# 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: $7.49 \times 10^{-6}$ 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

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# 5

# ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

The alternative methods for estimating emissions from equipment leaks are the following (in no specific order of preference):

- Average emission factor approach;
- Screening ranges approach; and
- Unit-specific correlation approach.

## 5.1 EMISSION CALCULATIONS USING THE AVERAGE EMISSION FACTOR APPROACH

The average emission factor approach is commonly used to calculate emissions when site-specific screening data are unavailable.

To estimate emissions using the average emission factor approach, the TOC concentration in weight percent within the equipment is needed. The TOC concentration in the equipment is important because equipment (and VOC or HAP concentrations if speciation is to be performed) with higher TOC concentrations tend to have higher TOC leak rates. The various equipment should be grouped into "streams," such that all equipment within a stream has approximately the same TOC weight percent.

This approach for estimating emissions allows use of average emission factors developed by the EPA in combination with unit-specific data that are relatively simple to obtain. These data include: (1) the number of each type of component in a unit (valve, connector, etc.); (2) the service each component is in (gas, light liquid, or heavy liquid); (3) the TOC concentration of the stream; and (4) the time period each component was in that service.

EPA average emission factors have been developed for SOCMI process units, refineries, marketing terminals, and oil and gas production operations (EPA, November 1995). The method used by the EPA to develop emission factors for individual equipment leak emission sources is described in the *Protocol for Equipment Leak Emission Estimates* (EPA, November 1995). Tables 4.5-1 and 4.5-2 show the average emission factors for SOCMI process units and refineries, respectively.

## TABLE 4.5-1

## SOCMI AVERAGE EMISSION FACTORS[a]

| **Equipment Type** | **Service** | **Emission Factor (kg/hr per source)[b]** |
|---|---|---|
| Valves | Gas | 0.00597 |
| | Light liquid | 0.00403 |
| | Heavy liquid | 0.00023 |
| Pump seals[c] | Light liquid | 0.0199 |
| | Heavy liquid | 0.00862 |
| Compressor seals | Gas | 0.228 |
| Pressure relief valves | Gas | 0.104 |
| Connectors | All | 0.00183 |
| Open-ended lines | All | 0.0017 |
| Sampling connections | All | 0.0150 |

[a] Source: EPA, November 1995, Table 2-1.
[b] These factors are for TOC emission rates.
[c] The light liquid pump seal factor can be used to estimate the leak rate from agitator seals.

## TABLE 4.5-2

## REFINERY AVERAGE EMISSION FACTORS[a]

| Equipment Type | Service | Emission Factor (kg/hr per source)[b] |
|---|---|---|
| Valves | Gas | 0.0268 |
| | Light liquid | 0.0109 |
| | Heavy liquid[d] | 0.00023 |
| Pump seals[c] | Light liquid | 0.114 |
| | Heavy liquid[d] | 0.021 |
| Compressor seals | Gas | 0.636 |
| Pressure relief valves | Gas | 0.16 |
| Connectors | All | 0.00025 |
| Open-ended lines | All | 0.0023 |
| Sampling connections | All | 0.0150 |

[a] Source: EPA, November 1995, Table 2-2. Based on data gathered in the 1970's.

[b] These factors are for non-methane organic compound emission rates.

[c] The light liquid pump seal factor can be used to estimate the leak rate from agitator seals.

[d] The American Petroleum Institute is conducting a program to develop revised emission factors for components in heavy liquid service. Contact state or local agencies to determine the appropriate application of heavy liquid emission factors.

Although the average emission factors are in units of kilogram per hour per individual source, it is important to note that these factors are most valid for estimating emissions from a population of equipment. However, the average emission factor approach may present the largest potential error, among the other approaches, when applied to estimate emissions from equipment populations. The average factors are not intended to be used for estimating emissions from an individual piece of equipment over a short time period (i.e., 1 hour).

When the average emission factors are used to estimate TOC mass emissions from refineries, it is necessary to adjust the refinery emission factors because they represent only non-methane emissions. To estimate TOC emissions, methane and non-methane organic compounds must be included. Two guidelines for adjusting the refinery emission factors are as follows:

- The adjustment should be applied only to equipment containing a mixture of organic and methane, and
- The maximum adjustment for the methane weight fraction should not exceed 0.10, even if the equipment contains greater than 10 weight percent methane. (This reflects that equipment in the Refinery Assessment Study (EPA, April and July 1980) typically contained 10 weight percent or less methane).

Because the average emission factors for refineries must be adjusted when estimating TOC emissions, there is one equation (Equation 4.5-1) for using the average emission factors to estimate emissions from SOCMI marketing terminals, and oil and gas production operations and a second equation (Equation 4.5-2) for using the emission factors to estimate emissions from refinery operations.

These equations can be used to estimate TOC emission from all of the equipment of a given equipment type in a stream:

$$E_{TOC} = F_A \times WF_{TOC} \times N \tag{4.5-1}$$

$$E_{TOC} = F_A \times \frac{WF_{TOC}}{WF_{TOC} - WF_{methane}} \times WF_{TOC} \times N \tag{4.5-2}$$

where:

$E_{TOC}$ = Emission rate of TOC from all equipment in the stream of a given equipment type (kg/hr);

$F_A$ = Applicable average emission factor[1] for the equipment type (kg/hr per source);
$WF_{TOC}$ = Average weight fraction of TOC in the stream;
$WF_{methane}$ = Average weight fraction of methane in the stream;
$WF_{TOC}$ = Average weight fraction of TOC in the stream; and
N = Number of pieces of the applicable equipment type in the stream.

If there are several streams at a process unit, the total VOC emission rate for an equipment type is the sum of VOC emissions from each of the streams. The total emission rates for all of the equipment types are summed to generate the process unit total VOC emission rate from leaking equipment.

An example of the average emission factor approach is demonstrated for Streams A and B included in Table 4.4-1. Note that Stream A contains water, which is not a TOC. Therefore, this is accounted for when total TOC emissions are estimated from Stream A. Table 4.5-3 summarizes the average emission factor approach calculations.

## TABLE 4.5-3

## AVERAGE EMISSION FACTOR METHOD

| Stream ID | Equipment Count | TOC Emission Factor (kg/hr per source) | Weight Fraction of TOC | Hours of Operation (hr/yr) | VOC Emissions[a] (kg/yr) |
|---|---|---|---|---|---|
| A | 15 | 0.0199 | 0.80 | 8,760 | 2,092 |
| B | 12 | 0.0199 | 1.00 | 4,380 | 1,046 |
| **Total Emissions** | | | | | 3,138 |

[a] VOC Emissions = (no. of components) × (emission factor) × (wt. fraction TOC) × ($WP_{VOC}/WP_{TOC}$) × (hours of operation).

