New Field Study Improves GHG Emission Factors for Petroleum Industry

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ABSTRACT

New leak quantification data gathered at oil and gas production facilities show that the average size of leaks has decreased significantly over the last 20 years.

The new study was conducted by STAR Environmental, the same company that generated the oil and gas data used in EPA's standard reference on fugitive emissions factors, EPA-453/R-95-017 – "1995 Protocol for Equipment Leak Emission Estimates"[1].

When grouped into five exponential size categories, the 1995 EPA data followed a slightly skewed population distribution. Specifically, when grouped by standard cubic feet per hour (scf/hr) as "Very Small" (less than 0.010 scf/hr), "Small" (0.010 to 0.099 scf/hr), "Medium" (0.100 to 0.999 scf/hr), "Large" (1.000 to 9.999 scf/hr), and "Very Large" (equal to or greater than 10.00 scf/hr), the leak population was 1%, 28%, 35%, 29%, and 7%, respectively.

As expected, the total emissions increased exponentially, viz. 0%, 0%, 5%, 33%, and 62%, respectively.

The most recent study by STAR Environmental found that the population of "Very Large" leaks has decreased significantly. This population reduction is paralleled by a substantial reduction in total fugitive emissions into the atmosphere from the oil and gas industries.

STAR quantified leaks using a new hand-held quantifier that incorporates technology developed by Gas Technology Institute, NFP.

This paper presents findings of the new study of petroleum industry and compares current data to the 1995 EPA data.

INTRODUCTION

One element of Greenhouse Gas Emissions (GHG) is fugitive methane emissions from equipment components (valves, flange, connections, compressors, etc.) at petroleum facilities, refineries, marketing terminals, and chemical plants. Many companies and agencies are currently using fugitive emissions factors published by the US Environmental Protection Agency in document EPA-453/R-95-017 – "1995 Protocol for Equipment Leak Emission Estimates"[1].

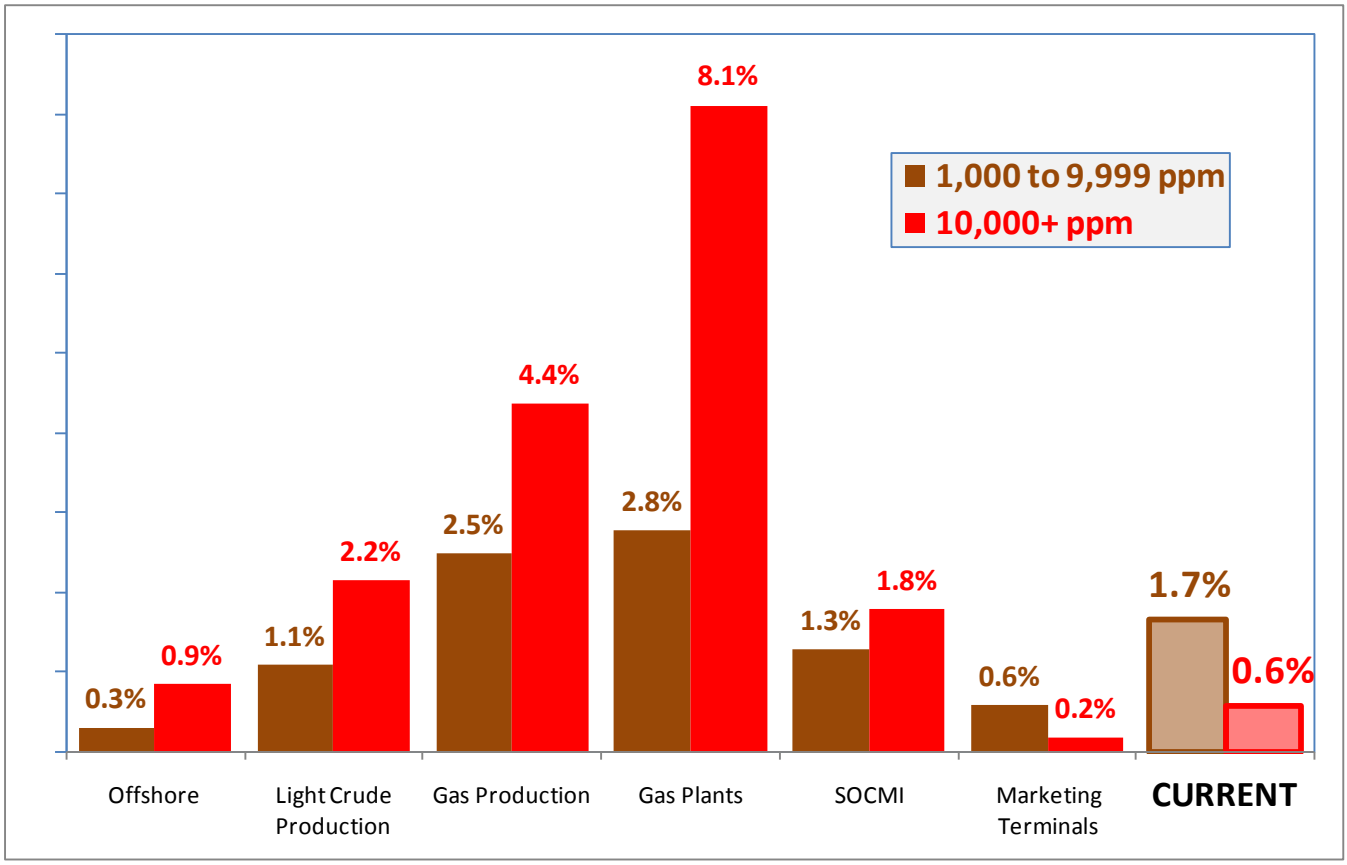
Data in the EPA document were gathered nearly 20 years ago, long before Leak Detection and Repair (LDAR) programs became commonplace. Recent screening and quantification data show significantly lower emission rates than those published in the EPA document.

