VOLUME II: CHAPTER 4

PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

Final Report

November 1996

Prepared by:
Eastern Research Group
1600 Perimeter Park
Post Office Box 2010
Morrisville, North Carolina 27560

Prepared for:
Point Sources Committee
Emission Inventory Improvement Program

4

PREFERRED METHOD FOR ESTIMATING EMISSIONS

The EPA correlation equation approach is the preferred method when actual screening values are available. This approach involves entering the screening value into the correlation equation, which predicts the mass emission rate based on the screening value. For new sources, when no actual screening values are available, average emission factors can be used temporarily to determine fugitive emissions from equipment leaks until specific and/or better data are available. However, it is recommended that the local environmental agency be contacted to discuss the best approach and assumptions when data are not available.

This approach offers a good refinement to estimating emissions from equipment leaks by providing an equation to predict mass emission rate as a function of screening value for a particular equipment type. This approach is most valid for estimating emissions from a population of equipment and is not intended for estimating emissions from an individual equipment piece over a short time period (i.e., 1 hour). EPA correlation equations relating screening values to mass emission rates have been developed by the EPA for SOCMI process units and for the petroleum industry (EPA, November 1995).

Correlations for SOCMI are available for: (1) gas valves; (2) light liquid valves; (3) connectors; (4) single equation for light liquid pump seals. Correlation equations, for the petroleum industry that apply to refineries, marketing terminals, and oil and gas production operations data are available for: (1) valves; (2) connectors; (3) flanges; and (4) pump seals; (5) open-ended lines; and (6) other. The petroleum industry correlations apply to all services for a given equipment type.

An example of the EPA correlation equation approach is demonstrated for Streams A and B described in Table 4.4-1. This example is for a hypothetical chemical processing facility and is shown for the sole purpose of demonstrating the emission estimating techniques described in this chapter. As mentioned before, the correlation approach involves entering screening values into a correlation equation to generate an emission rate for each equipment piece. In Table 4.4-2, example screening values and the resulting emissions for each individual equipment piece are presented. Emissions from the pump that was not screened are estimated using the corresponding average emission factor.

TABLE 4.4-1

SAMPLE DATA FOR EXAMPLE CALCULATIONS[a]

Stream ID	Equipment Type/Service	Equipment Count	Hours of Operation[b] (hr/yr)	Stream Composition	
				Constituent	Weight Fraction
A	Pumps/light liquid	15	8,760	Ethyl acrylate	0.80
				Water	0.20
B	Pumps/light liquid	12	4,380	Ethyl acrylate	0.10
				Styrene	0.90
C	Valves/gas	40	8,760	Ethyl acrylate	0.65
				Ethane	0.25
				Water vapor	0.10

[a] Source: EPA, November 1995, Table A-1.
[b] Hours of operation include all of the time in which material is contained in the equipment.

TABLE 4.4-2

EPA CORRELATION EQUATION METHOD[a]

Equipment ID[b]	Screening Value (ppmv)	VOC Mass Emissions[c] (kg/yr)
A-1	0	0.066
A-2	0	0.066
A-3	0	0.066
A-4	0	0.066
A-5	0	0.066
A-6	20	2.0
A-7	50	4.2
A-8	50	4.2
A-9	100	7.4
A-10	100	7.4
A-11	200	13
A-12	400	23
A-13	1,000	49
A-14	2,000	87
A-15	5,000	190
Total Stream A Emissions:		390
B-1	0	0.033
B-2	0	0.033
B-3	0	0.033
B-4	10	0.55
B-5	30	1.4
B-6	250	7.9
B-7	500	14
B-8	2,000	44
B-9	5,000	93
B-10	8,000	140
B-11	25,000	350
B-12 (100% VOC)[d]	Not screened	87
Total Stream B Emissions:		**740**
Total Emissions		**1,130**

[a] Source: EPA, November, 1995, Table A-4.
[b] Equipment type: Light liquid pumps.
Correlation equation: Leak rate (kg/hr) = $1.90 \times 10^{-5} \times (\text{Screening Value})^{0.824}$; Default-zero mass emission rate: 7.49×10^{-6} kg/hr.
Hours of operation: Stream A = 8,760; Stream B = 4,380.
[c] VOC Emissions = (correlation equation or default-zero emission rate) × (WP_{VOC}/WP_{TOC}) × (hours of operation).
[d] VOC Emissions = (average emission factor) × (wt. fraction of TOC) × (WP_{VOC}/WP_{TOC}) × (hours of operation).