---

[1] Emission factors presented in the *1995 Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) are for TOC emission rates, except for refineries that are for non-methane organic compound emission rates.

## 5.2 EMISSION CALCULATIONS USING THE SCREENING RANGES APPROACH

The screening ranges approach requires screening data to be collected for the equipment in the process unit. This approach is applied in a similar manner as the average emission factor approach in that equipment counts are multiplied by the applicable emission factor. However, because the screening value on which emissions are based is a measurement of only organic compound leakage, no adjustment is made for inorganic compounds.

This approach may be applied when screening data are available as either "greater than or equal to 10,000 ppmv" or as "less than 10,000 ppmv." As with the average factors, the SOCMI, marketing terminal, and oil and gas production operations screening range factors predict TOC emissions, whereas the refinery screening range factors predict non-methane organic compound emissions. Thus, when using the average refinery screening range factors to estimate TOC emissions from refineries, an adjustment must be made to the factors to include methane emissions. The maximum adjustment for the methane weight factors should not exceed 0.10, even if the equipment contains greater than 10 weight percent methane.

Because the average screening range factors for refineries must be adjusted when estimating TOC emissions, there is one equation (Equation 4.5-3) for using the average screening range factors to estimate emissions from SOCMI, marketing terminals, and oil and gas production operations and a second equation (Equation 4.5-4) for using the screening range factors to estimate emissions from refinery operations. These equations are described below:

$$E_{TOC} = (F_G \times N_G) + (F_L \times N_L) \qquad (4.5\text{-}3)$$

$$E_{TOC} = \frac{WF_{TOC}}{WF_{TOC} - WF_{methane}} \left[ (F_G \times N_G) + (f_L \times N_L) \right] \qquad (4.5\text{-}4)$$

where:

$E_{TOC}$ = TOC emission rate for an equipment type (kg/hr);

$F_G$ = Applicable emission factor[1] for sources with screening values greater than or equal to 10,000 ppmv (kg/hr per source);

---

[1] Emission factors presented in the *1995 Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) are for TOC emission rates, except for refineries that are for non-methane organic compound emission rates.

$WP_{TOC}$ = Average weight percent of TOC in the stream;
$WP_{methane}$ = Average weight percent of methane in the stream;
$N_G$ = Equipment count (specific equipment type) for sources with screening values greater than or equal to 10,000 ppmv;
$F_L$ = Applicable emission factor for sources with screening values less than 10,000 ppmv (kg/hr per source); and
$N_L$ = Equipment count (specific equipment type) for sources with screening values less than 10,000 ppmv.

Assuming all of the organic compounds in the stream are classified as VOCs, the total VOC emission for each stream is calculated as the sum of TOC emissions associated with each specific equipment type in the stream.

The screening range emission factors are a better indication of the actual leak rate from individual equipment than the average emission factors. Nevertheless, available data indicate that measured mass emission rates can vary considerably from the rates predicted by use of these factors.

An example of the screening value ranges approach is demonstrated in Table 4.5-4 using the example of a hypothetical chemical processing facility presented in Section 4 for Streams A and B (Table 4.4-1). The calculations are similar to those used for the average emission factor approach, except that a TOC emission factor for each screening value range is used. Emissions from equipment that could not be screened are calculated using average emission factors. VOC emissions using the screening value range approach are 1,480 kg/yr. In comparison, VOC emissions using the average emission factor approach for the same Streams A and B are 3,138 kg/yr, as shown in Table 4.5-3.

## 5.3 EMISSION CALCULATIONS USING UNIT-SPECIFIC CORRELATION APPROACH

Correlation equations may be developed for specific units rather than using correlation equations developed by the EPA. Once the correlations are developed, they are applied in the same way as described for the EPA correlations.

Before developing unit-specific correlations it is recommended that the validity of the EPA correlations to a particular process unit be evaluated because of the high cost of bagging. This can be done measuring as few as four leak rates of a particular equipment type in a particular service. The measured emission rate can be compared with the predicted rates obtained using the EPA correlations. If there is a consistent trend (i.e., all measured values are less than values predicted by the EPA correlation equation or all measured values are larger) the EPA correlation equation may not provide reasonable emission estimates for the

## TABLE 4.5-4

## SCREENING VALUE RANGES METHOD[a]

| Stream ID | Equipment Count[b] | Emission Factor (kg/hr per source) | Hours of Operation (hr/yr) | VOC Emissions (kg/yr) |
|---|---|---|---|---|
| Components screening ≥ 10,000 ppmv[c] | | | | |
| B | 1 | 0.243 | 4,380 | 1,060 |
| Components screening < 10,000 ppmv[c] | | | | |
| A | 15 | 0.00187 | 8,760 | 246 |
| B | 10 | 0.00187 | 4,380 | 82 |
| Components not screened[d] | | | | |
| B (TOC wt. fraction equal to 1.0) | 1 | 0.0199 | 4,380 | 87 |
| Total emissions | | | | 1,480 |

[a] Source: EPA, November, 1995, Table A-3.

[b] It was assumed that none of the light liquid pumps in Stream A have a screening value greater than or equal to 10,000 ppmv, one of the light liquid pumps in Stream B screens greater than 10,000 ppmv, and one of the pumps in Stream B could not be screened.

[c] VOC emissions = (no. of components) × (TOC emission factor) × $(WP_{VOC}/WP_{TOC})$ × (hours of operation).

[d] VOC emissions = (no. of components) × (average TOC emission factor) × $(WP_{VOC})$ × (hours of operation).

process unit. There is a more formal comparison, the Wilcoxon signed-rank test, which can be performed by comparing the logarithm of the measured mass emission rates to the logarithm of the corresponding rates predicted by the EPA correlation.

In developing new unit-specific correlations, a minimum number of leak rate measurements and screening value pairs must be obtained. The *Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) provides detailed information on the methodology to be followed. In general, the following consideration should be observed:

- Process unit equipment should be screened to know the distribution of screening values at the unit;

- Mass emission data must be collected from individual sources with screening values distributed over the entire range; and

- A random sample of a minimum of six components from each of the following screening value ranges (in ppmv) should be selected for bagging: 1-100; 101-1,000; 1,001-10,000; 10,001-100,000; and >100,000. Therefore, a minimum of 30 emissions rate/screening value pairs should be obtained to estimate emissions across the entire range of screening values.

