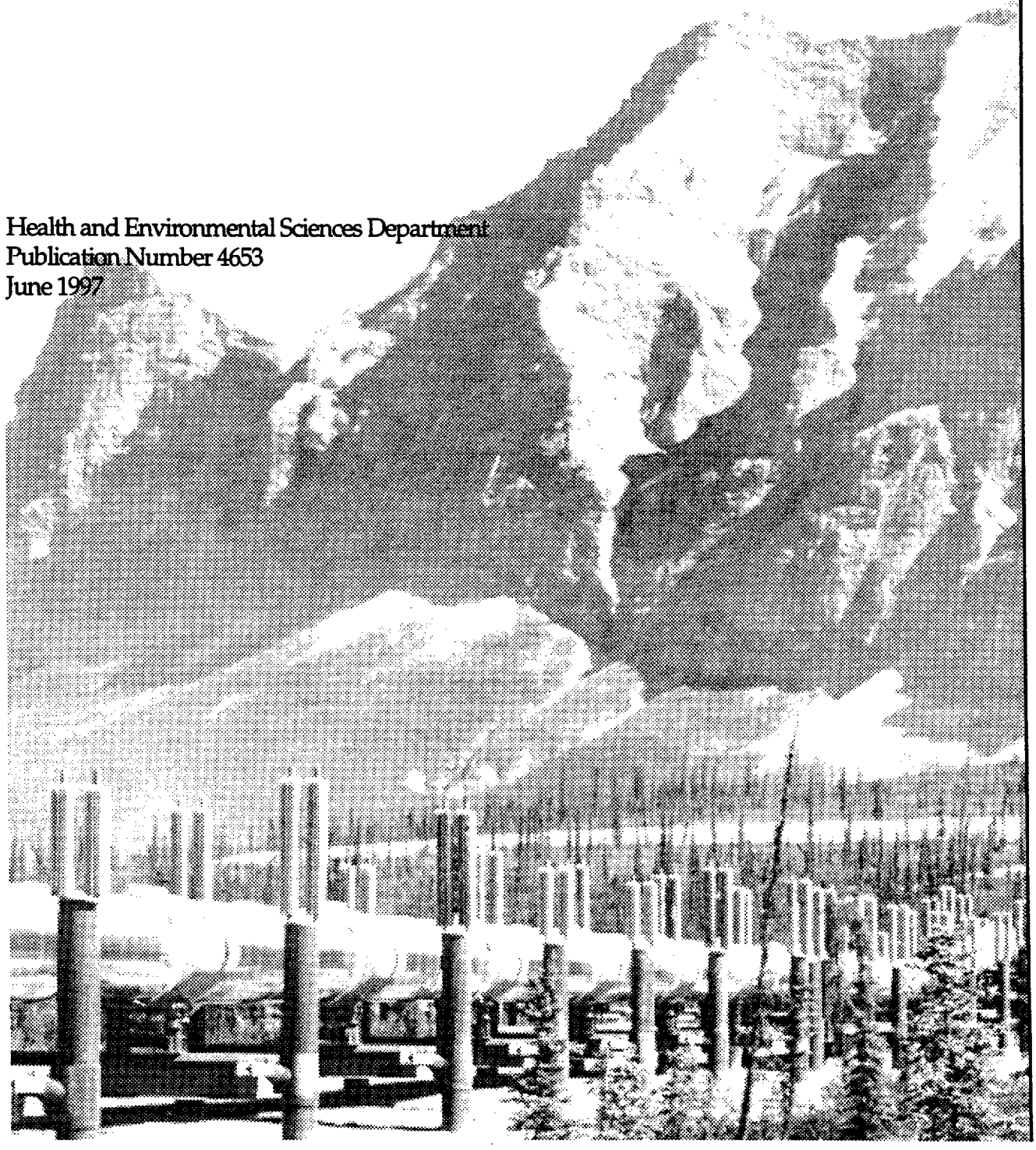
American Petroleum Institute

STEP Strategies for Today's Environmental Partnership

FUGITIVE EMISSION FACTORS FOR CRUDE OIL AND PRODUCT PIPELINE FACILITIES



Health and Environmental Sciences Department
Publication Number 4653
June 1997

One of the most significant long-term trends affecting the future vitality of the petroleum industry is the public's concerns about the environment, health and safety. Recognizing this trend, API member companies have developed a positive, forward-looking strategy called STEP: Strategies for Today's Environmental Partnership. This initiative aims to build understanding and credibility with stakeholders by continually improving our industry's environmental, health and safety performance; documenting performance; and communicating with the public.

API ENVIRONMENTAL MISSION AND GUIDING ENVIRONMENTAL PRINCIPLES

The members of the American Petroleum Institute are dedicated to continuous efforts to improve the compatibility of our operations with the environment while economically developing energy resources and supplying high quality products and services to consumers. We recognize our responsibility to work with the public, the government, and others to develop and to use natural resources in an environmentally sound manner while protecting the health and safety of our employees and the public. To meet these responsibilities, API members pledge to manage our businesses according to the following principles using sound science to prioritize risks and to implement cost-effective management practices:

- To recognize and to respond to community concerns about our raw materials, products and operations.
- To operate our plants and facilities, and to handle our raw materials and products in a manner that protects the environment, and the safety and health of our employees and the public.
- To make safety, health and environmental considerations a priority in our planning, and our development of new products and processes.
- To advise promptly, appropriate officials, employees, customers and the public of information on significant industry-related safety, health and environmental hazards, and to recommend protective measures.
- To counsel customers, transporters and others in the safe use, transportation and disposal of our raw materials, products and waste materials.
- To economically develop and produce natural resources and to conserve those resources by using energy efficiently.
- To extend knowledge by conducting or supporting research on the safety, health and environmental effects of our raw materials, products, processes and waste materials.
- To commit to reduce overall emission and waste generation.
- To work with others to resolve problems created by handling and disposal of hazardous substances from our operations.
- To participate with government and others in creating responsible laws, regulations and standards to safeguard the community, workplace and environment.
- To promote these principles and practices by sharing experiences and offering assistance to others who produce, handle, use, transport or dispose of similar raw materials, petroleum products and wastes.

Fugitive Emission Factors for Crude Oil and Product Pipeline Facilities

Health and Environmental Sciences Department

API PUBLICATION NUMBER 4653

PREPARED UNDER CONTRACT BY:

MICHAEL WEBB
STAR ENVIRONMENTAL
PO BOX 2132
ST. GEORGE, UTAH 84771

JUNE 1997

American Petroleum Institute

FOREWORD

API PUBLICATIONS NECESSARILY ADDRESS PROBLEMS OF A GENERAL NATURE. WITH RESPECT TO PARTICULAR CIRCUMSTANCES, LOCAL, STATE, AND FEDERAL LAWS AND REGULATIONS SHOULD BE REVIEWED.

API IS NOT UNDERTAKING TO MEET THE DUTIES OF EMPLOYERS, MANUFACTURERS, OR SUPPLIERS TO WARN AND PROPERLY TRAIN AND EQUIP THEIR EMPLOYEES, AND OTHERS EXPOSED, CONCERNING HEALTH AND SAFETY RISKS AND PRECAUTIONS, NOR UNDERTAKING THEIR OBLIGATIONS UNDER LOCAL, STATE, OR FEDERAL LAWS.

NOTHING CONTAINED IN ANY API PUBLICATION IS TO BE CONSTRUED AS GRANTING ANY RIGHT, BY IMPLICATION OR OTHERWISE, FOR THE MANUFACTURE, SALE, OR USE OF ANY METHOD, APPARATUS, OR PRODUCT COVERED BY LETTERS PATENT. NEITHER SHOULD ANYTHING CONTAINED IN THE PUBLICATION BE CONSTRUED AS INSURING ANYONE AGAINST LIABILITY FOR INFRINGEMENT OF LETTERS PATENT.

ACKNOWLEDGMENTS

THE FOLLOWING PEOPLE ARE RECOGNIZED FOR THEIR CONTRIBUTIONS OF TIME AND EXPERTISE DURING THIS STUDY AND IN THE PREPARATION OF THIS REPORT:

API STAFF CONTACT

Paul Martino, Health and Environmental Sciences Department

MEMBERS OF THE PIPELINE EMISSION FACTORS PROJECT GROUP

Denise Michelson, Chairperson, Arco Transportation Company
Lee Gilmer, Texaco Research
Karel Jelinek, BP Oil
John King, Shell Development Company
Gary Kizior, Amoco Corporation
George Lauer, Arco
Miriam Lev-On, Arco
Dan Van Der Zanden, Chevron Research & Technology

ABSTRACT

The objective of this project was to develop a set of emission factors for fugitive hydrocarbon emissions from equipment components at crude oil and product pipeline facilities. To accomplish this, more than 33,000 equipment components were screened on ten pipeline facilities within the United States. Total emissions from the pipelines screened in this study ranged from 0.11 pounds-per-day to 10.34 pounds-per-day when calculated using instrument screening values and 1995 EPA Correlations/Factors. The same sites would be predicted to have total emissions ranging from 0.13 pounds-per-day to 8.45 pounds-per-day using the emission factors developed in this study.

TABLE OF CONTENTS

Section	Page
EXECUTIVE SUMMARY	ES-1
1. STUDY METHODOLOGY	1-1
INTRODUCTION	1-1
Objectives	1-1
Scope	1-1
DESCRIPTION OF METHODOLOGY	1-2
Study Site Selection	1-3
Component Counting Procedures	1-4
Emissions Screening Procedures	1-5
DATA MANAGEMENT	1-6
Development of Emissions Factors	1-6
Calculation of Site Specific Emissions	1-7
2. RESULTS AND ANALYSIS	2-1
DATA COLLECTION	2-1
DEVELOPMENT OF EMISSION FACTORS	2-4
Emissions from Default Zero Components	2-4
Emissions from Components with Screening Values Between Background and 100,000 ppmv	2-5
Emissions from Components with Screening Values of 100,000 ppmv or More	2-5
Calculation of Total Emissions and Emission Factors	2-6
CALCULATION OF TOTAL EMISSIONS FROM EACH PIPELINE	2-12
Calculation of Total Emissions Using Screening Values and EPA Correlations/Factors	2-12
Calculation of Total Emissions Using Inventories and This Study's Emission Factors	2-13
Comparison of Two Methods for Calculating Site Specific Fugitive Emissions	2-14
3. CONCLUSIONS	3-1
4. REFERENCES	R-1

TABLE OF CONTENTS (Continued)

Section		Page
ATTACHMENT A	COMPONENTS WITH SCREENING VALUES ABOVE BACKGROUND BUT LESS THAN 100,000 PPMV	A-1
ATTACHMENT B	CALCULATION OF SITE SPECIFIC EMISSIONS USING SCREENING VALUES AND 1995 EPA CORRELATIONS/FACTORS	B-1