VOC emission estimates using the EPA correlation equation approach are 1,130 kg/yr. On the other hand, VOC emission estimates using the average emission factor approach and screening value range for the same Streams A and B included in Table 4.4-1 are 3,138 and 1,480 kg/yr, respectively (see Section 5, Tables 4.5-3 and 4.5-4).

The leak rate/screening value correlations, default zero emission rates, and pegged emission rates are presented in Table 4.4-3 for SOCMI and in Table 4.4-4 for the petroleum industry. Example calculations utilizing the information presented in Tables 4.4-2 through 4.4-3 are demonstrated in Example 4.4-1.

The EPA correlation equations can be used to estimate emissions when the adjusted screening value (adjusted for the background concentration) is not a "pegged" screening value (the screening value that represents the upper detection limit of the monitoring device) or a "zero" screening value (the screening value that represents the minimum detection limit of the monitoring device). All non-zero and non-pegged screening values can be entered directly into the EPA correlation equation to predict the mass emissions (kg/hr) associated with the adjusted screening value (ppmv) measured by the monitoring device.

The correlation equations mathematically predict zero emissions for zero screening values (note that any screening value that is less than or equal to ambient [background] concentration is considered a screening value of zero). However, data collected by EPA show this prediction to be incorrect. Mass emissions have been measured from equipment having a screening value of zero. This is because the lower detection limit of the monitoring devices used is larger than zero and because of the difficulty in taking precise measurements close to zero. The default-zero emission rates are applicable only when the minimum detection limit of the portable monitoring device is 1 ppmv or less above background. In cases where a monitoring device has a minimum detection limit greater than 1 ppmv, the available default-zero emission leak rates presented in Tables 4.4-3 and 4.4-4 of this section are not applicable. For these cases, an alternative approach for determining a default-zero leak rate is to (1) determine one-half the minimum screening value of the monitoring device, and (2) enter this screening value into the applicable correlation to determine the associated default-zero leak rate.

In instances of pegged screening values, the true screening value is unknown and use of the correlation equation is not appropriate. Pegged emission rates have been developed using mass emissions data associated with known screening values of 10,000 ppmv or greater and for known screening values of 100,000 ppmv or greater. When the monitoring device is pegged at either of these levels, the appropriate pegged emission rate should be used to estimate the mass emissions of the component.

TABLE 4.4-3

CORRELATION EQUATIONS, DEFAULT ZERO EMISSION RATES, AND PEGGED EMISSION RATES FOR ESTIMATING SOCMI TOC EMISSION RATES[a]

Equipment Type	Default Zero Emission Rate (kg/hr per source)	Pegged Emission Rates (kg/hr per source)		Correlation Equation (kg/hr per source)[b]
		10,000 ppmv	100,000 ppmv	
Gas valves	6.6E-07	0.024	0.11	Leak Rate = 1.87E-06 × $(SV)^{0.873}$
Light liquid valves	4.9E-07	0.036	0.15	Leak Rate = 6.41E-06 × $(SV)^{0.797}$
Light liquid pumps[c]	7.5E-06	0.14	0.62	Leak Rate = 1.90E-05 × $(SV)^{0.824}$
Connectors	6.1E-07	0.044	0.22	Leak Rate = 3.05E-06 × $(SV)^{0.885}$

[a] Source: EPA, November 1995, Tables 2-9, 2-11, and 2-13. To estimate emissions: Use the default zero emission rates only when the screening value (adjusted for background) equals 0.0 ppmv; otherwise use the correlation equations. If the monitoring device registers a pegged value, use the appropriate pegged emission rate.

[b] SV is the screening value (ppmv) measured by the monitoring device.

[c] The emission estimates for light liquid pump seals can be applied to compressor seals, pressure relief valves, agitator seals, and heavy liquid pumps.

