San Joaquin Valley
Unified Air Pollution Control District

Emission Inventory Methodology
330 - Natural Gas Transmission Losses

I. Purpose

This methodology is to be used to determine area source fugitive emissions from the natural gas transmission and distribution systems. It is based on methodologies developed by the EPA's Emission Inventory Improvement Program (EPA, 2004) and Sonoma Technology Inc. (STI, 2002).

II. Applicability

The following source categories apply to emissions resulting from fugitive emissions from the natural gas transmission systems.

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

III. Point Source Reconciliation

This emission category doesn't reconcile against the point source inventory.

IV. Methodology Description

This category is used to inventory fugitive emissions 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 trying to maintain a constant pressure throughout the lines.

V. Activity Data

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

For Transmission Emissions:
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

For Distribution Emissions:
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

Transmission and distribution mileage was obtained from the Office of Pipeline Safety within the U.S. Department of Transportation (OPS, 2005). Transmission pipeline mileage is reported on both the state and county level. Distribution pipeline mileage and the number of service connections are reported at the state level. Distribution pipeline and service connections were then disaggregated to the County level using the number of housing units per county as a surrogate (STI, 2002). The emission factors developed by the EPA were applied to calculate total methane emissions. ARB's speciation profiles were used to obtain VOC emissions. Following are the 2004 pipeline statistics for California.

Transmission Mileage	
Total State Transmission Mileage	12,289.4
Distribution Mileage	
Total Steel Unprotected Pipeline	9,377.0
Total Steel Protected Pipeline	43,090.6
Total Plastic Pipeline	45,569.0
Total Cast Iron Pipeline	244.0
Service Connections	
Total Services	8,125,923.0
Total Unprotected Steel Services	81,230.0
Total Protected Steel Services	3,212,525.0

The transmission mileage for the state and each county are reported as both intrastate and interstate. The combination of the two are the total mileage for the state and given county. The data for each county in the District is described below.

Natural gas Transmission Mileage for the Counties in the SJVAPCD 2004			
			Total Transmission Mileage
Fresno	44.0	593.4	637.4
Kern	404.0	1016.5	1420.5
Kings	19.0	220.4	239.4
Madera	0.0	121.4	121.4
Merced	0.0	153.2	153.2
San Joaquin	0.0	327.8	327.8
Stanislaus	0.0	199.8	199.8
Tulare	0.0	161.9	161.9
			3261.4

Distribution pipeline is calculated using the number of housing units per county as a surrogate. The housing data was obtained from a California Department of Finance report (Sheya and Gage, 2006). The total distribution pipeline mileage within the state is multiplied by the percent of total state housing within each county. The following table illustrates the disaggregation of distribution pipeline within the District.

	Mileage of Distribution Pipeline				
					Plastic Main
Fresno	2.2%	5.4	206.3	948.0	1002.5
Kern	2.0%	4.9	187.5	861.8	911.4
Kings	0.3%	0.7	28.1	129.3	136.7
Madera	0.3%	0.7	28.1	129.3	136.7
Merced	0.6%	1.5	56.3	258.5	273.4
San Joaquin	1.7%	4.1	159.4	732.5	774.7
Stanislaus	1.3%	3.2	121.9	560.2	592.4
Tulare	1.0%	2.4	93.8	430.9	455.7
					4283.5

The total number of services in the state is given by the Office of Pipeline Safety. They are broken up into Total Services, Unprotected Steel Services, and Protected Steel Services. The number of services, as with the distribution pipeline, is also disaggregated to the county level using the number of housing units per county as a surrogate. The results are shown below.

	Number of Services			
				Protected Steel
Fresno	2.2%	178,770.3	1,787.1	70,675.6
Kern	2.0%	162,518.5	1,624.6	64,250.5
Kings	0.3%	24,377.8	243.7	9,637.6
Madera	0.3%	24,377.8	243.7	9,637.6
Merced	0.6%	48,755.5	487.4	19,275.2
San Joaquin	1.7%	138,140.7	1,380.9	54,612.9
Stanislaus	1.3%	105,637.0	1,056.0	41,762.8
Tulare	1.0%	81,259.2	812.3	32,125.3
				301,977.5

VII. Emission Factors

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

		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

VIII. Sample Calculations

To calculate the total methane emissions 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 are then summed up at the end of this section.