The *Protocol* document (EPA, November 1995) provides some alternatives to developing a correlation equation with fewer than 30 bags. These alternatives are based on experience in measuring leak rates and developing leak rate/screening value correlations. However, other source selection strategies can be used if an appropriate rationale is given.

Methodologies for generating leak rate/screening value correlations with mass emissions data and screening values are presented in Appendix B of the *1995 Protocol* document. Once correlations are developed using the methodologies outlined in Appendix B, they are applied in the same manner as described in the example for the EPA correlations.

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# 6

# QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. Quality assurance (QA) and quality control (QC) of an inventory are accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Chapter 4 of Volume VI (the *QA Source Document)* of this series describes some QA/QC methods for performing these procedures.

Volume II, Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*, presents recommended standard procedures to follow that ensure the reported inventory data are complete and accurate. Chapter 1, should be consulted for current EIIP guidance for QA/QC checks for general procedures, recommended components of a QA plan, and recommended components for point source inventories. The QA plan discussion includes recommendations for data collection, analysis, handling, and reporting. The recommended QC procedures include checks for completeness, consistency, accuracy, and the use of approved standardized methods for emission calculations, where applicable.

## 6.1 SCREENING AND BAGGING DATA COLLECTION

To ensure that data quality is maintained while screening and data collection take place, it is recommended that data be recorded on prepared data sheets. Figures 4.6-1 provides an example data sheet that may be used to log measurements taken during a screening program.

To ensure highest quality of the data collected during the bagging program, QA/QC procedures must be followed. Quality assurance requirements include accuracy checks of the instrumentation used to perform mass emission sampling. Quality control requirements include procedures to be followed when performing equipment leak mass emissions sampling.

Figures 4.6-2 and 4.6-3 present examples of data collection forms to be used when collecting data in the field. Accuracy checks on the instrumentation and monitoring devices used to perform mass emission sampling include a leak rate check performed in the laboratory, blind standards to be analyzed by the laboratory instrumentation, and drift checks on the portable monitoring device.

# EXAMPLE FIELD SHEET FOR EQUIPMENT SCREENING DATA

Detector Model No: ____________________

Operator Name: ____________________

Date: ____________________

| Component ID | Component Type | Location/ Stream | Service | Operating hr/yr | Screening value (ppmv) | Background (ppmv) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
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Comments:

FIGURE 4.6-1. EXAMPLE FIELD SHEET FOR EQUIPMENT SCREENING DATA

## EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS BAGGING TEST (VACUUM METHOD)

---

Equipment Type ____________________
Equipment Category ____________________
Line Size ____________________
Stream Phase (G/V, LL, HL)____________________
Barometric Pressure ____________________
Ambient Temperature ____________________
Stream Temperature ____________________

Component ID ____________________
Plant ID ____________________
Date ____________________
Analysis Team ____________________
____________________
Instrument ID ____________________
Stream Pressure____________________

Stream Composition (Wt. %) ____________,____________________
____________________,____________________,____________________

Time — Bagging Test Measurement Data

____________ Initial Screening (ppmv) Equipment Piece[a] ____ Bkgd. ____________________
____________ Background Bag Organic Compound Conc. (ppmv)[b] ____________________
____________ Sample Bag 1 Organic Compound Conc. (ppmv) ____________________
____________ Dry Gas Meter Reading (L/min) ____________________
____________ Vacuum Check in Bag (Y/N) (Must be YES to collect sample.)
____________ Dry Gas Meter Temperature[c] (°C) ____________________
____________ Dry Gas Meter Pressure[c] (mmHg) ____________________
____________ Sample Bag 2 Organic Compound Conc. (ppmv) ____________________
____________ Dry Gas Meter Reading (L/min) ____________________
____________ Vacuum Check in Bag (Y/N) (Must be YES to collect sample.)
____________ Dry Gas Meter Temperature[c] (°C) ____________________
____________ Dry Gas Meter Pressure[c] (mmHg) ____________________
Condensate Accumulation: Starting Time ____ Final Time ____________________
Organic Condensate Collected (mL) ____________________
Density of Organic Condensate (g/mL) ____________________
____________ Final Screening (ppmv) Equip. Piece[a] _____ Bkgd. ____________________

---

[a] The vacuum method is not recommended if the screening value is approximately 10 ppmv or less.
[b] Collection of a background bag is optional.
[c] Pressure and temperature are measured at the dry gas meter.

FIGURE 4.6-2. EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS BAGGING TEST (VACUUM METHOD)

## EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS BAGGING TEST (BLOW-THROUGH METHOD)

Equipment Type ____________________
Equipment Category ____________________
Line Size ____________________
Stream Phase (G/V, LL, HL)____________
Barometric Pressure ____________________
Ambient Temperature ____________________
Stream Temperature ____________________
Component ID ____________________
Plant ID ____________________
Date ____________________
Analysis Team ____________________
____________________
Instrument ID ____________________
Stream Pressure ____________________
Stream Composition (Wt. %) ___________,____________________
____________________,____________________,____________________
____________________

Time ____ Bagging Test Measurement Data

____________ Initial Screening (ppmv) Equipment Piece ____ Bkgd. ____________________
____________ Background Bag Organic Compound Conc. (ppmv)[a] ____________________
____________ Sample Bag 1 Organic Compound Conc. (ppmv) ____________________
____________ Dilution Gas Flow Rate (L/min) ____________________
____________ $O_2$ Concentration (volume %) ____________________
____________ Bag Temperature (°C) ____________________
____________ Sample Bag 2 Organic Compound Conc. (ppmv) ____________________
____________ Dilution Gas Flow Rate (L/min) ____________________
____________ $O_2$ Concentration (volume %) ____________________
____________ Bag Temperature (°C) ____________________
Condensate Accumulation: Starting Time ____ Final Time ____________________
Organic Condensate Collected (mL)____________________
Density of Organic Condensate (g/mL) ____________________
____________ Final Screening (ppmv) Equipment Piece _____ Bkgd. ____________________

---

[a] Collection of a background bag is optional. However, it is recommended in cases where the screening value is less than 10 ppmv and there is a detectable oxygen level in the bag.

FIGURE 4.6-3. EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS BAGGING TEST (BLOW-THROUGH METHOD)

## 6.2 OTHER QA/QC ISSUES

At a minimum, the approach and data used to estimate emissions should be peer reviewed to assure correctness. In addition, some sample calculations should be performed to verify that calculations were done correctly.