LIST OF TABLES

Table		Page
ES-1	EPA Default Zero Factors, Correlation Equations, and Pegged Source Factors (100,000 ppmv)	ES-2
ES-2	Emission Factors for Uncontrolled Pipelines	ES-3
ES-3	Comparison of Two Methods for Calculating Site Specific Fugitive Emissions from Pipelines	ES-3
2-1	Components Screened	2-2
2-2	Number (and percentage) of Components with Screening Values Between Background and 100,000 ppmv	2-2
2-3	Number (and percentage) of Components with Screening Values of 100,000 ppmv or More	2-2
2-4	Frequency of Components with Screening Values Above Background at Uncontrolled Pipelines, Production Sites, and Marketing Terminals (includes pegged sources)	2-3
2-5	EPA Default Zero Factors, Correlation Equations, and Pegged Source Factors (100,000 ppmv)	2-4
2-6	Default Zero Emissions from Uncontrolled Pipelines	2-5
2-7	Fugitive Emissions from Pegged Sources (100,000 ppmv) at Uncontrolled Pipelines	2-6
2-8	Calculation of Emission Factors for Uncontrolled Pipelines	2-7
2-9	Comparison of Pipeline Emission Factors to Production Emission Factors (lb/component-day)	2-8
2-10	Comparison of Pipeline Emission Factors to Marketing Terminal and Refinery Emission Factors(lb/component-day)	2-8
2-11	Calculation of Total Emissions for Site 1 Using Screening Values and 1995 EPA Correlations/Factors	2-12
2-12	Total Emissions Calculated for Ten Pipelines Using Screening Values and 1995 EPA Correlations/Factors	2-13
2-13	Total Emissions from Light Crude Oil Pipelines Calculated Using This Study's Factors	2-13
2-14	Total Emissions from Heavy Crude Oil Pipelines Calculated Using This Study's Factors	2-14
2-15	Total Emissions from Product Pipelines Calculated Using This Study's Factors	2-14

LIST OF TABLES (Continued)

Table		Page
2-16	Comparison of Two Methods for Calculating Site Specific Fugitive Emissions from Pipelines	2-14
3-1	Emission Factors for Uncontrolled Pipelines	3-1

LIST OF FIGURES

Figure		Page
1-1	Pipeline Study Sites	1-3
2-1	Frequency of Components with Screening Values Above Background at Uncontrolled Pipelines, Production Sites, and Marketing Terminals	2-3
2-2	Comparison of Emission Factors for Threaded Connections	2-9
2-3	Comparison of Emission Factors for Flanges	2-9
2-4	Comparison of Emission Factors for Valves	2-10
2-5	Comparison of Emission Factors for Open Ended Lines	2-10
2-6	Comparison of Emission Factors for Pump Seals	2-11
2-7	Comparison of Emission Factors for Other Components	2-11

EXECUTIVE SUMMARY

Emission factors for fugitive hydrocarbon emissions were developed for light crude oil pipelines, heavy crude oil pipelines, and product pipelines. Pipeline facilities included in this study were originating pump stations, booster pump stations, break-out pump stations, central shipping stations, and terminals. This study included both controlled and uncontrolled pipeline facilities. Uncontrolled facilities are facilities that are not regulated by agency enforced fugitive emissions monitoring programs. Facilities that are regulated by agency enforced programs are considered to be controlled facilities.

A total of 33,588 threaded connections, flanges, valves, open ended lines (also referred to as "open ended valves"), pump seals, and other components on ten pipelines across the United States of America were screened with portable hydrocarbon detection equipment. A total of 109 components were found to have instrument screening values above the background concentration but below the pegged value(100,000 ppmv). One component (a pump seal on an uncontrolled light crude oil pipeline) was found to have an instrument screening value higher than 100,000 ppmv.

Pipeline components were grouped into the following categories:

- Light crude oil -- uncontrolled (five pipelines);
- Light crude oil -- controlled (one pipeline);
- Heavy crude oil -- uncontrolled (one pipeline);
- Product -- uncontrolled (two pipelines); and
- Product -- controlled (one pipeline).

Emission frequencies (number of components with measurable hydrocarbon emissions per 100 components screened) of uncontrolled light crude oil and uncontrolled heavy crude oil pipeline facilities are similar to the emission frequencies of light crude and heavy crude production sites, respectively (see Table 2-4 and Figure 2-1 on page 2-3). The emission frequency of uncontrolled product pipeline facilities is between the

emission frequencies of heavy crude production and marketing terminals. Based on the limited number of data points obtained at controlled pipelines, their emission frequencies may be considered similar, though possibly lower, than the emission frequencies of uncontrolled pipeline facilities.

Emission factors were calculated for components at light crude oil, heavy crude oil, and product pipeline facilities using the 1995 Evironmental Protection Agency (EPA) default zero factors, correlation equations, and pegged source factors (100,000 ppmv). Emissions from components with screening values equal to background were calculated using the default zero factors. Emissions from components with screening values above background but less than 100,000 ppmv were calculated using correlation equations. The measured screening values were corrected for background if the background was 5% or more of the measured screening values. Emissions from one component that pegged the portable detection instrument at 100,000 ppmv were calculated using a pegged source factor. EPA default zero factors, correlation equations, and pegged source factors (100,000 ppmv) are shown in Table ES-1. The pipeline emission factors developed in this study are shown in Table ES-2.

Table ES-1. EPA Default Zero Factors, Correlation Equations, and Pegged Source Factors (100,000 ppmv)

Component	Default Zero Factor (lb/day)	Correlation Equation	Pegged Source Factor (100,000 ppmv)
Threaded	0.00040	$THC_{(lb/day)} = 7.99E\text{-}05(SV^*)^{0.735}$	1.6 lb/day
Flange	0.00002	$THC_{(lb/day)} = 2.35E\text{-}04(SV)^{0.703}$	4.4 lb/day
Valve	0.00041	$THC_{(lb/day)} = 1.21E\text{-}04(SV)^{0.746}$	7.4 lb/day
Open-end	0.00011	$THC_{(lb/day)} = 1.14E\text{-}04(SV)^{0.704}$	4.2 lb/day
Pump Seal	0.00127	$THC_{(lb/day)} = 2.55E\text{-}03(SV)^{0.610}$	8.5 lb/day
Other	0.00021	$THC_{(lb/day)} = 6.98E\text{-}04(SV)^{0.589}$	5.8 lb/day

SOURCE: US EPA Protocol for Equipment Leak Emission Estimates (EPA-453/R-95-017), Nov. 1995.
**SV refers to the measured screening value.*

Table ES-2. Emission Factors for Uncontrolled Pipeline Facilities (lb/component-day)

	Threaded	Flanges	Valves	OEL*	Pumps	Others
Light Crude	0.00040	0.00002	0.00043	0.00080	0.12214	0.00021
Heavy Crude	0.00040	0.00002	0.00041	0.00055	0.04175	0.00021
Product	0.00043	0.00002	0.00075	0.00358	0.11062	0.00251

**Open Ended Lines.*

Emission factors for components at uncontrolled light crude oil pipeline facilities are generally lower than emission factors for the same components at light crude oil production sites (see Figures 2-2 to 2-7 on pages 2-9 to 2-11). Emission factors for uncontrolled heavy crude oil pipeline facilities are approximately the same as those for heavy crude oil production. For most equipment component types, emission factors for uncontrolled product pipelines are lower than for the same components at marketing terminals.

Total fugitive hydrocarbon emissions were calculated for each pipeline using two methods: 1) site specific screening values with EPA Correlations/Factors, and 2) site specific inventories with emission factors developed in this study. The two sets of emission rates are shown in Table ES-3.

Table ES-3. Comparison of Two Methods for Calculating Site Specific Fugitive Emissions from Pipeline Facilities

		Calculated Emissions (lb/day)		Difference(lb/day)
Pipeline Number	Pipeline Type	Using EPA Correlations/ Factors	Using This Study's Factors	This Study's Factors vs. EPA Correlations/ Factors
1	Light Crude (U)*	5.04	4.51	-0.53
2	Light Crude (U)*	1.92	6.90	4.98
3	Light Crude (U)*	6.45	8.45	2.00
4	Light Crude (U)*	10.34	3.29	-7.05
5	Light Crude (U)*	0.25	0.73	0.48
6	Light Crude (C)**	0.36	0.37	0.01
7	Heavy Crude (U)*	1.32	1.32	0.00
8	Product (U)*	1.35	1.43	0.08
9	Product (U)*	6.34	6.25	-0.09
10	Product(C)**	0.11	0.13	0.02

**U = Uncontrolled.* ***C = Controlled.*

Total emissions from the pipelines calculated using instrument screening values and 1995 EPA Correlations/Factors range from 0.11 pounds-per-day to 10.34 pounds-per-day; total emissions calculated using component counts (inventories) and the new emission factors developed in this study range from 0.13 pounds-per-day to 8.45 pounds-per-day.

Section 1
STUDY METHODOLOGY

INTRODUCTION

Fugitive hydrocarbon emission data from petroleum production facilities, refineries, and marketing terminals were collected during several recent field studies sponsored in part by the American Petroleum Institute. The US Environmental Protection Agency (EPA) used the data to develop several models for predicting fugitive emissions from these segments of the petroleum industry. However, none of these studies included pipeline facilities used to transport crude oil or petroleum products.

The current study focused on fugitive hydrocarbon emissions from crude oil pipelines and product pipeline facilities.

Objectives

The main objective of this study was to develop emission factors for crude oil pipelines and product pipelines that would be acceptable to the EPA. Additional objectives were the following:

1. Obtain component inventories at typical pipeline facilities; and
2. Determine the percentage of components that have fugitive hydrocarbon emissions.

Scope

Ten pipeline facilities located across the United States of America (USA) were selected for the project. All components in use except those on tank tops were inventoried and screened using EPA Method 21 guidelines. Emission factors were developed for six types of components (threaded connections, flanges, valves, open-ended lines, pump seals, and others) at three types of pipeline facilities (light crude oil, heavy crude oil, and product). Fugitive emission rates were calculated for each of the sites using the new emission factors.

DESCRIPTION OF METHODOLOGY

A variety of crude oil pipeline and product pipeline facilities was selected. Six light crude oil pipelines, one heavy crude oil pipeline, and three product pipelines were included. The following types of pipeline facilities were inventoried and screened:

- Originating pump stations. These stations receive crude oil directly from the production field. Most stations have tank batteries that briefly store the produced oil between the time it is produced and the time it is shipped out in the pipeline. Typically, the crude oil has been stabilized (dissolved gases have been removed) before it is received at the originating pump station. Originating stations range from small to large depending on the number of surrounding wells and their production rates. Small stations may have one to three medium-sized oil storage tanks and one or more shipping pumps ranging from 200 horsepower to possibly 500 horsepower. Large stations may have as many as 20 storage tanks and several shipping pumps of 1,000 horsepower or more.

- Booster pump stations. These stations contain one or more pumps, inlet and outlet headers, and perhaps pipeline scraper ("pigs") receivers and launchers. These stations are used to increase pressure inside the line when the pipeline climbs in elevation or when internal friction has reduced the pressure to the minimum pressure desired. A pipeline in flat terrain may have a booster station every 50 to 100 miles; booster stations may be closer in rising terrain and less close in declining terrain. Booster stations do not have oil storage tanks. These stations are typically small; many cover less than an acre.