Given:

Fresno County Pipeline Statistics 2004	
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)

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

$$E_T = 637.4\ Miles\ of\ Transmission\ Pipeline \times \frac{0.61\ metric\ tons\ of\ methane}{mile\text{ - }year}$$

$$= \frac{388.8\ metric\ tons\ of\ methane}{year}$$

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

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

$$E_{CID} = 5.4\ Miles\ of\ Cast\ Iron\ Distribution\ Pipeline \times \frac{4.75\ metric\ tons\ of\ methane}{mile\text{ - }year}$$

$$= \frac{25.7\ metric\ tons\ of\ methane}{year}$$

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

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

$$E_{USD} = 206.3\ Miles\ of\ Unprotected\ Steel\ Distribution\ Pipeline \times \frac{2.25\ metric\ tons\ of\ methane}{mile\text{ - }year}$$

$$= \frac{464.2\ metric\ tons\ of\ methane}{year}$$

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

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

$$E_{PSD} = 948\ Miles\ of\ Protected\ Steel\ Distribution\ Pipeline \times \frac{0.08\ metric\ tons\ of\ methane}{mile\text{ - }year}$$

$$= \frac{75.8\ metric\ tons\ of\ methane}{year}$$

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

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

$$E_{PMD} = 1{,}002.5\ Miles\ of\ Plastic\ Main\ Distribution\ Pipeline \times \frac{0.54\ metric\ tons\ of\ methane}{mile\text{ - }year}$$

$$= \frac{541.4\ metric\ tons\ of\ methane}{year}$$

Emissions Due to Total Number of Services (E_S)

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

$$E_S = 178{,}770.3\ Services \times \frac{0.014\ metric\ tons\ of\ methane}{mile\text{ - }year} = \frac{2502.8\ metric\ tons\ of\ methane}{year}$$

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

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

$$E_{US} = 1{,}787.1\ Unprotected\ Steel\ Services \times \frac{0.033\ metric\ tons\ of\ methane}{mile\text{ - }year}$$

$$= \frac{59.0\ metric\ tons\ of\ methane}{year}$$

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

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

$$E_{PS} = 70{,}675.6\ Protected\ Steel\ Services \times \frac{0.0035\ metric\ tons\ of\ \ methane}{mile\text{ - }year}$$

$$= \frac{247.4\ metric\ tons\ of\ \ methane}{year}$$

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:

Summary 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	388.8
E_{CID}, Emissions from Cast Iron Distribution Pipeline	25.7
E_{USD}, Emissions from Unprotected Steel Distribution Pipeline	464.2
E_{PSD}, Emissions from Protected Steel Distribution Pipeline	75.8
E_{PMD}, Emissions from Plastic Main Distribution Pipeline	541.4
E_S, Emissions from Total Number of Services	2502.8
E_{US}, Emissions from Unprotected Steel Services	59.0
E_{PS}, Emissions from Protected Steel Services	247.4
E_{TOTAL}, Total Emissions from Transmission and Distribution Systems	4305.1

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.

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

$$TOG\ \ Emissions = \frac{\left(\frac{4305.1\ metric\ tons\ of\ \ methane}{year}\right)}{\left(\frac{0.937\ metric\ tons\ of\ \ methane}{1\ ton\ of\ \ TOG}\right)} = \frac{4594.6\ metric\ tons\ of\ \ TOG}{year}$$

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 (1000 kg) to regular tons (2000 lbs).

$$Total\ VOC\ Emissions = TOG\ Emissions \times Fraction\ VOC \times \left(\frac{2205\ lbs}{metric\ ton}\right) \times \left(\frac{1\ ton}{2000\ lbs}\right)$$

$$Total\ VOC\ \ Emissions = \frac{4{,}594.6\ metric\ tons\ \ TOG}{year} \times \frac{0.012\ \ metric\ tons\ \ VOC}{metric\ ton\ TOG} \times \frac{2205\ lbs}{metric\ ton} \times \frac{1\ ton}{2000 lbs}$$

$$= \frac{60.8\ tons\ of\ \ VOC}{year}$$

Therefore, there are 60.8 tons of fugitive VOC emissions every year from the transmission and distribution of natural gas in Fresno County.

IX. Assumptions

a. VOC's are considered to be all non-methane, non-ethane hydrocarbons (EPA, 2005).

b. The emission factors from the EPA's Emission Inventory Improvement Program are accurate.

c. VOC's are the only pollutant emitted.

d. The ratio of housing in a county relative to the state total reflects distribution pipeline mileage and service connections.

e. Gathering pipelines are included as part of the transmission pipelines.

f. The speciation of methane and VOC from ARB's Speciation Profile is correct.

X. Frequency of Update

Actual Housing distribution numbers are updated every time there is a census (every ten years). However, the California Department of Finance grows housing data every year from the last official census. The Office of Pipeline Safety updates transmission and distribution mileage along with service connections annually. ARB's CEIDARs database is also updated on a yearly basis. It is therefore recommended that this methodology be updated every year.

		Source of Emissions (Point Source Inventory / Data Gathering)
330-318-0110-0000	1	Data Gathering

XI. 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.

Daily: ARB Code 24 (24 hours per day - uniform activity during the day)
Weekly: ARB Code 7 (7 days per week - uniform activity every day of the week)
Monthly: 8.33% of yearly activity each month (Uniform monthly activity)

XII. Spatial Variation

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

XIII. Growth Factor

See Appendix A.