TABLE 4.4-4

CORRELATION EQUATIONS, DEFAULT ZERO EMISSION RATES, AND PEGGED EMISSION RATES FOR ESTIMATING PETROLEUM INDUSTRY TOC EMISSION RATES[a]

Equipment Type/Service	Default Zero Emission Rate (kg/hr per source)[b]	Pegged Emission Rates (kg/hr per source)[c]		Correlation Equation (kg/hr per source)[d]
		10,000 ppmv	100,000 ppmv	
Connector/All	7.5E-06	0.028	0.030	Leak Rate = 1.51E-06 × $(SV)^{0.735}$
Flange/All	3.1E-07	0.085	0.084	Leak Rate = 4.44E-06 × $(SV)^{0.703}$
Open-Ended Line/All	2.0E-06	0.030	0.079	Leak Rate = 2.16E-06 × $(SV)^{0.704}$
Pump/All	2.4E-05	0.074	0.160[e]	Leak Rate = 4.82E-05 × $(SV)^{0.610}$
Valve/All	7.8E-06	0.064	0.140	Leak Rate = 2.28E-06 × $(SV)^{0.746}$
Other[f]/All	4.0E-06	0.073	0.110	Leak Rate = 1.32E-05 × $(SV)^{0.589}$

[a] Source: EPA, November 1995, Tables 2-10, 2-12, and 2-14. Developed from the combined 1993 refinery, marketing terminal, and oil and gas production operations data. To estimate emissions: use the default zero emission rates only when the screening value (adjusted for background) equals 0.0 ppmv; otherwise use the correlation equations. If the monitoring device registers a pegged value, use the appropriate pegged emission rate.

[b] Default zero emission rates were based on the combined 1993 refinery and marketing terminal data only (default zero data were not collected from oil and gas production facilities).

[c] The 10,000 ppmv pegged emission rate was based on components screened at greater than 10,000 ppmv; however, in some cases, most of the data could have come from components screened at greater than 100,000 ppmv, thereby resulting in similar pegged emission rates for both the 10,000 and 100,000 ppmv pegged levels (e.g., connector and flanges).

[d] SV is the screening value (ppmv) measured by the monitoring device.

[e] Only two data points were available for the pump 100,000 ppmv pegged emission rate; therefore, the ratio of the pump 10,000 ppmv pegged emission rate to the overall 10,000 ppmv pegged emission rate was multiplied by the overall 100,000 ppmv pegged emission rate to approximate the pump 100,000 ppmv pegged emission rate.

[f] The other equipment type includes instruments, loading arms, pressure relief valves, stuffing boxes, vents, compressors, and dump lever arms.

Example 4.4-1:

- Stream A, Equipment IDs: A-1, A-2, A-3, A-4, and A-5
  Equipment Type: Light-liquid Pumps
  Hours of Operation: 8,760 hours
  SV (Screening value) = 0 ppmv
  SOCMI default-zero TOC emission rate (kg/hr/source)
  $= 7.5 \times 10^{-6}$ (from Table 4.4-3)
  VOC emissions per equipment ID (kg/yr)
  $= 7.5 \times 10^{-6}$ kg/hr × (0.80/0.80) × 8,760 hr
  = 0.066
- Stream A, Equipment ID: A-6
  Equipment Type: Light-liquid Pumps
  Hours of Operation: 8,760 hours
  SV (Screening value) = 20 ppmv
  SOCMI Correlation Equation:
  TOC Leak Rate (kg/hr)
  $= 1.90 \times 10^{-5} (SV)^{0.824}$ (from Table 4.4-3)
  $= 1.90 \times 10^{-5} (20)^{0.824}$
  $= 2.24 \times 10^{-4}$
  VOC emissions (kg/yr)
  $= 2.24 \times 10^{-4}$ kg/hr × 8,760 hr × (0.80/0.80)
  = 2.0
- Stream A, Equipment IDs: A-7 and A-8
  Equipment Type: Light-liquid Pumps
  SV (Screening value) = 50 ppmv
  SOCMI Correlation Equation:
  TOC Leak Rate (kg/hr)
  $= 1.90 \times 10^{-5} (SV)^{0.824}$ (from Table 4.4-3)
  $= 1.90 \times 10^{-5} (50)^{0.824}$
  $= 4.77 \times 10^{-4}$
  VOC emissions (kg/yr)
  $= 4.77 \times 10^{-4}$ kg/hr × 8,760 hr × (0.80/0.80)
  = 4.2

This page is intentionally left blank.