- Break-out pump stations. Break-out pump stations are like booster pump stations except that they have storage tanks. The storage tanks may serve any of several purposes. They may be used to accommodate surges in shipping rates from the originating pump stations. They may also be used to receive production directly from wells located along the pipeline route. If the pipeline is a common carrier (used to ship oil or product from more than one company), the tanks may be used to control differences in shipping and receiving schedules of the different companies. A break-out station typically has from two to ten storage tanks and two to six pumps.

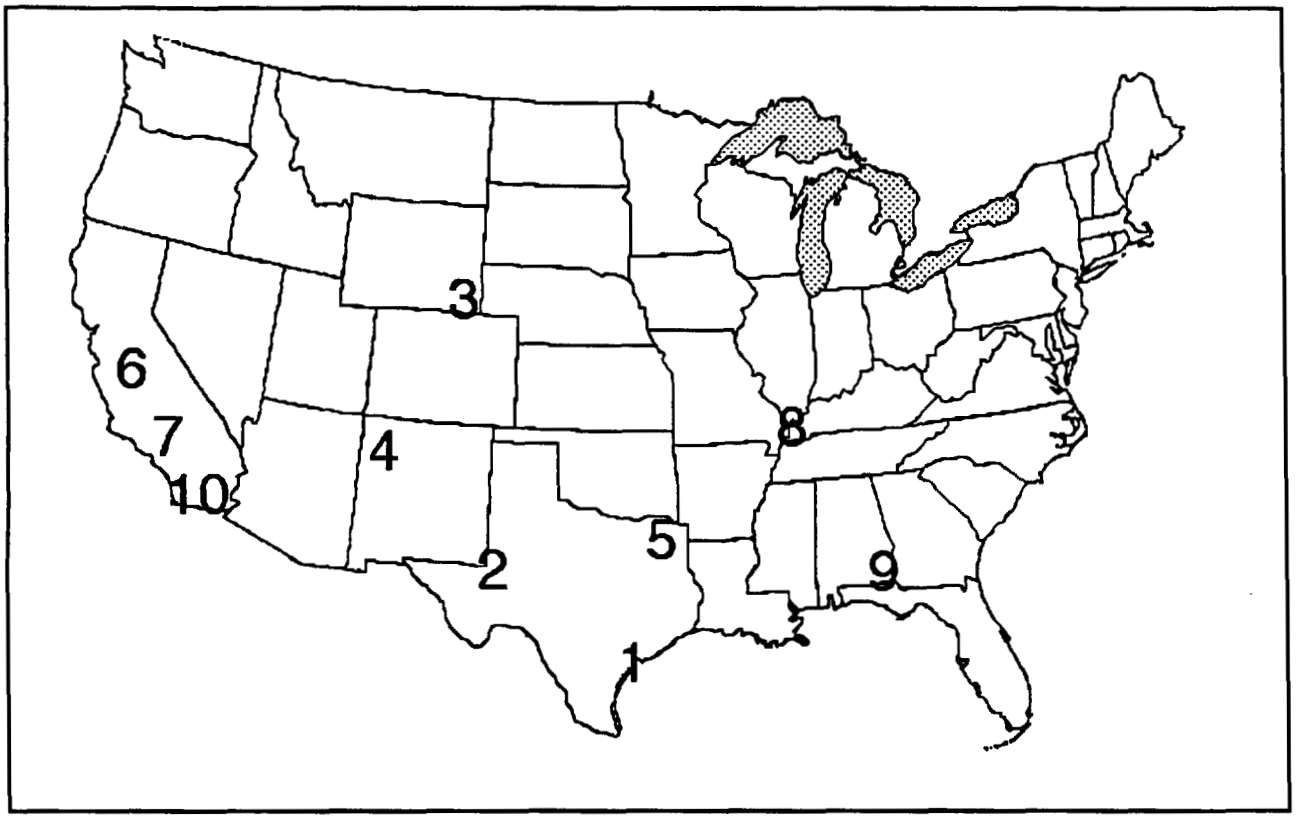
- Central shipping stations. A central shipping station is similar to a break-out station but larger. Typical shipping stations have 20 or more large storage tanks and 20 or more pumps as high as 3,000 horsepower. These stations are capable of receiving and storing oil or product from several pipeline systems. The central station usually feeds crude oil or product into one or more large lines for long distance transportation (1,000 miles or more).

- Terminals. The terminus of a crude oil pipeline may be at a refinery or chemical plant that uses the oil as feedstock. The terminus of a product pipeline may be a distribution system and/or marketing terminal where the product can be loaded into trucks or railroad cars.

Study Site Selection

A variety of crude oil pipeline and product pipeline facilities was selected from locations across the United States. Figure 1-1 shows the approximate locations of the pipeline facilities included in the study.

Figure 1-1. Pipeline Study Sites



- Site 1 -- Texas Gulf Coast (Light Crude Oil). This was a medium-sized originating pump station that receives oil directly from several production fields located within 100 miles. Crude oil is stored on-site then transferred to a nearby end-user.

- Site 2 -- West Texas (Light Crude Oil). The pipeline system included several remote originating pump stations and booster stations as well as a large central shipping station that pressurizes the oil for long distance transportation.

- Site 3 -- Wyoming (Light Crude Oil). A large originating pump station and two breakout stations along a 400 mile section of the pipeline were screened.
- Site 4 -- New Mexico (Light Crude Oil). A medium-sized originating station and several booster stations were screened along 300 miles of pipeline. Two river-crossing block valve stations were screened.
- Site 5 -- Northeast Texas (Light Crude Oil). This site was a small originating pump station.
- Site 6 -- California (Light Crude Oil). An originating pump station, booster stations, and a terminal were included in this group. This site had an agency mandated quarterly monitoring program for fugitive emissions.
- Site 7 -- California (Heavy Crude Oil). An originating pump station and booster stations for heavy crude oil were screened. The crude oil had an API Gravity of 13° and was being transported at a temperature of 180°F.
- Site 8 -- Midwest (Product). A medium-sized facility that included tankage and shipping pumps located directly adjacent to a refinery as well as piping adjacent to a marketing terminal located approximately 200 miles from the refinery. The product being shipped at the time of screening was diesel fuel at a temperature of 60°F.
- Site 9 -- Southern States (Product). A large central shipping station and medium-sized breakout station were included in the screening. The main products were commercial grades of gasoline and jet fuel.
- Site 10 -- California (Product). The site was a terminal and truck loading facility. The products were commercial grades of gasoline. This site had an agency mandated quarterly monitoring program for fugitive emissions.

Component Counting Procedures

All components in use at each site except components on tank tops were counted (inventoried). Tubing fittings and tubing valves were included in the inventory. Elbows were counted as two connectors or flanges unless welded; unions and "tees" were counted as three connections or flanges unless welded. Each pump seal was counted separately. Components were grouped in the following categories:

Threaded connections
Tubing connections
Flanges
Valves
Open ended lines
Pressure relief valves
Pump seals
Miscellaneous

Components at each site were generally counted and recorded in small clusters such as: Header, Meter loop, Pump, Tank farm, Sump Area.

Emissions Screening Procedures

All components included in the inventory were screened using commercially available portable hydrocarbon monitoring instruments that met the following requirements of EPA Method 21 -- "Determination of Volatile Organic Compounds Leaks":

1. The instruments had flame ionization detectors (FID);
2. The instruments responded to hydrocarbons in concentration between 1 and 100,000 ppmv in air and the instrument output was readable within 2.5 percent;
3. The probe tips did not exceed 0.25 inches in outside diameter;
4. The instruments contained electrically driven pumps that sampled between 0.1 and 3.0 liters per minute;
5. The instruments were intrinsically safe; and
6. The sampling configuration used with the instruments responded to hydrocarbons within 5 seconds.

All portable detection instruments were calibrated daily with 10,000 ppmv and 100 (or 40) ppmv methane-in-air calibration gases. Screening was conducted as close to the surface of the components as possible without fouling the sample inlet or restricting flow to the instrument. This was done by attaching small-diameter flexible tubing directly to the instrument inlet. During screening, the sample inlet of the tube was shielded to minimize the effects of wind (if any).

All instrument screening values higher than background were recorded. When a component was found to be emitting hydrocarbons, the highest point of emissions was found and the sampling tube inlet was left at that point for a minimum of 15 seconds (more than twice the response time). The highest reading obtained for each component was recorded. Readings between 1 and 100,000 ppmv were determined from the voltage output of the instruments. No dilution techniques were employed to extend the range above 100,000 ppmv.

DATA MANAGEMENT

The number of equipment components in each category were recorded. All instrument screening values (SV) above background were recorded as were the related background readings.

Development of Emissions Factors

Component emissions were calculated for light crude oil pipelines, heavy crude oil pipelines, and product pipelines using the 1995 EPA default zero factors, correlation equations, and pegged source factors (100,000 ppmv). Emissions from components with screening values equal to background were calculated using the default zero factors. Emissions from components with screening values above background but less than 100,000 ppmv were calculated using correlation equations. The measured screening values were corrected for background if the background was 5% or more of the measured screening values. Emissions from components that pegged the portable detection instrument at 100,000 ppmv were calculated using the pegged source factors.

Emission factors were calculated by adding the emissions from the three screening value ranges and dividing the sum by the total number of components.

Calculation of Site Specific Emissions

Two methods were used to calculate emissions from individual sites. The first method used the actual screening values found at each site and the 1995 EPA default zero factors, correlation equations, and pegged source factors. The second method used the component inventories and the emission factors developed in this study. The predictions of the two methods were compared.

Section 2
RESULTS AND ANALYSIS

DATA COLLECTION

A total of 33,588 components on ten pipelines were inventoried and screened for fugitive hydrocarbon emissions. The pipeline screening data were grouped into five categories according to fluid being transported, and whether or not the pipeline was subject to an agency-mandated program to control fugitive hydrocarbon emissions. The categories and the number of pipelines in the categories are the following:

- Light crude oil -- uncontrolled (five pipelines);
- Light crude oil -- controlled (one pipeline);
- Heavy crude oil -- uncontrolled (one pipeline);
- Product -- uncontrolled (two pipelines); and
- Product -- controlled (one pipeline).

The light crude oils all had API Gravities of 30° or more. The heavy crude oil had an API Gravity of 13°; it was being transported at a temperature of 180°F. Fluids in the product pipelines included diesel fuel, aviation fuel, and various grades of gasoline.

Table 2-1 shows the number of components screened. Tables 2-2 and 2-3, respectively, show the number (and percentage) of components with screening values above background but below 100,000 ppmv and the number (and percentage) of components with screening values of 100,000 ppmv or more. Only one component was found to have a screening value of 100,000 ppmv or more; it was a pump seal on a light crude oil pipeline that did not have an agency-mandated monitoring program. Pipelines with agency-mandated fugitive emissions control programs are identified with a "(C)"; pipelines without agency-mandated fugitive emissions control programs are identified with a "(U)".