EPA-453/R-95-017 - 1995 PROTOCOL FOR EQUIPMENT LEAK EMISSION ESTIMATES

During the early-1990's, the American Petroleum Institute (API) commissioned fugitive hydrocarbon emissions studies of oil and gas production operations, refineries, and marketing terminals. The oil and gas study was jointly commissioned by the Gas Research Institute (GRI); the refinery study was jointly commissioned by the Western States Petroleum Association (WSPA). STAR Environmental collected all data for the oil and gas production studies[2,3]. Data from the three studies formed the basis for EPA Document, EPA-453/R-95-017, "1995 Protocol for Equipment Leak Emission Estimates". The document also included data from the Synthetic Organic Chemical Manufacturing Industry (SOCMI).

The oil and gas production facilities generally represented uncontrolled facilities; the marketing terminals were also considered to represent uncontrolled facilities. No information was available on refineries. Figure 1 compares the frequencies of "large emitters" (1,000 ppmv to 9,999 ppmv (ppmv = parts-per-million, by volume)) and "leakers" (10,000 ppmv and higher) for six facility types included in the EPA document to the frequencies found currently at natural gas facilities.

Figure 1. EPA 453/R-95-017 valve screening data vs. current data

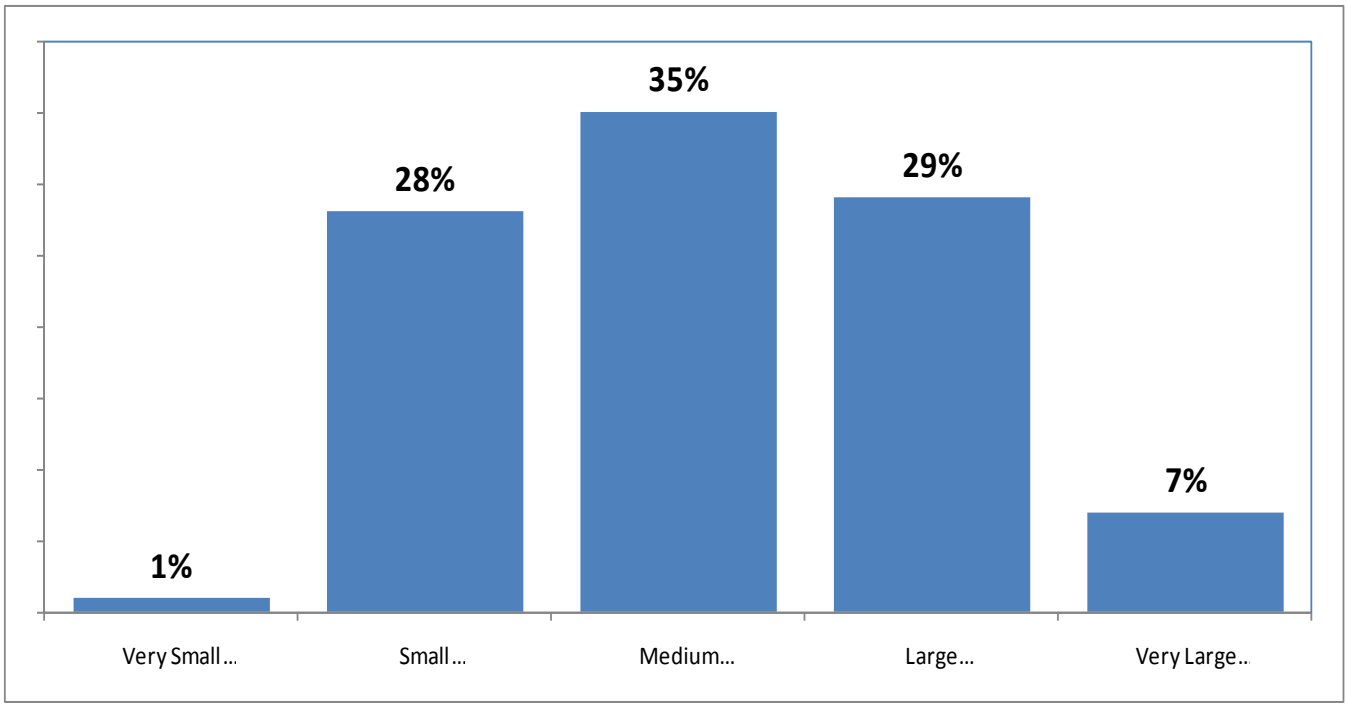


Gas production facilities and gas plants had "large emitter" frequencies that were higher than the frequency found currently at natural gas facilities. All facility types except Marketing Terminals had "leaker" frequencies that were significantly higher than the frequency found currently at natural gas facilities. Marketing Terminals are a special type of facility; they generally have a small number of components in a small area that is constantly manned. It is not surprising that the leaker frequency was very low at these sites.

Three-hundred and two (302) leaking valves were quantified at the production facilities and gas plants. The average emission rate was 2.75 scf/hr. When grouped into five exponential size categories, the

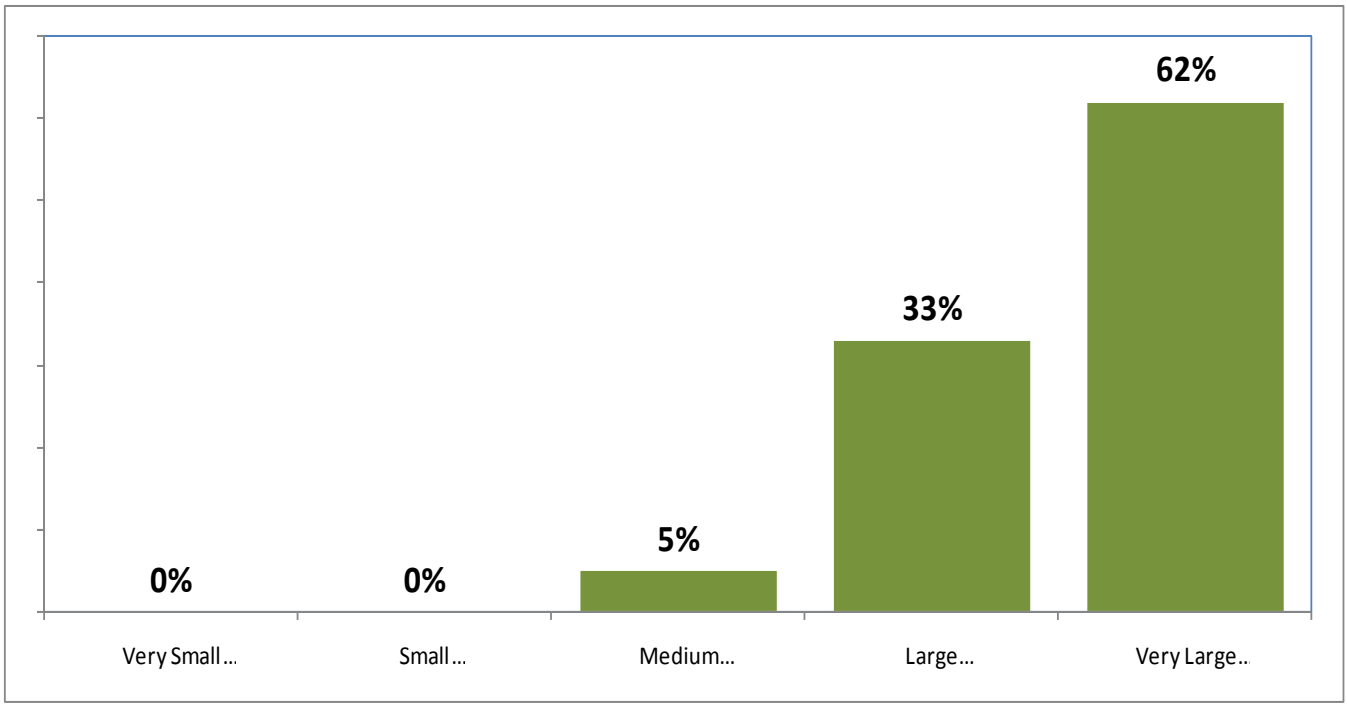
leaking valves (10,000 ppmv and higher) had a slightly skewed population distribution. Specifically, when grouped as "Very Small" (less than 0.010 scf/hr), "Small" (0.010 to 0.099 scf/hr), "Medium" (0.100 to 0.999 scf/hr), "Large" (1.000 to 9.999 scf/hr), and "Very Large" (equal to or greater than 10.00 scf/hr), the leak population was 1%, 28%, 35%, 29%, and 7%, respectively. Figure 2 shows the leak distribution by size.