If any of the methods that require screening or bagging data were used, the sample design should be reviewed to assure that all relevant equipment types were sampled. Furthermore, the adequacy of sample sizes should be verified.

## 6.3 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Three examples are given here to illustrate DARS scoring using the preferred and alternative methods. The DARS provides a numerical ranking on a scale of 1 to 10 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement of the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see the *QA Source Document* (Volume VI, Chapter 4), and Volume II, Chapter 1, *Introduction to Stationary Point Sources Emission Inventory Development*.

For each example, assume emissions are being estimated for a petroleum marketing terminal. Table 4.6-1 gives a set of scores for the preferred method, the EPA correlation approach. Note that a perfect score (1.0) is not possible with any of the methods described in this chapter because all are based on the use of surrogates rather than direct measurement of emissions. The spatial congruity attribute is not particularly relevant for this category, and thus is given a score of 1.0. Both measurement and specificity scores are relatively high (0.8) because the correlation equation is based on a representative sample from the specific category. The measurement attribute score assumes that the pollutants of interest were measured directly. The temporal attribute scores are 0.7 because the data (for the correlation equation and for the screening values) are presumed to be one time samples, but the throughputs are assumed not to vary much over time.

Tables 4.6-2 and 4.6-3 give DARS scores for the average emission factor approach and the unit-specific correlation approach respectively. Not surprisingly, the first approach gets lower DARS scores, while the second gets higher scores.

## TABLE 4.6-1

## DARS SCORES: EPA CORRELATION APPROACH

| Attribute | Scores | | |
|---|---|---|---|
| | Factor | Activity | Emissions |
| Measurement | 0.8 | 0.8 | 0.64 |
| Specificity | 0.8 | 1.0 | 0.80 |
| Spatial | 1.0 | 1.0 | 1.0 |
| Temporal | 0.7[a] | 0.7[a] | 0.49 |
| Composite Scores | 0.83 | 0.88 | 0.73 |

[a] Assumes a one-time sampling of equipment and little variation in throughput.

## TABLE 4.6-2

## DARS SCORES: AVERAGE EMISSION FACTOR APPROACH

| Attribute | Scores | | |
|---|---|---|---|
| | Factor | Activity | Emissions |
| Measurement | 0.6 | 0.5 | 0.3 |
| Specificity | 0.5 | 1.0 | 0.5 |
| Spatial | 1.0 | 1.0 | 1.0 |
| Temporal | 0.7 | 0.7 | 0.49 |
| Composite Scores | 0.7 | 0.8 | 0.57 |

### TABLE 4.6-3

### DARS SCORES: UNIT-SPECIFIC CORRELATION APPROACH

| **Attribute** | **Scores** | | |
|---|---|---|---|
| | **Factor** | **Activity** | **Emissions** |
| Measurement | 0.9 | 0.9 | 0.81 |
| Specificity | 1.0 | 1.0 | 1.0 |
| Spatial | 1.0 | 1.0 | 1.0 |
| Temporal | 0.7 | 0.7 | 0.49 |
| Composite Scores | 0.90 | 0.90 | 0.83 |

These examples are given as an illustration of the relative quality of each method. If the same analysis were done for an actual real site, the scores could be different but the relative ranking of methods should stay the same. Note, however, that if the source is not truly a member of the population used to develop the EPA correlation equations or the emission factors, these approaches are less appropriate and the DARS scores will probably drop.

If sufficient data are available, the uncertainty in the estimate should be evaluated. Qualitative and quantitative methods for conducting uncertainty analyses are described in the *QA Source Document* (Volume VI, Chapter 4).

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# 7

# DATA CODING PROCEDURES

This section describes the methods and codes available for characterizing fugitive emissions from equipment leaks using Source Classification Codes (SCCs) and Aerometric Information Retrieval System (AIRS) control device codes. Consistent categorization and coding will result in greater uniformity among inventories. The SCCs are the building blocks on which point source emissions data are structured. Each SCC represents a unique process or function within a source category that is logically associated with an emission point. Without an appropriate SCC, a process cannot be accurately identified for retrieval purposes. In addition, the procedures described here will assist the reader preparing data for input into a database management system. For example, the SCCs provided in Table 4.7-1 are typical of the valid codes recommended for describing equipment leaks. This table does not include all fugitive source SCCs, but does include those commonly used to identify equipment leaks. Refer to the CHIEF bulletin board for a complete listing of SCCs.

While the codes presented here are currently in use, they may change based on further refinement by the emission inventory community. As part of the EIIP, a common data exchange format is being developed to facilitate data transfer between industry, states, and EPA.

For equipment leaks, be careful to use only one SCC for each process or source category. Many of these are designated for the entire process unit on an annual basis. In some cases, the user may need to calculate emissions for multiple pieces of equipment and then sum up to the unit total. The process-specific codes should be used as often as possible.

## TABLE 4.7-1

## SOURCE CLASSIFICATION CODES AND DESCRIPTIONS FOR FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

| Source Description | Process Description | SCC | Units |
|---|---|---|---|
| Industrial Processes | | | |
| Chemical Manufacturing | Adipic Acid - Fugitive Emissions: General | 3-01-001-80 | Process Unit-Year |
| | Carbon Black Production; Furnace Process: Fugitive Emissions | 3-01-005-09 | Tons Produced |
| | Chlorine: Carbon Reactivation/Fugitives | 3-01-007-05 | Tons Produced |
| | Sulfuric Acid (Contact Process): Process Equipment Leaks | 3-01-023-22 | Tons 100% $H_2SO_4$ |
| | Terephthalic Acid/ Dimethyl Terephthalate: Fugitive Emissions | 3-01-031-80 | Process Unit-Year |
| | Aniline/Ethanolamines: Fugitive Emissions | 3-01-034-06 | Process Unit-Year |
| | Aniline/Ethanolamines: Fugitive Emissions | 3-01-034-14 | Process Unit-Year |
| | Pharmaceutical Preparations: Miscellaneous Fugitives | 3-01-060-22 | Tons Processed |
| | Pharmaceutical Preparations: Miscellaneous Fugitives | 3-01-060-23 | Tons Processed |
| | Inorganic Chemical Manufacturing (General): Fugitive Leaks | 3-01-070-01 | Tons Product |
| | Acetone/Ketone Production: Fugitive Emissions (Acetone) | 3-01-091-80 | Process Unit-Year |
| | Maleic Anhydride: Fugitive Emissions | 3-01-100-80 | Process Unit-Year |
| | Fugitive Emissions (Formaldehyde) | 3-01-120-07 | Process Unit-Year |