Table 2-1. Components Screened

	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Light Crude (U)*	15,252	3,869	3,398	254	131	292	23,196
Light Crude(C)**	601	315	254	9	0	0	1,179
Heavy Crude(U)*	1,580	250	371	47	12	11	2,271
Product (U)*	4,521	858	1,000	97	39	127	6,642
Product (C)**	209	39	52	0	0	0	300

Table 2-2. Number (and percentage) of Components with Screening Values Between Background and 100,000 ppmv

	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Light Crude (U)*	4(0.03%)	0(0.00%)	18(0.53%)	4(1.57%)	21(16.03%)	0(0.00%)	47(0.20%)
Light Crude(C)**	0(0.00%)	0(0.00%)	1(0.39%)	0(0.00%)	0(0.00%)	0(0.00%)	1(0.08%)
Heavy Crude(U)*	0(0.00%)	0(0.00%)	1(0.27%)	1(2.13%)	7(58.33%)	0(0.00%)	9(0.40%)
Product (U)*	6(0.13%)	0(0.00%)	10(1.00%)	9(9.28%)	21(53.85%)	6(4.72%)	52(0.78%)
Product (C)**	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)

Table 2-3. Number (and percentage) of Components with Screening Values of 100,000 ppmv or More

	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Light Crude (U)*	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	1(0.76%)	0(0.00%)	1(0.004%)
Light Crude(C)**	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.000%)
Heavy Crude(U)*	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.000%)
Product (U)*	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.000%)
Product (C)**	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.000%)

**U=Uncontrolled.* ***C=Controlled.*

Table 2-4 compares the emission frequencies (number of components with measurable hydrocarbon emissions per 100 components screened) of components with screening values above background (including pegged sources) at uncontrolled pipelines with similar emission frequencies at production sites and marketing terminals. Figure 2-1 shows the same data graphically. The emission frequencies of uncontrolled light crude oil and uncontrolled heavy crude oil pipelines are similar to those of light crude and heavy crude production sites, respectively. The emission frequency of uncontrolled product pipelines is between the frequencies of heavy crude production and marketing terminals. The emitter frequencies of the two controlled pipelines may be considered

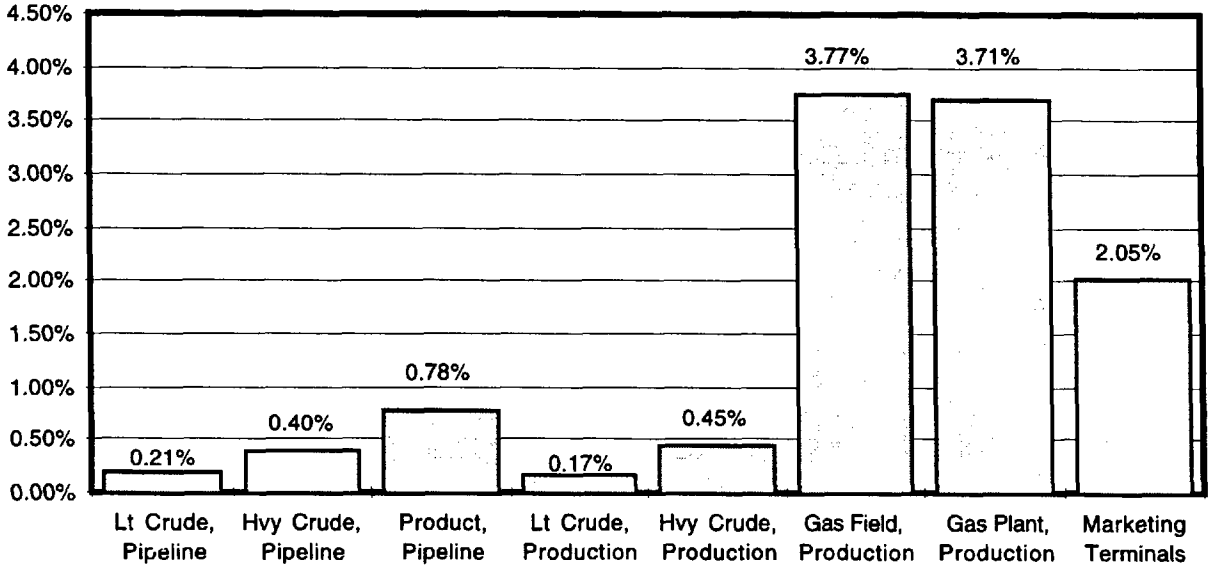
similar to the emitter frequencies of uncontrolled pipelines based on the limited number of data points available.

Table 2-4. Frequency of Components with Screening Values Above Background at Uncontrolled Pipelines, Production Sites, and Marketing Terminals (includes pegged sources)

	Screened	Elevated Screening Values	% Elevated Screening Values
PIPELINE			
Light Crude (U)*	23,196	48	0.21%
Heavy Crude (U)*	2,271	9	0.40%
Product (U)*	6,642	52	0.78%
PRODUCTION**			
Light Crude	48,652	84	0.17%
Heavy Crude	13,756	62	0.45%
Gas Field	40,178	1,513	3.77%
Gas Plant	57,126	2,122	3.71%
PRODUCTS***			
Marketing Terminal	6,161	126	2.05%

U = Uncontrolled.* * SOURCE: STAR Environmental, 1995, p. 1-3.*
**** SOURCE: Radian Corporation, 1993.*

Figure 2-1. Frequency of Components with Screening Values Above Background at Uncontrolled Pipelines, Production Sites, and Marketing Terminals



DEVELOPMENT OF EMISSION FACTORS

Emission factors were calculated for uncontrolled light crude oil pipelines, uncontrolled heavy crude oil pipelines, and uncontrolled product pipelines using the 1995 EPA default zero factors, correlation equations, and pegged source factors at 100,000 ppmv (see Table 2-5). Emissions from components with screening values equal to background were calculated using the default zero factors. Emissions from components with screening values above background but less than 100,000 ppmv were calculated using correlation equations. The measured screening values were corrected for background if the background was 5% or more of the measured screening values. Emissions from one component that pegged the portable detection instrument at 100,000 ppmv were calculated using a pegged source factor.

Table 2-5. EPA Default Zero Factors, Correlation Equations, and Pegged Source Factors (100,000 ppmv)

Component	Default Zero Factor (lb/day)	Correlation Equation	Pegged Source Factor (100,000 ppmv)
Threaded	0.00040	$THC_{(lb/day)} = 7.99E\text{-}05(SV)^{0.735}$	1.6 lb/day
Flange	0.00002	$THC_{(lb/day)} = 2.35E\text{-}04(SV)^{0.703}$	4.4 lb/day
Valve	0.00041	$THC_{(lb/day)} = 1.21E\text{-}04(SV)^{0.746}$	7.4 lb/day
Open-end	0.00011	$THC_{(lb/day)} = 1.14E\text{-}04(SV)^{0.704}$	4.2 lb/day
Pump Seal	0.00127	$THC_{(lb/day)} = 2.55E\text{-}03(SV)^{0.610}$	8.5 lb/day
Other	0.00021	$THC_{(lb/day)} = 6.98E\text{-}04(SV)^{0.589}$	5.8 lb/day

**SOURCE: US EPA Protocol for Equipment Leak Emission Estimates (EPA-453/R-95-017), Nov. 1995.*

Emissions from Default Zero Components

Table 2-6 shows the calculated amount of fugitive emissions from components with screening values equal to the background concentration (default zeros) at uncontrolled pipelines.

Table 2-6. Default Zero Emissions from Uncontrolled Pipelines

	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
COUNT							
Light Crude	15,248	3,869	3,380	250	109	292	23,147
Heavy Crude	1,580	250	370	46	5	11	2,262
Product	4,515	858	990	88	18	121	6,590
EPA Factor*	0.00040	0.00002	0.00041	0.00011	0.00127	0.00021	lb/day
EMISSIONS (lb/day)							
Light Crude	6.099	0.077	1.386	0.028	0.138	0.061	7.790
Heavy Crude	0.632	0.005	0.152	0.005	0.006	0.002	0.802
Product	1.806	0.017	0.406	0.010	0.023	0.025	2.287

**SOURCE: US EPA Protocol for Equipment Leak Emission Estimates (EPA-453/R-95-017), Nov. 1995.*

Emissions from Components with Screening Values Between Background and 100,000 ppmv

Emissions from components with screening values above background but less than 100,000 ppmv were calculated using the EPA correlation equations shown in Table 2-5. Tables A-2 through A-5, respectively, in Attachment A show all the components with their screening values as measured in ppmv, associated background values (BG), screening values corrected for background (if the changes were 5% or more), and the emission rates in pounds-per-day.

Emissions from Components with Screening Values of 100,000 ppmv or More

Emissions from components with screening values that exceeded the range of the instrument (pegged sources) were calculated using 1995 EPA 100,000 ppmv pegged source factors. Table 2-7 shows the amount of fugitive emissions calculated from pegged sources at uncontrolled pipelines.

Table 2-7. Fugitive Emissions from Pegged Sources (100,000 ppmv) at Uncontrolled Pipelines

	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
COUNT							
Light Crude	0	0	0	0	1	0	1
Heavy Crude	0	0	0	0	0	0	0
Product	0	0	0	0	0	0	0
EPA Factor*	1.6	4.4	7.4	4.2	8.5	5.8	lb/day
EMISSIONS (lb/day)							
Light Crude	0.0	0.0	0.0	0.0	8.5	0.0	8.5
Heavy Crude	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Product	0.0	0.0	0.0	0.0	0.0	0.0	0.0

**SOURCE: US EPA Protocol for Equipment Leak Emission Estimates (EPA-453/R-95-017), Nov. 1995.*

Calculation of Total Emissions and Emission Factors

Total emissions were calculated for each component type at uncontrolled pipelines by adding the emissions from default zeros (Table 2-5), components with screening values between background and 100,000 ppmv (Tables A-2, A-3, A-4, and A-5, Attachment A), and components with screening values of 100,000 ppmv or more (Table 2-7). Emission factors were calculated by dividing these totals by the total number of components. Table 2-8 shows the results of these calculations.