Figure 2. Size distribution of leaking valves in EPA 453/R-95-017 valve data.



As expected, the total emissions from these five categories of leaking valves increased exponentially, viz. 0%, 0%, 5%, 33%, and 62%, respectively (see Figure 3).

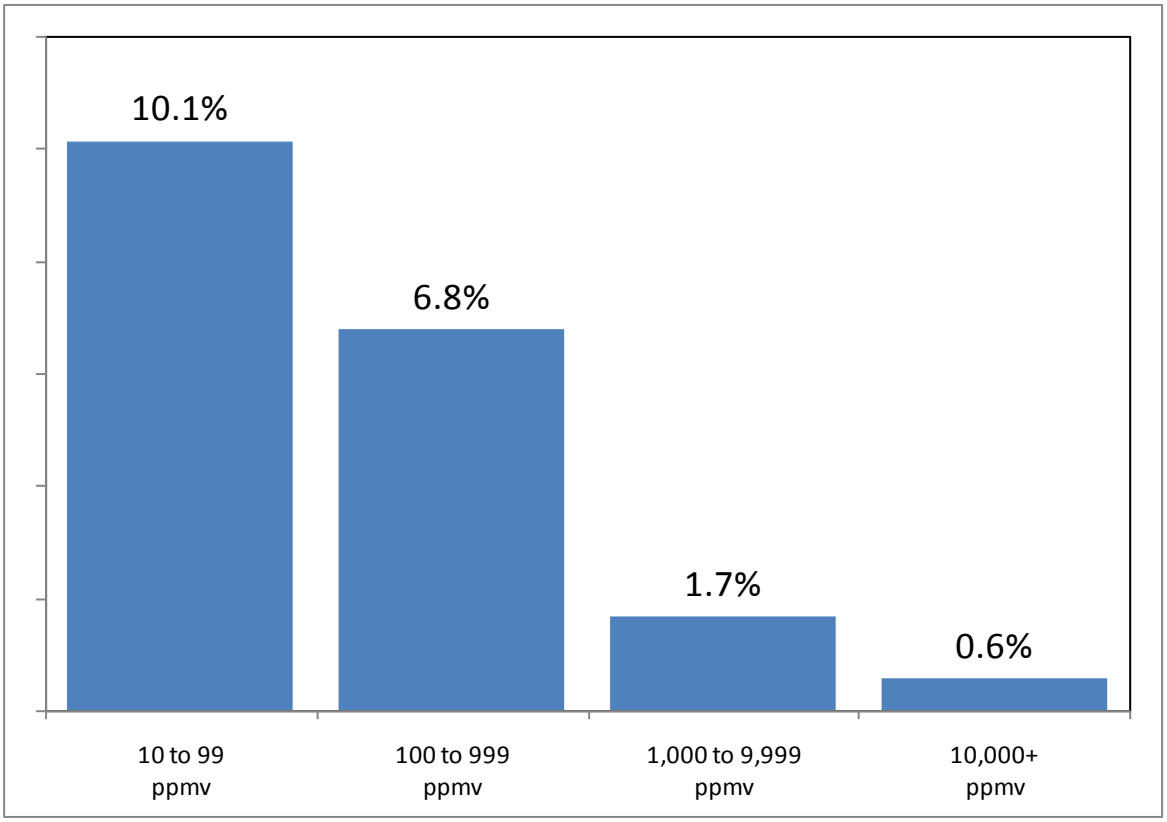
Figure 3. EPA 453/R-95-017 percentage of valve emissions by size distribution.