## TABLE 4.7-1

## (CONTINUED)

| Source Description | Process Description | SCC | Units |
|---|---|---|---|
| Industrial Processes | | | |
| Chemical Manufacturing | Fugitive Emissions (Acetaldehyde) | 3-01-120-17 | Process Unit-Year |
| | Fugitive Emissions (Acrolein) | 3-01-120-37 | Process Unit-Year |
| | Chloroprene: Fugitive Emissions | 3-01-124-80 | Process Unit-Year |
| | Chlorine Derivatives: Fugitive Emissions (Ethylene Dichloride) | 3-01-125-09 | Process Unit-Year |
| | Chlorine Derivatives: Fugitive Emissions (Chloromethanes) | 3-01-125-14 | Process Unit-Year |
| | Chlorine Derivatives: Fugitive Emissions (Perchloroethylene) | 3-01-125-24 | Process Unit-Year |
| | Chlorine Derivatives: Fugitive Emissions (Trichloroethane) | 3-01-125-29 | Process Unit-Year |
| | Chlorine Derivatives: Fugitive Emissions (Trichloroethylene) | 3-01-125-34 | Process Unit-Year |
| | Chlorine Derivatives: Fugitive Emissions (Vinyl Chloride) | 3-01-125-50 | Process Unit-Year |
| | Chlorine Derivatives: Fugitive Emissions (Vinylidene Chloride) | 3-01-125-55 | Process Unit-Year |
| | Fluorocarbons/ Chloroflourocarbons: Fugitive Emissions | 3-01-127-80 | Process Unit-Year |
| | Organic Acid Manufacturing: Fugitive Emissions | 3-01-132-27 | Process Unit-Year |

## TABLE 4.7-1

## (CONTINUED)

| Source Description | Process Description | SCC | Units |
|---|---|---|---|
| Industrial Processes | | | |
| Chemical Manufacturing | Acetic Anhydride: Fugitive Emissions | 3-01-133-80 | Process Unit-Year |
| | Butadiene: Fugitive Emissions | 3-01-153-80 | Process Unit-Year |
| | Cumene: Fugitive Emissions | 3-01-156-80 | Process Unit-Year |
| | Cyclohexane: Fugitive Emissions | 3-01-157-80 | Process Unit-Year |
| | Cyclohexanone/ Cyclohexanol: Fugitive Emissions | 3-01-158-80 | Process Unit-Year |
| | Vinyl Acetate: Fugitive Emissions | 3-01-167-80 | Process Unit-Year |
| | Ethyl Benzene: Fugitive Emissions | 3-01-169-80 | Process Unit-Year |
| | Ethylene Oxide: Fugitive Emissions | 3-01-174-80 | Process Unit-Year |
| | Glycerin (Glycerol): Fugitive Emissions | 3-01-176-80 | Process Unit-Year |
| | Toluene Diisocyanate: Fugitive Emissions | 3-01-181-80 | Process Unit-Year |
| | Methyl Methacrylate: Fugitive Emissions | 3-01-190-80 | Process Unit-Year |
| | Nitrobenzene: Fugitive Emissions | 3-01-195-80 | Process Unit-Year |
| | Olefin Prod.: Fugitive Emissions (Propylene) | 3-01-197-09 | Process Unit-Year |
| | Olefin Prod.: Fugitive Emissions (Ethylene) | 3-01-197-49 | Process Unit-Year |
| | Phenol: Fugitive Emissions | 3-01-202-80 | Process Unit-Year |
| | Propylene Oxide: Fugitive Emissions | 3-01-205-80 | Process Unit-Year |
| | Styrene: Fugitive Emissions | 3-01-206-80 | Process Unit-Year |

## TABLE 4.7-1

## (CONTINUED)

| Source Description | Process Description | SCC | Units |
|---|---|---|---|
| Industrial Processes | | | |
| Chemical Manufacturing | Caprolactam: Fugitive Emissions | 3-01-210-80 | Process Unit-Year |
| | Linear Alkylbenzene: Fugitive Emissions | 3-01-211-80 | Process Unit-Year |
| | Methanol/Alcohol Production: Fugitive Emissions (Methanol) | 3-01-250-04 | Process Unit-Year |
| | Ethylene Glycol: Fugitive Emissions | 3-01-251-80 | Process Unit-Year |
| | Glycol Ethers: Fugitive Emissions | 3-01-253-80 | Process Unit-Year |
| | Nitriles, Acrylonitrile, Adiponitrile Prod.: Fugitive Emissions | 3-01-254-09 | Process Unit-Year |
| | Nitriles, Acrylonitrile, Adiponitrile Prod.: Fugitive Emissions | 3-01-254-20 | Process Unit-Year |
| | Benzene/Toluene/ Aromatics/Xylenes: Fugitive Emissions (Aromatics) | 3-01-258-80 | Process Unit-Year |
| | Chlorobenzene: Fugitive Emissions | 3-01-301-80 | Process Unit-Year |
| | Carbon Tetrachloride: Fugitive Emissions | 3-01-302-80 | Tons Product |
| | Allyl Chloride: Fugitive Emissions | 3-01-303-80 | Process Unit-Year |
| | Allyl Alcohol: Fugitive Emissions | 3-01-304-80 | Process Unit-Year |
| | Epichlorohydrin: Fugitive Emissions | 3-01-305-80 | Process Unit-Year |
| | General Processes: Fugitive Leaks | 3-01-800-01 | Process Unit-Year |

## TABLE 4.7-1

## (CONTINUED)

| Source Description | Process Description | SCC | Units |
|---|---|---|---|
| Industrial Processes | | | |
| Chemical Manufacturing | Fugitive Emissions: Specify In Comments Field | 3-01-888-02 | Tons Product |
| | Fugitive Emissions: Specify In Comments Field | 3-01-888-01 | Tons Product |
| | Fugitive Emissions: Specify In Comments Field | 3-01-888-03 | Tons Product |
| | Fugitive Emissions: Specify In Comments Field | 3-01-888-04 | Tons Product |
| | Fugitive Emissions: Specify In Comments Field | 3-01-888-05 | Process Unit-Year |
| Primary Metal Production | By-Product Coke Manufacturing-Equipment Leaks | 3-03-003-61 | Process Unit-Year |
| | Primary Metal Production - Equipment Leaks | 3-03-800-01 | Facility-Annual |
| Secondary Metal Production | Secondary Metal Production-Equipment Leaks | 3-04-800-01 | Facility-Annual |
| Petroleum Industry | Pipeline Valves And Flanges | 3-06-008-01 | 1000 Barrels Refined |
| | Vessel Relief Valves | 3-06-008-02 | 1000 Barrels Refined |
| | Pump Seals Without Controls | 3-06-008-03 | 1000 Barrels Refined |
| | Compressor Seals | 3-06-008-04 | 1000 Barrels Refined |
| | Misc: Sampling/Non-Asphalt Blowing/Purging/Etc. | 3-06-008-05 | 1000 Barrels Refined |
| | Pump Seals With Controls | 3-06-008-06 | 1000 Barrels Refined |