Table 2-8. Calculation of Emission Factors for Uncontrolled Pipelines

	Threaded	Flanges	Valves	OEL	Pumps	Others
EMISSIONS FROM UNCONTROLLED LIGHT CRUDE OIL PIPELINES (lb/day)						
Default Zeros	6.099	0.077	1.386	0.028	0.138	0.061
Emitters	0.0705	—	0.0912	0.1743	7.3737	—
Pegged Sources	—	—	—	—	8.5	—
Total	6.170	0.077	1.477	0.202	16.0	0.061
EMISSIONS FROM UNCONTROLLED HEAVY CRUDE OIL PIPELINES (lb/day)						
Default Zeros	0.632	0.005	0.152	0.005	0.006	0.002
Emitters	—	—	0.0013	0.0209	0.4947	—
Pegged Sources	—	—	—	—	—	—
Total	0.632	0.005	0.153	0.026	0.501	0.002
EMISSIONS FROM UNCONTROLLED PRODUCT PIPELINES (lb/day)						
Default Zeros	1.806	0.017	0.406	0.010	0.023	0.025
Emitters	0.1312	—	0.3479	0.3374	4.2909	0.2937
Pegged Sources	—	—	—	—	—	—
Total	1.937	0.017	0.754	0.347	4.314	0.319
COMPONENT INVENTORIES						
Light Crude	15,252	3,869	3,398	254	131	292
Heavy Crude	1,580	250	371	47	12	11
Product	4,521	858	1,000	97	39	127
EMISSION FACTORS (lb/component-day)						
Light Crude	0.00040	0.00002	0.00043	0.00080	0.12214	0.00021
Heavy Crude	0.00040	0.00002	0.00041	0.00055	0.04175	0.00021
Product	0.00043	0.00002	0.00075	0.00358	0.11062	0.00251

Table 2-9 compares the pipeline emission factors to production emission factors. Table 2-10 compares the pipeline emission factors to marketing terminal and refinery emission factors. Figures 2-2 through 2-7 compare all of the factors.

Table 2-9. Comparison of Pipeline Emission Factors to Production Emission Factors (lb/component-day)

	Lt Crude Pipe	Hvy Crude Pipe	Product Pipe	*Gas, Production	*Light Oil, Production	*Heavy Oil, Production	*Water/LO, Production
Threaded	0.00040	0.00040	0.00043	0.01100	0.01100	0.00040	0.00580
Flange	0.00002	0.00002	0.00002	0.02100	0.00580	0.00002	0.00015
Valve	0.00043	0.00041	0.00075	0.24000	0.13000	0.00044	0.00520
Open-End	0.00080	0.00055	0.00358	0.11000	0.07400	0.00740	0.01300
Pump	0.12214	0.04175	0.11062	0.13000	0.69000	none	0.00130
Other	0.00021	0.00021	0.00251	0.47000	0.40000	0.00160	0.74000

**SOURCE: US EPA Protocol for Equipment Leak Emission Estimates (EPA-453/R-95-017), Nov. 1995.*

Table 2-10. Comparison of Pipeline Emission Factors to Marketing Terminal and Refinery Emission Factors (lb/component-day)

	Lt Crude Pipe	Hvy Crude Pipe	Product Pipe	*Gas, Marketing Terminal	*Light Liq., Marketing Terminal	**Heavy Liquid, Refinery
Threaded	0.00040	0.00040	0.00043	0.00222	0.00042	0.00190
Flange	0.00002	0.00002	0.00002	0.00222	0.00042	0.00168
Valve	0.00043	0.00041	0.00075	0.00069	0.00228	0.00422
Open-End	0.00080	0.00055	0.00358	0.00635	0.00688	0.00045
Pump	0.12214	0.04175	0.11062	0.00344	0.02857	0.19800
Other	0.00021	0.00021	0.00251	0.00635	0.00688	0.00149

**SOURCE: US EPA Protocol for Equipment Leak Emission Estimates (EPA-453/R-95-017), Nov. 1995.*
*** SOURCE: Hal Taback Company, 1996.*

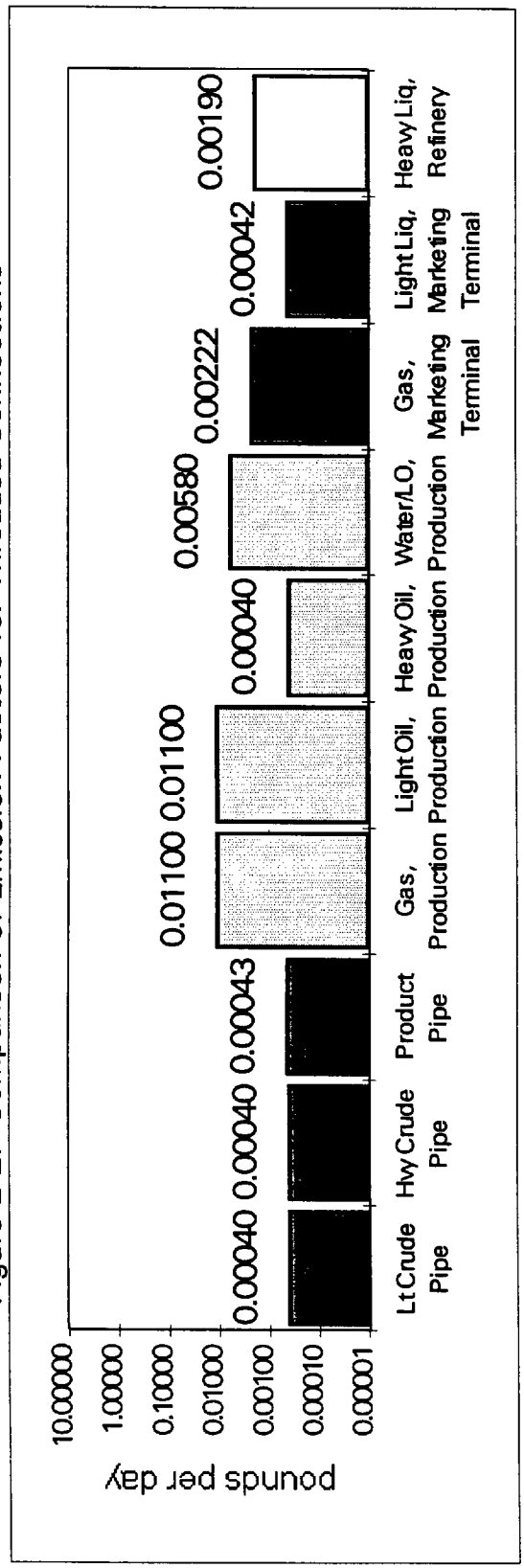


Figure 2-2. Comparison of Emission Factors for Threaded Connections

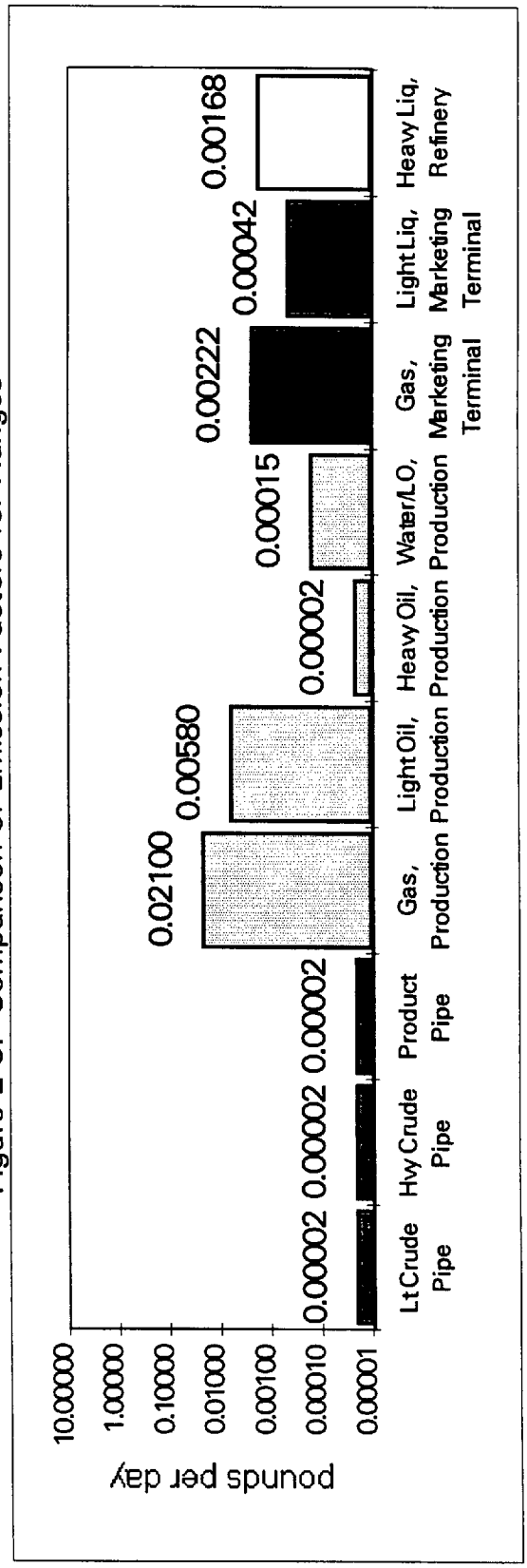


Figure 2-3. Comparison of Emission Factors for Flanges

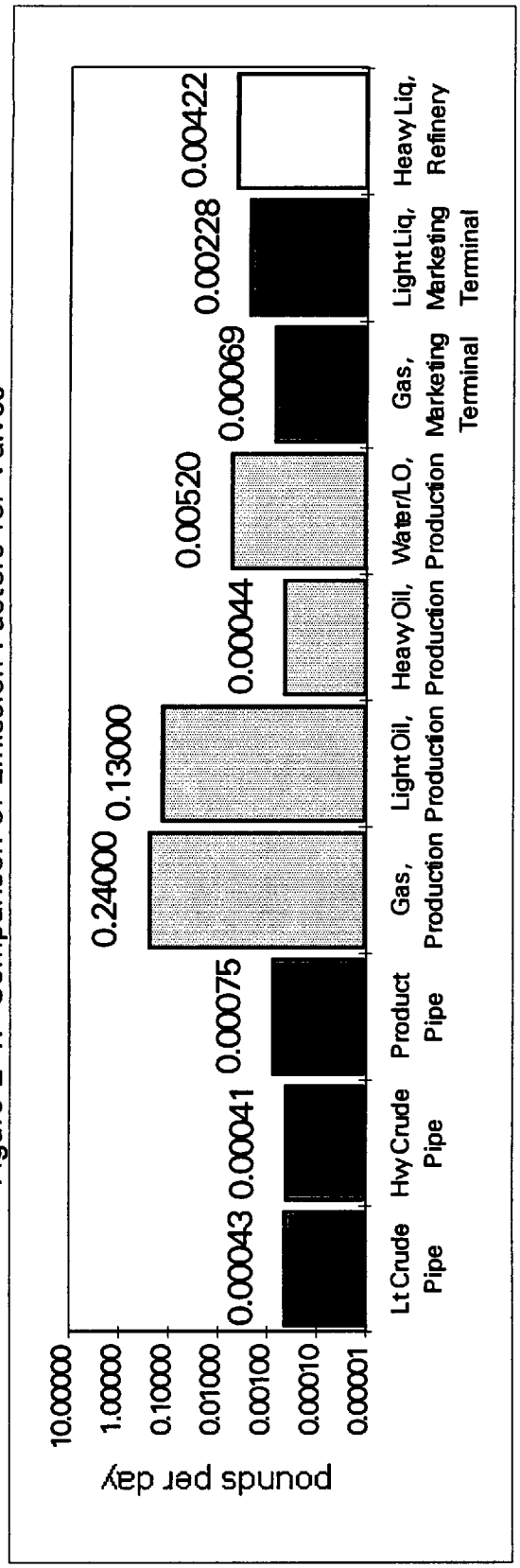


Figure 2-4. Comparison of Emission Factors for Valves
pounds per day
10.00000
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
0.00043
0.00041
0.00075
0.24000
0.13000
0.00044
0.00520
0.00069
0.00228
0.00422
Lt Crude Pipe
Hvy Crude Pipe
Product Pipe
Gas, Production
Light Oil, Production
Heavy Oil, Production
Water/LO, Production
Gas, Marketing Terminal
Light Liq, Marketing Terminal
Heavy Liq, Refinery

