gas	520	0.012	0.012

XIII. Assessment Of Methodology

This methodology is based on the EPA's preferred method for calculating statewide emissions. VOC fugitive emissions from natural gas distribution and transmission pipelines are then disaggregated to the county level using housing distribution. Future research may lead to a more accurate distribution of pipeline mileage and a more accurate number of service connections per county. Also, there is no definitive composition of natural gas. Gas composition differs from source to source

In addition, this methodology is based upon the following assumptions:

- VOC's are considered to be all non-methane, non-ethane hydrocarbons (EPA, 2005).
- The emission factors from the EPA's Emission Inventory Improvement Program are accurate.

- VOC's are the only pollutant emitted.
- The ratio of housing in a county relative to the state total reflects distribution pipeline mileage and service connections.
- Gathering pipelines are included as part of the transmission pipelines.
- The speciation of methane and VOC from ARB's Speciation Profile is correct.

XIV. Emissions

Following is the 2006 area source emissions inventory for REIC 330-318-0110-0000 estimated by this methodology. Emissions are reported for each county in the District.

Table 9. Area source emissions for REIC 330-318-0110-0000 (2006).

County	Emissions (tons/year)					
	NOx	CO	SOx	VOC[1]	PM_{10}	$PM_{2.5}$
Fresno	--	--	--	74.1	--	--
Kern[2]	--	--	--	99.6	--	--
Kings	--	--	--	24.8	--	--
Madera	--	--	--	13.0	--	--
Merced	--	--	--	19.3	--	--
San Joaquin	--	--	--	67.0	--	--
Stanislaus	--	--	--	40.6	--	--
Tulare	--	--	--	31.1	--	--
TOTAL	--	--	--	366.5	--	--

(1) The District only reports ROG to ARB. As noted in Section XII, ROG is the same as VOC.
(2) Includes both the Valley and non-Valley portions of Kern County.

Following is the 2006 point source emissions inventory for REIC 330-318-0110-0000 as reported to the District by our permit holders. Emissions are reported for each county in the District.

Table 10. Point source emissions for REIC 330-318-0110-0000 (2006).

County	Emissions (tons/year)					
	NOx	CO	SOx	VOC[1]	PM_{10}	$PM_{2.5}$
Fresno	--	--	--	0.0	--	--
Kern[2]	--	--	--	0.0	--	--
Kings	--	--	--	0.0	--	--
Madera	--	--	--	0.0	--	--
Merced	--	--	--	0.0	--	--
San Joaquin	--	--	--	0.0	--	--
Stanislaus	--	--	--	0.0	--	--
Tulare	--	--	--	0.0	--	--
TOTAL	--	--	--	0.0	--	--

(1) The District only reports ROG to ARB. As noted in Section XII, ROG is the same as VOC.
(2) Includes both the Valley and non-Valley portions of Kern County.

Following is the 2006 total unreconciled (point source plus area source) emissions inventory for REIC 330-318-0110-0000. Emissions are reported for each county in the District.

Table 11. Total emissions for REIC 330-318-0110-0000 (2006).

County	Emissions (tons/year)					
	NOx	CO	SOx	VOC[1]	PM_{10}	$PM_{2.5}$
Fresno	--	--	--	74.1	--	--
Kern[2]	--	--	--	99.6	--	--
Kings	--	--	--	24.8	--	--
Madera	--	--	--	13.0	--	--
Merced	--	--	--	19.3	--	--
San Joaquin	--	--	--	67.0	--	--
Stanislaus	--	--	--	40.6	--	--
Tulare	--	--	--	31.1	--	--
TOTAL	--	--	--	366.5	--	--

(1) The District only reports ROG to ARB. As noted in Section XII, ROG is the same as VOC.
(2) Includes both the Valley and non-Valley portions of Kern County.

Following is the net change in total unreconciled emissions between this update (2006 inventory year) and the previous update (2004 inventory year) for REIC 330-318-0110-0000. The change in emissions are reported for each county in the District.

Table 12. Net emissions change for REIC 330-318-0110-0000 (2004-2006).

County	Emissions (tons/year)					
	NOx	CO	SOx	VOC[1]	PM_{10}	$PM_{2.5}$
Fresno	--	--	--	13.3	--	--
Kern[2]	--	--	--	8.6	--	--
Kings	--	--	--	-12.3	--	--
Madera	--	--	--	4.4	--	--
Merced	--	--	--	2.9	--	--
San Joaquin	--	--	--	6.8	--	--
Stanislaus	--	--	--	6.2	--	--
Tulare	--	--	--	4.5	--	--
TOTAL	--	--	--	34.4	--	--

(1) The District only reports ROG to ARB. As noted in Section XII, ROG is the same as VOC.

(2) Includes both the Valley and non-Valley portions of Kern County.

XV. Revision History

2006. The methodology was reformatted to the new District standard. Process rates were updated.

2005. This is a new District methodology based on methodologies developed by the EPA's Emission Inventory Improvement Program (EPA, 2004) and Sonoma Technology Inc. (STI, 2002).

XVI. Update Schedule

In an effort to provide inventory information to ARB and other District programs and maximize limited resources, the District has developed an update cycle based on emissions within the source category as shown in Table 12.

Table 13. Area source update frequency criteria

Total Emissions (tons/day)	Update Cycle (years)
≤1	4
>1 and <= 2.5	3
>2.5 and <=5	2
>5	1

Since there is 1 ton per day (377 tons per year) of VOC emissions from this source category, it will be updated every four years.

Table 14. Natural gas transmission loss area source methodology update frequency

EIC	Frequency (years)	Source of Emissions (Point Source Inventory / Data Gathering)
330-318-0110-0000	4	Data Gathering

XVII. References

1. Pacific Gas & Electric Company (2006). California Gas Transmission - Interactive System Map. <http://www.pge.com/pipeline/about/system_maps/statemap.shtml>

2. Sonoma Technology, Inc., STI (2002). Central California ozone study, attachment H: "Petroleum Marketing". <http://www.arb.ca.gov/ei/areasrc/ccosmethods.html>

3. Sheya, D. and Gage L. (2007). California Department of Finance - Demographic Research Unit, E-5 Population and Housing Estimates for Cities, Counties and the State, 2001-2007, with 2000 Benchmark. <http://www.dof.ca.gov/HTML/DEMOGRAP/ReportsPapers/Estimates/E5/E5-06/E-5text2.asp>

4. United States Department of Transportation, Office of Pipeline Safety (2007).. Distribution and Transmission Annuals Data for 2006. <http://ops.dot.gov/stats/DT98.htm>

5. United States Environmental Protection Agency (2004). Emission Inventory Improvement Program - Volume VIII, Chapter 5, "Natural Gas and Oil Systems" August 2004.

6. United States Environmental Protection Agency (2005). Conversion Factors for Hydrocarbon Emission Components. EPA420-R-05-015, December 2005.