# TABLE 4.7-1

## (CONTINUED)

| Source Description | Process Description | SCC | Units |
|---|---|---|---|
| Industrial Processes | | | |
| Petroleum Industry | Blind Changing | 3-06-008-07 | 1000 Barrels Refined |
| | Pipeline Valves: Gas Streams | 3-06-008-11 | Valves In Operation |
| | Pipeline Valves: Light Liquid/Gas Stream | 3-06-008-12 | Valves In Operation |
| | Pipeline Valves: Heavy Liquid Stream | 3-06-008-13 | Valves In Operation |
| | Pipeline Valves: Hydrogen Streams | 3-06-008-14 | Valves In Operation |
| | Open-Ended Valves: All Streams | 3-06-008-15 | Valves In Operation |
| | Flanges: All Streams | 3-06-008-16 | Flanges In Operation |
| | Pump Seals: Light Liquid/Gas Streams | 3-06-008-17 | Seals In Operation |
| | Pump Seals: Heavy Liquid Streams | 3-06-008-18 | Seals In Operation |
| | Compressor Seals: Gas Streams | 3-06-008-19 | Seals In Operation |
| | Compressor Seals: Heavy Liquid Streams | 3-06-008-20 | Seals In Operation |
| | Drains: All Streams | 3-06-008-21 | Drains In Operation |
| | Vessel Relief Valves: All Streams | 3-06-008-22 | Valves In Operation |
| | Fugitive Emissions - Specify In Comments Field | 3-06-888-01 | 1000 Barrels Refined |
| | Fugitive Emissions - Specify In Comments Field | 3-06-888-02 | 1000 Barrels Refined |
| | Fugitive Emissions - Specify In Comments Field | 3-06-888-03 | 1000 Barrels Refined |

## TABLE 4.7-1

## (CONTINUED)

| Source Description | Process Description | SCC | Units |
|---|---|---|---|
| Industrial Processes | | | |
| Petroleum Industry | Fugitive Emissions - Specify In Comments Field | 3-06-888-04 | 1000 Barrels Refined |
| | Fugitive Emissions - Specify In Comments Field | 3-06-888-05 | 1000 Barrels Refined |
| Rubber And Miscellaneous Plastics Products | Rubber And Miscellaneous Plastic Parts - Equipment Leaks | 3-08-800-01 | Facility-Annual |
| Oil And Gas Production | Crude Oil Production - Complete Well | 3-10-001-01 | Wells/Year In Operation |
| | Crude Oil Production - Oil Well Cellars | 3-10-001-08 | Sq Ft Of Surface Area |
| | Crude Oil Production - Compressor Seals | 3-10-001-30 | Number Of Seals |
| | Crude Oil Production - Drains | 3-10-001-31 | Number Of Drains |
| | Natural Gas Production - Valves | 3-10-002-07 | Million Cubic Feet |
| | Natural Gas Production - Drains | 3-10-002-31 | Number Of Drains |
| | Fugitive Emissions - Specify In Comments Field | 3-10-888-01 | Process-Unit/Year |
| | Fugitive Emissions - Specify In Comments Field | 3-10-888-02 | Process-Unit/Year |
| | Fugitive Emissions - Specify In Comments Field | 3-10-888-03 | Process-Unit/Year |
| | Fugitive Emissions - Specify In Comments Field | 3-10-888-04 | Process-Unit/Year |
| | Fugitive Emissions - Specify In Comments Field | 3-10-888-05 | 100 Barrel Feed Prod. |
| | Fugitive Emissions - Specify In Comments Field | 3-10-888-11 | Million Cubic Feet |

## TABLE 4.7-1

## (CONTINUED)

| Source Description | Process Description | SCC | Units |
|---|---|---|---|
| Industrial Processes | | | |
| Transportation Equipment | Transportation Equipment - Equipment Leaks | 3-14-800-01 | Facility-Annual |
| Petroleum & Solvent Evaporation | | | |
| Organic Solvent Evaporation | Dry Cleaning - Misc. Trichloroethylene Fugitives | 4-01-001-63 | Tons Clothes Cleaned |
| | Fugitive Emissions - Specify In Comments Field | 4-01-888-01 | Tons Product |
| | Fugitive Emissions - Specify In Comments Field | 4-01-888-02 | Tons Product |
| | Fugitive Emissions - Specify In Comments Field | 4-01-888-03 | Tons Product |
| | Fugitive Emissions - Specify In Comments Field | 4-01-888-04 | Tons Product |
| | Fugitive Emissions - Specify In Comments Field | 4-01-888-05 | Tons Product |
| | Fugitive Emissions - Specify In Comments Field | 4-01-888-98 | Gallons |
| Surface Coating Operations | Surface Coating Operations - Equipment Leaks | 4-02-800-01 | Facility-Annual |
| Organic Chemical Transportation | Organic Chemical Transportation - Equipment Leaks | 4-08-800-01 | Facility-Annual |
| Organic Solvent Evaporation | Waste Solvent Recovery Operations - Fugitive Leaks | 4-90-002-06 | Process-Unit/Year |
| Waste Disposal | | | |
| Solid Waste Disposal - Government | Solid Waste Disposal: Govt. - Equipment Leaks | 5-01-800-01 | Facility-Annual |
| Solid Waste Disposal - Commercial/ Institutional | Solid Waste Disposal: Comm./Inst. - Equipment Leaks | 5-02-800-01 | Facility-Annual |
| Solid Waste Disposal - Industrial | Solid Waste Disposal: Indus. - Equipment Leaks | 5-03-800-01 | Facility-Annual |