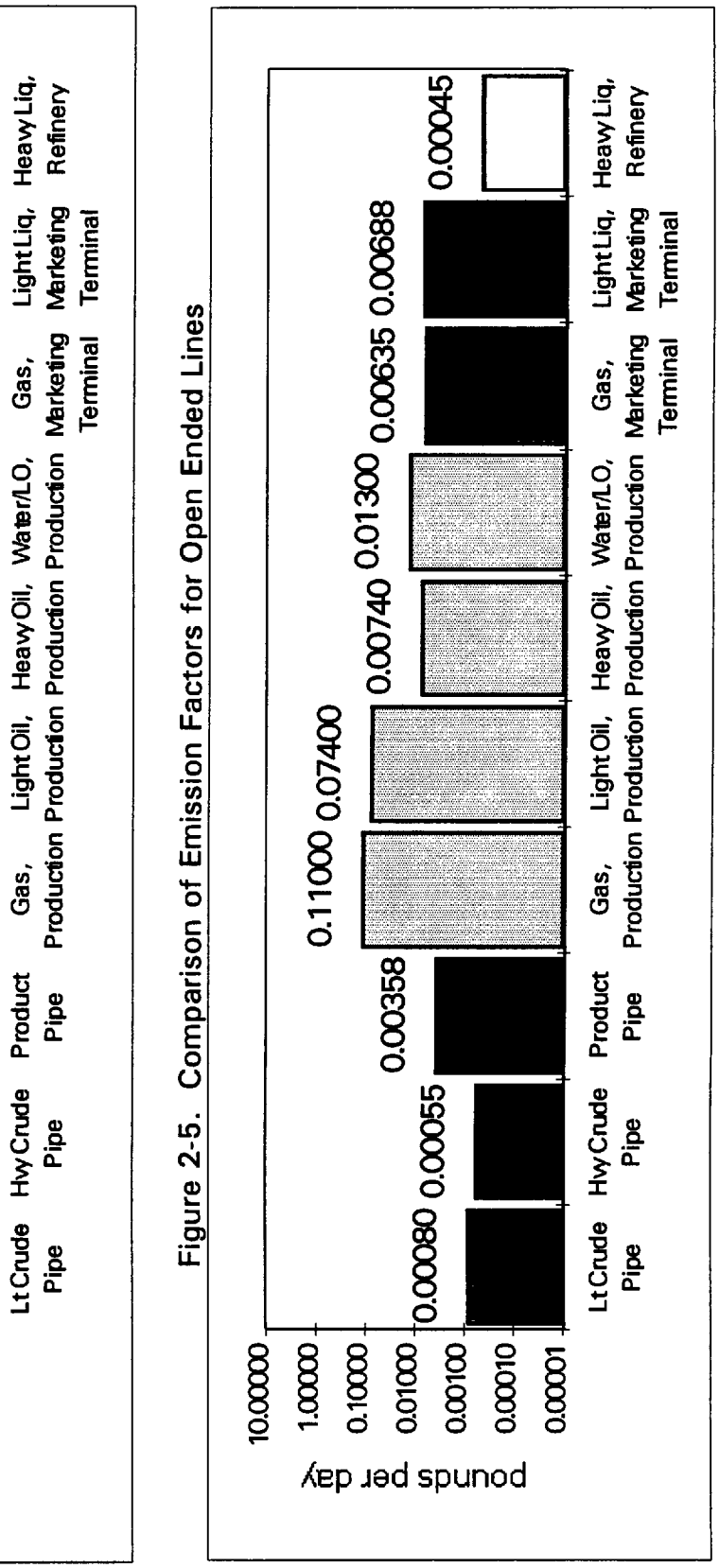


Figure 2-5. Comparison of Emission Factors for Open Ended Lines
pounds per day
10.00000
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
0.00080
0.00055
0.00358
0.11000
0.07400
0.00740
0.01300
0.00635
0.00688
0.00045
Lt Crude Pipe
Hvy Crude Pipe
Product Pipe
Gas, Production
Light Oil, Production
Heavy Oil, Production
Water/LO, Production
Gas, Marketing Terminal
Light Liq, Marketing Terminal
Heavy Liq, Refinery

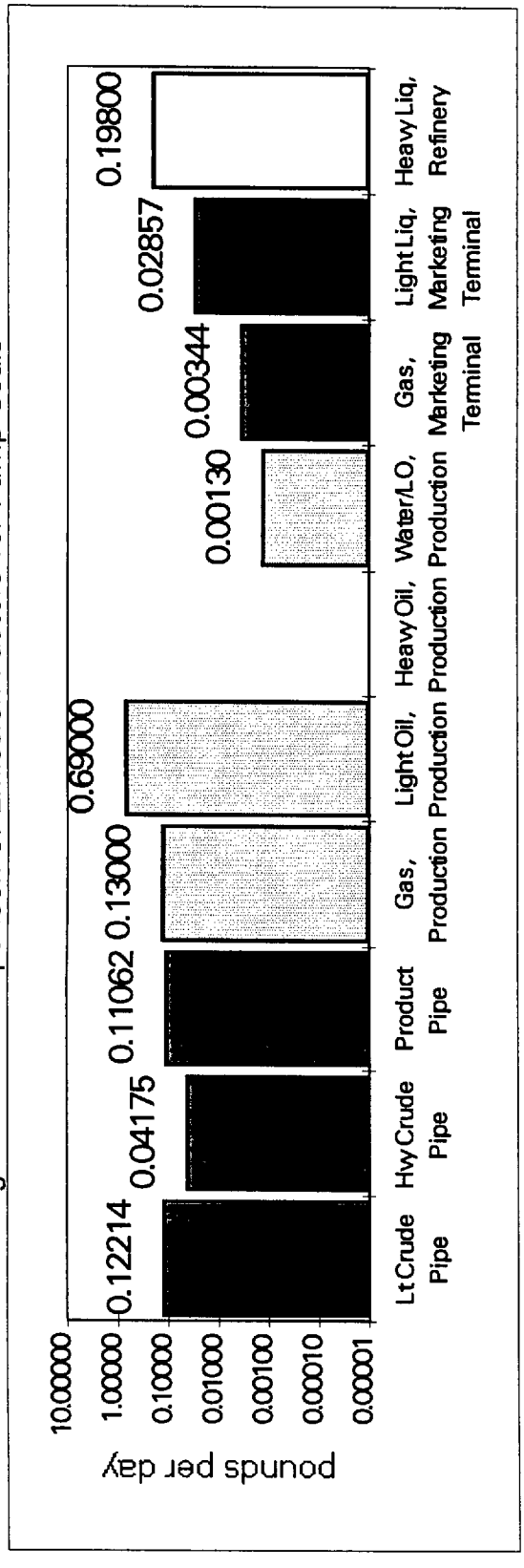


Figure 2-6. Comparison of Emission Factors for Pump Seals
pounds per day
10.00000
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
0.12214
0.04175
0.11062
0.13000
0.69000
0.00130
0.00344
0.02857
0.19800
Lt Crude Pipe
Hy Crude Pipe
Product Pipe
Gas, Production
Light Oil, Production
Heavy Oil, Production
Water/LO, Production
Gas, Marketing Terminal
Light Liq, Marketing Terminal
Heavy Liq, Refinery

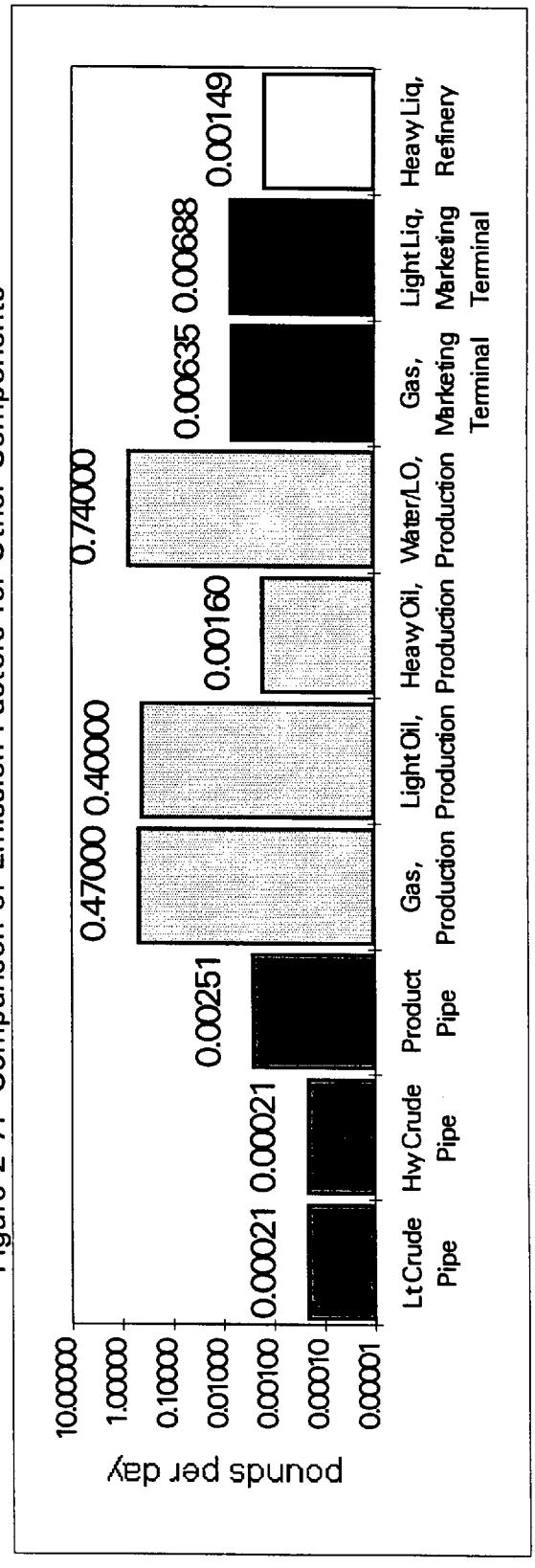


Figure 2-7. Comparison of Emission Factors for Other Components
pounds per day
10.00000
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
0.00021
0.00021
0.00251
0.47000
0.40000
0.00160
0.74000
0.00635
0.00688
0.00149
Lt Crude Pipe
Hy Crude Pipe
Product Pipe
Gas, Production
Light Oil, Production
Heavy Oil, Production
Water/LO, Production
Gas, Marketing Terminal
Light Liq, Marketing Terminal
Heavy Liq, Refinery

CALCULATION OF TOTAL EMISSIONS FROM EACH PIPELINE

Emissions were calculated for each pipeline using two methods: 1) site specific screening values with EPA Correlations/Factors, and 2) site specific inventories with emission factors developed in this study. The two sets of emission rates are compared below.