CURRENT DATA – SCREENING VALUES

Current screening data for 32,624 valves at natural gas facilities were analyzed for screening value distribution. Figure 4 shows the distribution for all valves regardless of service (gas or liquid) and leak definition (499 ppmv or 9,999 ppmv).

Figure 4. Size distribution of leaking valves in current valve data (32,624 individual valves).



Figures 5 through 8 show the screening value (SV) distribution when separated by service type (LLq =Light Liquid Service; Gas = Gas Service) and leak definition (9,999 ppmv or 499 ppmv).

Figures 5 and 7 show very little difference in screening value distribution between Light Liquid service valves and Gas Service valves when the leak definition is 9,999 ppmv.

Figures 5 and 6 show the dramatic reduction in medium emitters (100 to 999 ppmv), large emitters (1,000 to 9,999 ppmv), and screening values at or above 10,000 ppmv when the leak definition for valves in Light Liquid Service is reduced from 9,999 ppmv to 499 ppmv.

Figures 7 and 8 show the even more dramatic reduction in screening value distribution when the leak definition is reduced for valves in Gas Service.

Figure 5. SV of 21,206 LLiq service valves (9,999 ppmv leak definition)

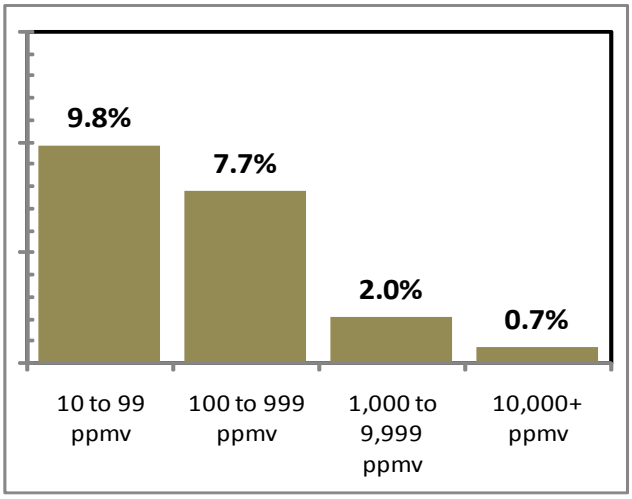


Figure 6. SV of 5,188 LLiq service valves (499 ppmv leak definition)

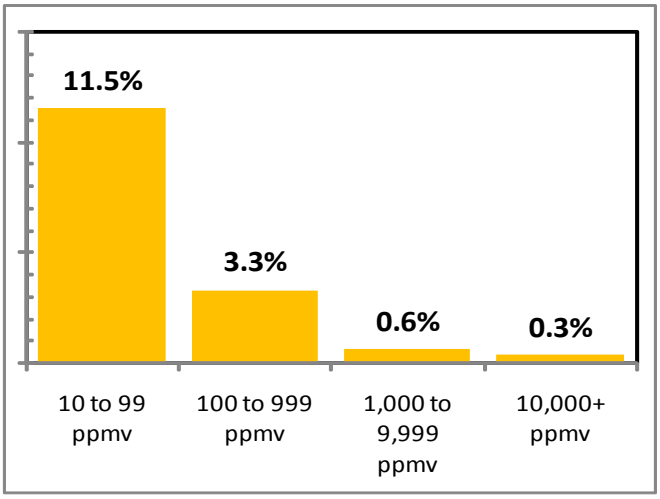


Figure 7. SV of 3,835 Gas service valves (9,999 ppmv leak definition)