## TABLE 4.7-1

## (CONTINUED)

| Source Description | Process Description | SCC | Units |
|---|---|---|---|
| Waste Disposal | | | |
| Site Remediation | Site Remediation - Equipment Leaks | 5-04-800-01 | Facility-Annual |
| MACT Source Categories | | | |
| Styrene Or Methacrylate-based Resins | Styrene Or Methacrylate-based Resins - Equipment Leaks | 6-41-800-01 | Facility-Annual |
| Cellulose-based Resins | Cellulose-based Resins - Equipment Leaks | 6-44-800-01 | Facility-Annual |
| Miscellaneous Resins | Miscellaneous Resins - Equipment Leaks | 6-45-800-01 | Facility-Annual |
| Vinyl-based Resins | Vinyl-based Resins - Equipment Leaks | 6-46-800-01 | Facility-Annual |
| Miscellaneous Polymers | Miscellaneous Polymers - Equipment Leaks | 6-48-800-01 | Facility-Annual |
| MACT Miscellaneous Processes (Chemicals) | MACT Misc. Processes (Chemicals) - Equipment Leaks | 6-84-800-01 | Facility-Annual |
| MACT Miscellaneous Processes (Chemicals) | MACT Misc. Processes (Chemicals) - Equipment Leaks | 6-85-800-01 | Facility-Annual |

# 8

# REFERENCES

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# APPENDIX A

# ESTIMATING LEAK DETECTION AND REPAIR (LDAR) CONTROL EFFECTIVENESS

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# ESTIMATING LDAR CONTROL EFFECTIVENESS

Some process units/facilities may want to develop control efficiencies specific to their process/facility if they have different leak definitions than what is in the federal programs. The LDAR monitoring frequency and leak definitions at some state equipment leak control programs may also be significantly different from federal programs. Table 4.A-1 presents a summary of controls required by federal requirement leak control programs.

The control efficiency of monitoring equipment at various leak definitions and monitoring frequencies may be estimated from the leak frequency before and after an LDAR program is implemented. Tables 4.A-2, and 4.A-3 present equations relating average leak rate to fraction leaking at SOCMI facilities and petroleum refineries. Once the initial and final leak frequencies are determined, they can be entered into the applicable equation to calculate the corresponding average leak rates at these leak frequencies. The control effectiveness for an LDAR program can be calculated from the initial leak rate and the final leak rate.

$$\mathrm{Eff} = (\mathrm{ILR} - \mathrm{FLR})/\mathrm{ILR} \times 100 \qquad (4.A\text{-}1)$$

where:

Eff = Control effectiveness (percent)
ILR = Initial leak rate (kg/hr per source)
FLR = Final leak rate (kg/hr per source)

The methodology for estimating leak frequencies is discussed in detail in Chapter 5 of the *Equipment Leaks Enabling Document* (EPA, July 1992). The methodology requires knowledge of screening data and equipment repair times.

## REFERENCE

EPA. July 1992. *Equipment Leaks Enabling Document*. Final Report. Internal Instruction Manual for ESD Regulation Development. U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, Reasearch Triangle Park, North Carolina.

# TABLE 4.A-1

## CONTROLS REQUIRED BY EQUIPMENT LEAK CONTROL PROGRAMS

| Equipment Type | Service | Petroleum Refinery CTG[a] | SOCMI CTG | Petroleum Refinery NSPS[b] | HON |
|---|---|---|---|---|---|
| Valves | Gas | Quarterly LDAR at 10,000 ppm | Quarterly LDAR at 10,000 ppm | Monthly LDAR at 10,000 ppm; decreasing frequency with good performance | Monthly LDAR with >2% leakers; quarterly LDAR with <2% leakers; decreasing frequency with good performance. Initially at 10,000 ppm, annually at 500 ppm |
| | Light liquid | Annual LDAR at 10,000 ppm | Quarterly LDAR at 10,000 ppm | Monthly LDAR at 10,000 ppm; decreasing frequency with good performance | Monthly LDAR with >2% leakers; quarterly LDAR with <2% leakers; decreasing frequency with good performance. Initially at 10,000 ppm, annually at 500 ppm |
| Pumps | Light liquid | Annual LDAR at 10,000 ppm; weekly visual inspection | Quarterly LDAR at 10,000 ppm; weekly visual inspection | Monthly LDAR at 10,000 ppm; weekly visual inspection; or dual mechanical seals with controlled degassing vents | Monthly LDAR; weekly visual inspection. Leak definition decreases from 10,000 ppm; or dual mechanical seals or closed-vent system |
| Compressors | Gas | Quarterly LDAR at 10,000 ppm | Quarterly LDAR at 10,000 ppm | Daily visual inspection; dual mechanical seal with barrier fluid and closed-vent system or maintained at a higher pressure than the compressed gas | Daily visual inspection. Dual mechanical seal with barrier fluid and closed-vent system or maintained at a higher pressure than the compressed gas |
| Connectors | Gas and light liquid | None | None | None | Annual LDAR at 500 ppm with >0.5% leakers; decreasing frequency with good performance |

## TABLE 4.A-1

## (CONTINUED)

| Equipment Type | Service | Petroleum Refinery CTG[a] | SOCMI CTG | Petroleum Refinery NSPS[b] | HON |
|---|---|---|---|---|---|
| Pressure relief devices | Gas | Quarterly LDAR at 10,000 ppm | Quarterly LDAR at 10,000 ppm | No detectable emissions | No detectable emissions or closed-vent system |
| Sampling connections | All | None | None | Closed-loop or in situ sampling | Closed-loop, closed-purge, closed vent or in situ sampling |
| Open-ended lines | All | Cap, blind flange, plug, or second valve | Cap, blind flange, plug, or second valve | Cap, blind flange, plug, or second valve | Cap, blind flange, plug, or second valve |

[a] CTG = Control Techniques Guidelines.
[b] NSPS = New Source Performance Standard.