Calculation of Total Emissions Using Screening Values and EPA Correlations/Factors

Total emissions from each site were calculated in the same manner as shown in the previous section entitled "Calculation of Total Emissions and Emission Factors." EPA default zero factors were used for components with screening values that were the same as background. EPA correlation equations were used for components with screening values between background and 100,000 ppmv. An EPA pegged source factor was used for the single component with an instrument screening value of 100,000+ ppmv. Calculations for Site 1 are given below in Table 2-11; calculations for all ten sites are contained in Attachment B. Table 2-12 gives the total emissions calculated for each of the ten pipelines.

Table 2-11. Calculation of Total Emissions for Site 1
Using Screening Values and 1995 EPA Correlations/Factors

	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
INVENTORY							
Default Zeros	3,268	795	816	18	20	52	4,969
Emitters	1	—	2	—	3	—	6
Pegged Sources	—	—	—	—	—	—	0
TOTAL	3,269	795	818	18	23	52	4,975
EMISSIONS(lb/day)							
Default Zeros	1.3072	0.0159	0.3346	0.0020	0.0254	0.0109	1.6960
Emitters	0.0010	—	0.0040	—	3.3380	—	3.3430
Pegged Sources	—	—	—	—	—	—	0.0000
TOTAL	1.3082	0.0159	0.3386	0.0020	3.3634	0.0109	5.0390

Table 2-12. Total Emissions Calculated for Ten Pipelines Using Screening Values and 1995 EPA Correlations/Factors

Identification Number	Pipeline Type	Number of Default Zeros	Number of Emitters/Pegged	Emissions (lb/day)
1	Light Crude (U)	4,969	6	5.04
2	Light Crude (U)	4,718	20	1.92
3	Light Crude (U)	9,691	7	6.45
4	Light Crude (U)	3,000	15	10.34
5	Light Crude (U)	770	0	0.25
6	Light Crude (C)	1,178	1	0.36
7	Heavy Crude (U)	2,262	9	1.32
8	Product (U)	1,520	8	1.35
9	Product (U)	5,070	44	6.34
10	Product(C)	300	0	0.11

(U) = Uncontrolled. (C) = Controlled.

Calculation of Total Emissions Using Inventories and This Study's Emission Factors

Total emissions from each pipeline calculated using site specific inventories and this study's emission factors are shown in Tables 2-13 through 2-15.

Table 2-13. Total Emissions from Light Crude Oil Pipelines Calculated Using This Study's Factors

LIGHT CRUDE	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
INVENTORY							
Site 1 (U)	3,269	795	818	18	23	52	4,975
Site 2 (U)	3,061	972	612	43	44	6	4,738
Site 3 (U)	6,226	1,616	1,462	164	42	188	9,698
Site 4 (U)	2,237	320	376	29	18	35	3,015
Site 5 (U)	459	166	130	0	4	11	770
Site 6 (C)	601	315	254	9	0	0	1,179
FACTORS FROM THIS STUDY	0.00040	0.00002	0.00043	0.00080	0.12214	0.00021	lb/comp-day
EMISSIONS (lb/day)							
Site 1 (U)	1.31	0.02	0.35	0.01	2.81	0.01	4.51
Site 2 (U)	1.22	0.02	0.26	0.03	5.37	0.00	6.90
Site 3 (U)	2.49	0.03	0.63	0.13	5.13	0.04	8.45
Site 4 (U)	0.89	0.01	0.16	0.02	2.20	0.01	3.29
Site 5 (U)	0.18	0.00	0.06	0.00	0.49	0.00	0.73
Site 6 (C)	0.24	0.01	0.11	0.01	0.00	0.00	0.37

(U) = Uncontrolled. (C) = Controlled.

Table 2-14. Total Emissions from Heavy Crude Oil Pipelines Calculated Using This Study's Factors

HEAVY CRUDE	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
INVENTORY							
Site 7 (U)	1,580	250	371	47	12	11	2,271
FACTORS FROM THIS STUDY	0.00040	0.00002	0.00041	0.00055	0.04175	0.00021	lb/comp-day
EMISSIONS (lb/day)							
Site 7 (U)	0.63	0.01	0.15	0.03	0.50	0.00	1.32

Table 2-15. Total Emissions from Product Pipelines Calculated Using This Study's Factors

PRODUCT PIPELINE	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
INVENTORY							
Site 8 (U)	1,099	168	215	36	6	4	1,528
Site 9 (U)	3,422	690	785	61	33	123	5,114
Site 10 (C)	209	39	52	0	0	0	300
FACTORS FROM THIS STUDY	0.00043	0.00002	0.00075	0.00358	0.11062	0.00251	lb/comp-day
EMISSIONS (lb/day)							
Site 8 (U)	0.47	0.00	0.16	0.13	0.66	0.01	1.43
Site 9 (U)	1.47	0.01	0.59	0.22	3.65	0.31	6.25
Site 10 (C)	0.09	0.00	0.04	0.00	0.00	0.00	0.13

Comparison of Two Methods for Calculating Site Specific Fugitive Emissions

Table 2-16 compares the emissions calculated using the two methods.

Table 2-16. Comparison of Two Methods for Calculating Site Specific Fugitive Emissions from Pipelines

Pipeline Number	Pipeline Type	Calculated Emissions (lb/day)		Difference
		Using EPA Correlations/ Factors	Using This Study's Factors	This Study's Factors vs. EPA Correlations/ Factors (lb/day)
1	Light Crude (U)	5.04	4.51	-0.53
2	Light Crude (U)	1.92	6.90	4.98
3	Light Crude (U)	6.45	8.45	2.00
4	Light Crude (U)	10.34	3.29	-7.05
5	Light Crude (U)	0.25	0.73	0.48
6	Light Crude (C)	0.36	0.37	0.01
7	Heavy Crude (U)	1.32	1.32	0.00
8	Product (U)	1.35	1.43	0.08
9	Product (U)	6.34	6.25	-0.09
10	Product(C)	0.11	0.13	0.02

(U) = Uncontrolled. *(C) = Controlled.*

Section 3
CONCLUSIONS

Leak frequencies of equipment components on uncontrolled crude oil pipelines are similar to leak frequencies at the same types of production sites (light crude oil or heavy crude oil). Leak frequencies of equipment components on uncontrolled product pipelines are similar to leak frequencies at marketing terminals.

Emission factors for uncontrolled pipelines are shown in Table 3-1. Emission factors for uncontrolled light crude oil pipelines are generally lower than emission factors for light crude oil production sites. Emission factors for uncontrolled heavy crude oil pipelines are approximately the same as those for heavy crude oil production. For most equipment component types, emission factors for uncontrolled product pipelines are lower than the same components at marketing terminals.

Table 3-1. Emission Factors for Uncontrolled Pipelines (lb/component-day)

	Threaded	Flanges	Valves	OEL	Pumps	Others
Light Crude	0.00040	0.00002	0.00043	0.00080	0.12214	0.00021
Heavy Crude	0.00040	0.00002	0.00041	0.00055	0.04175	0.00021
Product	0.00043	0.00002	0.00075	0.00358	0.11062	0.00251

Crude oil pipelines and product pipelines that are controlled by an agency-mandated fugitive emission monitoring program have similar, though possibly lower, leak frequencies and leak rates than their uncontrolled counterparts. Additional data would be needed to determine if this apparent result is real or simply an artifact of the individual sites screened in this study.

Total emissions from the pipelines screened in this study ranged from 0.11 pounds-per-day to 10.34 pounds-per-day when calculated using instrument screening values and 1995 EPA Correlations/Factors. The same sites would be predicted to have total emissions ranging from 0.13 pounds-per-day to 8.45 pounds-per-day using the emission factors developed in this study.

Section 4

REFERENCES

STAR Environmental, 1993. *Fugitive Hydrocarbon Emissions From Oil and Gas Production Operations*. API Publication Number 4589. American Petroleum Institute. Washington, D.C.

STAR Environmental, 1995. *Emissions Factors for Oil and Gas Production Operations*. API Publication Number 4615. American Petroleum Institute. Washington, D.C.

US Environmental Protection Agency (US EPA). *Protocol for Equipment Leak Emission Estimates*, November 1995; EPA-453/R-95-017.

Radian Corporation, 1993. *Development of Fugitive Emission Factors and Emission Profiles for Petroleum Marketing Terminals*. API Publication Number 4588. American Petroleum Institute. Washington, D.C.

Hal Taback Company, 1996. *Development of Emission Factors for Leaks in Refinery Components in Heavy Liquid Service*. API Publication Number 337. American Petroleum Institute. Washington, D.C.

ATTACHMENT A

COMPONENTS WITH SCREENING VALUES ABOVE BACKGROUND BUT LESS THAN 100,000 PPMV

ATTACHMENT A

COMPONENTS WITH SCREENING VALUES ABOVE BACKGROUND BUT LESS THAN 100,000 PPMV

Emissions from components with screening values above background but less than 100,000 ppmv were calculated using the EPA correlation equations shown in Table A-1. Tables A-2 through A-5 show all the components with their screening values as measured in ppmv, associated background values (BG), screening values corrected for background (if the changes were 5% or more), and the emission rates in pounds-per-day.