XIV. Control Level

There are currently no control factors associated with this area source category.

XV. Chemical Speciation

		Fractions	
			VOC
Composite Natural Gas	520	0.012	0.012

XVI. 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 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 provider to provider and location to location.

XVII. Emissions Comparison

Emissions for natural gas transmission losses in the San Joaquin Valley Air Pollution Control District are presented in the tables that follow. Note that the 2003 emissions data in ARB's CEIDARS database (http://www.arb.ca.gov/app/emsinv/dist/rpts/sub_eic.php) is as of June 1, 2006, and that CEIDARS emissions data is not static and subject to change.

CEIDARs Inventory Year 2003	
	VOC
Natural Gas Distribution – Transmission Losses	
Fresno	32.9
Kern	0.0
Kings	0.0
Madera	0.0
Merced	0.0
San Joaquin	0.0
Stanislaus	0.0
Tulare	0.0
	32.9

[1] Emissions in CEIDARS are reported in tons per day to 1/100th of a ton. Therefore, emissions of less than 0.005 tons per day (0.18 tons per year) are reported as zero.

2004 Emissions Calculated using this Methodology	
	VOC
Natural Gas Distribution – Transmission Losses	
Fresno	60.8
Kern	91.0
Kings	37.2
Madera	8.6
Merced	16.4
San Joaquin	60.2
Stanislaus	34.4
Tulare	26.6
	335.1

Change in Emissions 2003-2004	
	VOC
Natural Gas Distribution – Transmission Losses	
Fresno	27.9
Kern	91.0
Kings	37.2
Madera	8.6
Merced	16.4
San Joaquin	60.2
Stanislaus	34.4
Tulare	26.6
	302.3

XVIII. References

a. California Air Resources Board (2003) CEIDARS Emission Inventory Categorization Database. <http://www.arb.ca.gov/app/emsinv/dist/rpts/sub_eic.php>

b. Coleman, D. (2006). E-mail with location of transmission and distribution pipeline mileage data (from the Office of Pipeline Safety) to Yu Vu, San Joaquin Valley Unified APCD. Received 07/26/06. <http://primis.phmsa.dot.gov/comm/StatePages/htmGen/CA_detail1.html>

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

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

e. Sheya, D. and Gage L. (2006). California Department of Finance - Demographic Research Unit, E-5 Population and Housing Estimates for Cities, Counties, and the State, 2001-2006, with 2000 Benchmark. <http://www.dof.ca.gov/HTML/DEMOGRAP/ReportsPapers/Estimates/E5/E5-06/E-5text2.asp>

f. United States Department of Transportation, Office of Pipeline Safety (2004).. Distribution and Transmission Annuals Data for 1990-2005. <http://ops.dot.gov/stats/DT98.htm>

g. United States Census Bureau (2000). - Census 2000 Housing Units. <http://quickfacts.census.gov/hunits/>

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

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

XIX. Appendix A. California Air Resources Board Growth Parameters for EIC 330-318-0110-0000.

	Growth Activity Parameter by County							
								Tulare
2000	11662023.84	165009579.1	683018.5	1349136.32	123532.62	6677146.73	28457.07	3576.39
2001	12045311.18	170432830.2	705466.78	1393477.41	127592.68	6589767.37	29392.35	3693.93
2002	12466847.11	176397272.3	730155.19	1442243.34	132057.89	6511789.03	30420.96	3823.21
2003	12957726.11	183342871	758904.87	1499031.31	137257.64	6988946.99	31618.78	3973.74
2004	13346831.77	188848447.1	781693.92	1544045.5	141379.33	7430736.37	32568.26	4093.07
2005	13756747.33	194648469.1	805701.75	1591467.11	145721.45	7902808.15	33568.51	4218.78
2006	14363487.96	203233429.7	841237.18	1661658.69	152148.49	8511149.16	35049.05	4404.85
2007	14384823.59	203535314.1	842486.76	1664126.93	152374.49	8789311.3	35101.11	4411.39
2008	13804653.7	195326311.1	808507.52	1597009.22	146228.91	8781073.2	33685.41	4233.47
2009	13753760.99	194606214.5	805526.85	1591121.64	145689.82	9103344.54	33561.22	4217.86
2010	13687375.69	193666908.4	801638.81	1583441.77	144986.62	9422368.42	33399.23	4197.51
2015	13979391.65	197798732.3	818741.53	1617224.01	148079.86	11168712.17	34111.8	4287.06
2020	14739860.76	208558844.8	863280.49	1705199.86	156135.31	12954539.13	35967.45	4520.27
2025	15747172.61	222811611.4	922276.48	1821732.04	166805.48	14289134.28	38425.44	4829.18
2030	17041779.87	241129409.6	998098.72	1971500.35	180518.9	15463873.23	41584.48	5226.2