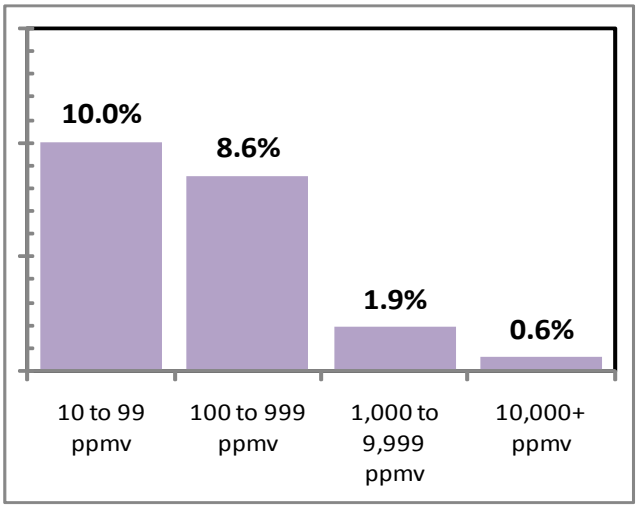
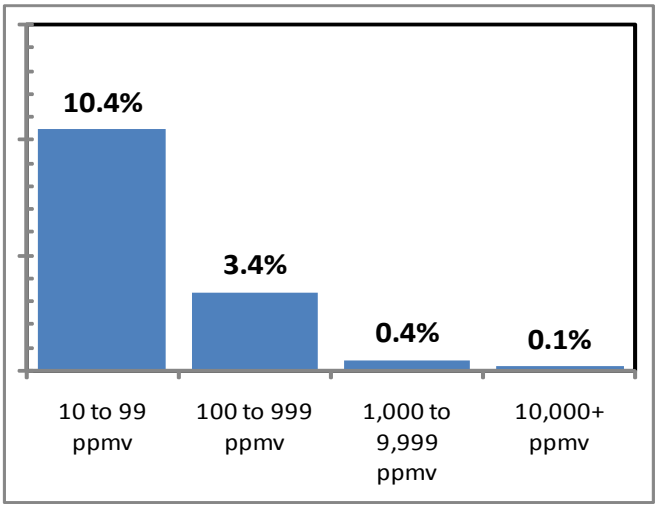


Figure 8. SV of 2,395 Gas service valves (499 ppmv leak definition)



CURRENT DATA – EMISSION RATES

Volumetric emission rates from a representative number of valves with current screening values of 100 ppmv or more were quantified using a hand-held version of the quantification system described in EPA document EPA-600/R-95-167 – "Evaluation of the High Volume Collection System (HVCS) for Quantifying Fugitive Organic Vapor Leaks"[4]

Mass emission rates from valves with screening values between 100 ppmv and 9,999 ppmv were consistent with emission rates reported in EPA-600/R-95-167. Mass emissions rates from valves with screening values of 10,000 or more ppmv were significantly lower than the emission rates reported in EPA-600/R-95-167.

CONCLUSIONS

Correlation equations and default zeros given in Section 2.3.3 of EPA-600/R-95-167 for valves at oil and gas facilities adequately predict emissions for screening values below 10,000 ppmv. Pegged source factors given in the same section over-predict emissions by a factor of two or more.

Likewise, emission factors given in Section 2.3.2 of EPA-600/R-95-167 adequately predict emissions for screening values below 10,000 ppmv but over predict emissions from valves with screening values of 10,000 or more ppmv.

Average emission factors given in Section 2.3.1 of EPA-600/R-95-167 over predict emissions by as much as an order of magnitude.

Updating the emission factors in EPA-600/R-95-167 to reflect the lower emission rates will more accurately predict Greenhouse Gas emissions from fugitive leaks from the petroleum industry.

REFERENCES

1.–"1995 Protocol for Equipment Leak Emission Estimates"; EPA-453/R-95-017; U.S. Environmental Protection Agency, Research Triangle Park, NC, 1995

2. "Fugitive Hydrocarbon Emissions from Oil and Gas Production Operations"; API Publication Number 4598; American Petroleum Institute, Washington, D.C., 1993.

3. "Emission Factors for Oil and Gas Production Operation"; API Publication Number 4615; American Petroleum Institute, Washington, D.C., 1995.

4. "Evaluation of the High Volume Collection System (HVCS) for Quantifying Fugitive Organic Vapor Leaks"; EPA-600/R-95-167; U.S. Environmental Protection Agency, Research Triangle Park, NC, 1995.

KEY WORDS

Fugitive emissions
Petroleum industry
GHG emissions
Emission factors
Oil and Gas production