Table A-1. 1995 EPA Correlation Equations

Component	Correlation Equation*
Threaded	$THC_{(lb/day)} = 7.99E\text{-}05(SV)^{0.735}$
Flange	$THC_{(lb/day)} = 2.35E\text{-}04(SV)^{0.703}$
Valve	$THC_{(lb/day)} = 1.21E\text{-}04(SV)^{0.746}$
Open-end	$THC_{(lb/day)} = 1.14E\text{-}04(SV)^{0.704}$
Pump Seal	$THC_{(lb/day)} = 2.55E\text{-}03(SV)^{0.610}$
Other	$THC_{(lb/day)} = 6.98E\text{-}04(SV)^{0.589}$

**SOURCE: US EPA Protocol for Equipment Leak Emission Estimates (EPA-453/R-95-017), Nov. 1995.*

Table A-2. Fugitive Emissions from Emitters at Uncontrolled Light Crude Pipelines

Site	Type	ppmv	BG	ppmv-BG	lb/day	Site	Type	ppmv	BG	ppmv-BG	lb/day
1	Thread	18	3	15	0.0006	4	OEL	600	3	600	0.0105
4	Thread	25	4	21	0.0008	2	OEL	2,000	5	2,000	0.0245
3	Thread	1,200	10	1,200	0.0148	4	OEL	6,000	4	6,000	0.0530
2	Thread	7,000	2	7,000	0.0543	4	OEL	12,000	3	12,000	0.0863
					0.0705						**0.1743**
2	VL	7	1	6	0.0005	1	PS	25	3	22	0.0175
2	VL	12	5	7	0.0005	2	PS	30	4	26	0.0194
2	VL	12	2	10	0.0007	4	PS	35	3	32	0.0220
2	VL	17	5	12	0.0008	2	PS	50	4	46	0.0275
2	VL	25	7	18	0.0010	2	PS	50	2	48	0.0282
1	VL	25	3	22	0.0012	4	PS	70	2	68	0.0349
4	VL	25	3	22	0.0012	4	PS	80	3	80	0.0376
4	VL	60	4	56	0.0024	4	PS	100	2	100	0.0441
1	VL	60	3	57	0.0025	2	PS	200	2	200	0.0674

Table A-2. Fugitive Emissions from Emitters at Uncontrolled Light Crude Pipelines (Continued)

Site	Type	ppmv	BG	ppmv-BG	lb/day
2	VL	150	5	150	0.0051
2	VL	150	1	150	0.0051
2	VL	150	2	150	0.0051
2	VL	200	5	200	0.0063
4	VL	250	4	250	0.0074
2	VL	400	2	400	0.0106
2	VL	400	1	400	0.0106
2	VL	500	1	500	0.0125
2	VL	800	5	800	0.0177
					0.0912

Site	Type	ppmv	BG	ppmv-BG	lb/day
3	PS	200	2	200	0.0674
2	PS	250	5	250	0.0772
4	PS	250	3	250	0.0772
3	PS	500	2	500	0.1178
4	PS	800	2	800	0.1570
4	PS	1,500	3	1,500	0.2303
3	PS	2,000	3	2,000	0.2745
3	PS	2,500	2	2,500	0.3145
3	PS	10,000	5	10,000	0.7326
1	PS	14,500	3	14,500	0.9190
3	PS	40,000	5	40,000	1.7066
1	PS	70,000	3	70,000	2.4010
					7.3737

Table A-3. Fugitive Emissions from Emitters at Controlled Light Crude Pipelines

Site	Type	ppmv	BG	ppmv-BG	lb/day
6	VL	100	4	100	0.0038

Table A-4. Fugitive Emissions from Emitters at Uncontrolled Heavy Crude Pipelines

Site	Type	ppmv	BG	ppmv-BG	lb/day
7	VL	30	5	25	0.0013
					0.0013
7	OEL	1,600	5	1600	0.0209
					0.0209

Site	Type	ppmv	BG	ppmv-BG	lb/day
7	PS	20	5	15	0.0139
7	PS	50	5	45	0.0271
7	PS	50	5	45	0.0271
7	PS	75	5	70	0.0355
7	PS	250	5	250	0.0772
7	PS	400	5	400	0.1028
7	PS	1,300	5	1,300	0.2111
					0.4947

Table A-5. Fugitive Emissions from Emitters at Uncontrolled Product Pipelines

Site	Type	ppmv	BG	ppmv-BG	lb/day
9	Thread	50	5	45	0.0013
9	Thread	125	5	125	0.0028
9	Thread	200	2	200	0.0040
9	Thread	400	5	400	0.0066
9	Thread	500	5	500	0.0078
9	Thread	18,000	4	18,000	0.1087
					0.1312
9	VL	40	5	35	0.0017
9	VL	50	5	45	0.0021
9	VL	50	5	45	0.0021
9	VL	60	5	55	0.0024
9	VL	150	5	150	0.0051
9	VL	250	2	250	0.0074
9	VL	325	5	325	0.0091
9	VL	400	5	400	0.0106
8	VL	1,600	4	1,600	0.0297
9	VL	32,000	5	32,000	0.2777
					0.3479
9	OEL	100	4	100	0.0030
9	OEL	150	5	150	0.0039
8	OEL	200	4	200	0.0048
9	OEL	325	4	325	0.0068
9	OEL	800	5	800	0.0128
8	OEL	9,000	4	9,000	0.0705
8	OEL	9,500	4	9,500	0.0732
8	OEL	10,500	4	10,500	0.0786
8	OEL	11,500	4	11,500	0.0838
					0.3374

Site	Type	ppmv	BG	ppmv-BG	lb/day
9	PS	50	5	45	0.0271
9	PS	50	5	45	0.0271
9	PS	65	2	65	0.0333
9	PS	100	5	100	0.0441
9	PS	125	5	125	0.0506
9	PS	125	5	125	0.0506
9	PS	150	5	150	0.0565
9	PS	150	5	150	0.0565
9	PS	200	5	200	0.0674
9	PS	200	5	200	0.0674
9	PS	250	5	250	0.0772
9	PS	325	5	325	0.0906
8	PS	500	4	500	0.1178
9	PS	500	5	500	0.1178
9	PS	625	5	625	0.1350
9	PS	1,000	5	1,000	0.1798
9	PS	1,600	5	1,600	0.2395
9	PS	2,500	5	2,500	0.3145
8	PS	3,000	4	3,000	0.3515
9	PS	5,000	5	5,000	0.4800
9	PS	40,000	2	40,000	1.7066
					4.2909
9	Other	60	5	55	0.0076
9	Other	225	5	225	0.0175
9	Other	400	5	400	0.0245
9	Other	2,000	5	2,000	0.0633
9	Other	2,500	5	2,500	0.0722
9	Other	5,000	5	5,000	0.1086
					0.2937

NOTE: All six "other" components were in-line "paddle wheel" flow meters. This was from a total population of 83 such flow meters.

ATTACHMENT B

CALCULATION OF SITE SPECIFIC EMISSIONS USING SCREENING VALUES AND 1995 EPA CORRELATIONS/FACTORS

ATTACHMENT B

CALCULATION OF SITE SPECIFIC EMISSIONS USING SCREENING VALUES AND 1995 EPA CORRELATIONS/FACTORS

Fugitive hydrocarbon emission rates were calculated for ten pipelines using actual screening values and 1995 EPA defaults zero factors, correlation equations, and pegged source factors (100,000 ppmv) taken from *Protocol for Equipment Leak Emission Estimates*, November 1995; EPA-453/R-95-017. EPA default zero factors were used for components with screening values that were the same as background. EPA correlation equations were used for components with corrected screening values between background and 100,000 ppmv. An EPA pegged source factor was used for the single component with an instrument screening value of 100,000+ ppmv.

SITE 1							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	3,268	795	816	18	20	52	4,969
Emitters	1		2		3		6
Pegged Sources							0
TOTAL	3,269	795	818	18	23	52	4,975
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	1.3072	0.0159	0.3346	0.0020	0.0254	0.0109	1.6960
Emitters	0.0010		0.0040		3.3380		3.3430
Pegged Sources							0.0000
TOTAL	1.3082	0.0159	0.3386	0.0020	3.3634	0.0109	5.0390

SITE 2							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	3,060	972	599	42	39	6	4,718
Emitters	1		13	1	5		20
Pegged Sources							0
TOTAL	3,061	972	612	43	44	6	4,738
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	1.2240	0.0194	0.2456	0.0046	0.0495	0.0013	1.5444
Emitters	0.0540		0.0770	0.0250	0.2200		0.3760
Pegged Sources							0.0000
TOTAL	1.2780	0.0194	0.3226	0.0296	0.2695	0.0013	1.9204

ATTACHMENT B

SITE 3							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	6,225	1,616	1,462	164	36	188	9,691
Emitters	1				6		7
Pegged Sources							0
TOTAL	6,226	1,616	1,462	164	42	188	9,698
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	2.4900	0.0323	0.5994	0.0180	0.0457	0.0395	3.2250
Emitters	0.0150				3.2130		3.2280
Pegged Sources							0.0000
TOTAL	2.5050	0.0323	0.5994	0.0180	3.2587	0.0395	6.4530

SITE 4							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	2,236	320	373	26	11	35	3,000
Emitters	1		3	3	7		14
Pegged Sources							1
TOTAL	2,237	320	376	29	18	35	3,015
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	0.8944	0.0064	0.1529	0.0029	0.0140	0.0074	1.0779
Emitters	0.0010		0.0110	0.1500	9.1030		9.2650
Pegged Sources							0.0000
TOTAL	0.8954	0.0064	0.1639	0.1529	9.1170	0.0074	10.3429

SITE 5							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	459	166	130	0	4	11	770
Emitters							0
Pegged Sources							0
TOTAL	459	166	130	0	4	11	770
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	0.1836	0.0033	0.0533	0.0000	0.0051	0.0023	0.2476
Emitters							0.0000
Pegged Sources							0.0000
TOTAL	0.1836	0.0033	0.0533	0.0000	0.0051	0.0023	0.2476

ATTACHMENT B

SITE 6							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	601	315	253	9	0	0	1,178
Emitters			1				1
Pegged Sources							0
TOTAL	601	315	254	9	0	0	1,179
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	0.2404	0.0063	0.1037	0.0010	0.0000	0.0000	0.3514
Emitters			0.0040				0.0040
Pegged Sources							0.0000
TOTAL	0.2404	0.0063	0.1077	0.0010	0.0000	0.0000	0.3554

SITE 7							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	1,580	250	370	46	5	11	2,262
Emitters			1	1	7		9
Pegged Sources							0
TOTAL	1,580	250	371	47	12	11	2,271
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	0.6320	0.0050	0.1517	0.0051	0.0064	0.0023	0.8024
Emitters			0.0010	0.0210	0.4950		0.5170
Pegged Sources							0.0000
TOTAL	0.6320	0.0050	0.1527	0.0261	0.5014	0.0023	1.3194

SITE 8							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	1,099	168	214	31	4	4	1,520
Emitters			1	5	2		8
Pegged Sources							0
TOTAL	1,099	168	215	36	6	4	1,528
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	0.4396	0.0034	0.0877	0.0034	0.0051	0.0008	0.5400
Emitters			0.0300	0.3110	0.4690		0.8100
Pegged Sources							0.0000
TOTAL	0.4396	0.0034	0.1177	0.3144	0.4741	0.0008	1.3500

ATTACHMENT B

SITE 9							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	3,416	690	776	57	14	117	5,070
Emitters	6		9	4	19	6	44
Pegged Sources							0
TOTAL	3,422	690	785	61	33	123	5,114
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	1.3664	0.0138	0.3182	0.0063	0.0178	0.0246	1.7470
Emitters	0.1310		0.3180	0.0270	3.8220	0.2940	4.5920
Pegged Sources							0.0000
TOTAL	1.4974	0.0138	0.6362	0.0333	3.8398	0.3186	6.3390

SITE 10							
INVENTORY	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	209	39	52	0	0	0	300
Emitters							0
Pegged Sources							0
TOTAL	209	39	52	0	0	0	300
EMISSIONS(lb/day)	Threaded	Flanges	Valves	OEL	Pumps	Others	TOTAL
Default Zeros	0.0836	0.0008	0.0213	0.0000	0.0000	0.0000	0.1057
Emitters							0.0000
Pegged Sources							0.0000
TOTAL	0.0836	0.0008	0.0213	0.0000	0.0000	0.0000	0.1057

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005
202-682-8000
http://www.api.org

Order No. I46530