## TABLE 4.A-2

## EQUATIONS RELATING AVERAGE LEAK RATE TO FRACTION LEAKING AT SOCMI UNITS

| Equipment Type | Leak Definition (ppmv) | Equations[a,b] |
|---|---|---|
| Gas valve | 500 | ALR = (0.04372) × (Lk Frac.) + 0.000017 |
| | 1000 | ALR = (0.04982) × (Lk Frac.) + 0.000028 |
| | 2000 | ALR = (0.05662) × (Lk Frac.) + 0.000043 |
| | 5000 | ALR = (0.06793) × (Lk Frac.) + 0.000081 |
| | 10000 | ALR = (0.07810) × (Lk Frac.) + 0.000131 |
| Light liquid valve | 500 | ALR = (0.04721) × (Lk Frac.) + 0.000027 |
| | 1000 | ALR = (0.05325) × (Lk Frac.) + 0.000039 |
| | 2000 | ALR = (0.06125) × (Lk Frac.) + 0.000059 |
| | 5000 | ALR = (0.07707) × (Lk Frac.) + 0.000111 |
| | 10000 | ALR = (0.08901) × (Lk Frac.) + 0.000165 |
| Light liquid pump | 500 | ALR = (0.09498) × (Lk Frac.) + 0.000306 |
| | 1000 | ALR = (0.11321) × (Lk Frac.) + 0.000458 |
| | 2000 | ALR = (0.13371) × (Lk Frac.) + 0.000666 |
| | 5000 | ALR = (0.19745) × (Lk Frac.) + 0.001403 |
| | 10000 | ALR = (0.24132) × (Lk Frac.) + 0.001868 |
| Connector | 500 | ALR = (0.04684) × (Lk Frac.) + 0.000017 |
| | 2000 | ALR = (0.07307) × (Lk Frac.) + 0.000035 |
| | 5000 | ALR = (0.09179) × (Lk Frac.) + 0.000054 |
| | 10000 | ALR = (0.11260) × (Lk Frac.) + 0.000081 |

[a] ALR = Average TOC leak rate (kg/hr per source).

[b] Lk Frac. = Fraction leaking.

# TABLE 4.A-3
# EQUATIONS RELATING AVERAGE LEAK RATE TO FRACTION LEAKING AT REFINERY PROCESS UNITS

| Equipment Type | Leak Definition (ppmv) | Equation[a,b] |
|---|---|---|
| Gas valve | 500 | ALR = (0.11140) × (Lk Frac.) + 0.000088 |
| | 1000 | ALR = (0.12695) × (Lk Frac.) + 0.000140 |
| | 10000 | ALR = (0.26200) × (Lk Frac.) + 0.000600 |
| Light liquid valve | 500 | ALR = (0.03767) × (Lk Frac.) + 0.000195 |
| | 1000 | ALR = (0.04248) × (Lk Frac.) + 0.000280 |
| | 10000 | ALR = (0.08350) × (Lk Frac.) + 0.001700 |
| Light liquid pump | 500 | ALR = (0.19579) × (Lk Frac.) + 0.001320 |
| | 1000 | ALR = (0.23337) × (Lk Frac.) + 0.001980 |
| | 10000 | ALR = (0.42500) × (Lk Frac.) + 0.012000 |
| Connector | 500 | ALR = (0.01355) × (Lk Frac.) + 0.000013 |
| | 1000 | ALR = (0.01723) × (Lk Frac.) + 0.000018 |
| | 10000 | ALR = (0.03744) × (Lk Frac.) + 0.000060 |

[a] ALR = Average non-methane organic compound leak rate (kg/hr per source).
[b] Lk Frac. = Fraction leaking.

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# APPENDIX B

# SOURCE SCREENING — RESPONSE FACTORS

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# SOURCE SCREENING — RESPONSE FACTORS

This appendix presents additional information on response factors and includes some guidelines on how to evaluate whether a RF correction to a screening value should be made. An RF is a correction factor that can be applied to a screening value to relate the actual concentration to the measured concentration of a given compound. The RF is calculated using the equation:

$$RF = AC/SV \qquad (4.B\text{-}1)$$

where:

RF = Response factor
AC = Actual concentration of the organic compound (ppmv)
SV = Screening value (ppmv)

The value of the RF is a function of several parameters. These parameters include the monitoring instrument, the calibration gas used to calibrate the instrument, the compound(s) being screened, and the screening value.

The EPA recommends that if a compound (or mixture) has an RF greater than 3, then the RF should be used to adjust the screening value before it is used in estimating emissions. When a compound has an RF greater than three for the recalibrated instrument, the emissions estimated using the unadjusted screening value will, generally, underestimate the actual emissions.

A detailed list of published RFs is presented in Appendix C of the *Protocol* document (EPA, November 1995). These RFs, developed for pure compounds, can be used to estimate the RF for a mixture by using the equation:

$$RF_m = \frac{1}{\sum_{i=1}^{n} (x_i/RF_i)} \qquad (4.B\text{-}2)$$

where:

$RF_m$ = Response factor of the mixture
n = Number of components in the mixture

$x_i$ = Mole fraction of constituent "i" in the mixture
$RF_i$ = Response factor of constituent i in the mixture

For more detail on the derivation of this equation, please refer to Appendix A of the *Protocol* document (EPA, November 1995).

In general, RFs can be used to correct all screening values, if so desired. The following steps can be carried out to evaluate whether an RF correction to a screening value should be made.

1. For the combination of monitoring instrument and calibration gas used, determine the RFs of a given material at an actual concentration of 500 ppmv and 10,000 ppmv. When it may not be possible to achieve an actual concentration of 10,000 ppmv for a given material, the RF at the highest concentration that can be safely achieved should be determined.

2. If the RFs at both actual concentrations are below 3, it is not necessary to adjust the screening values.

3. If either of the RFs are greater than 3, then the EPA recommends an RF be applied for those screening values for which the RF exceeds 3.

One of the following two approaches can be applied to correct screening values:

1. Use the higher of either the 500 ppmv RF or the 10,000 ppmv RF to adjust all screening values; or

2. Generate a response factor curve to adjust the screening values.

When it is necessary to apply RFs, site personnel should use engineering judgement to group process equipment into streams containing similar compounds. All components associated with a given stream can then be assigned the same RF, as opposed to calculating an RF for each individual equipment piece. Appendix A of the *Protocol* document (EPA, November 1995) presents an example about the application of response factors.

## REFERENCE

EPA. November 1995. *Protocol for Equipment Leak Emission Estimates*. U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, 453/R-95-017. Research Triangle Park, North Carolina.

# APPENDIX C

## MASS EMISSIONS SAMPLING — METHODS AND CALCULATION PROCEDURES

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## MASS EMISSIONS SAMPLING (BAGGING)

When bagging an equipment piece, two methods are generally employed in sampling source enclosures: the vacuum method (Figure 4.C-1) and the blow-through method (Figure 4.C-2). These two methods differ in the ways that the carrier gas is conveyed through the bag. In the vacuum method, a vacuum pump is used to pull air through the bag. In the blow-through method, a carrier gas such as nitrogen is blown into the bag. In general, the blow-through method has advantages over the vacuum method. These advantages are as follows:

- The blow-through method is more conducive to better mixing in the bag.
- The blow-through method minimizes ambient air in the bag and thus reduces potential error associated with background organic compound concentrations. (For this reason the blow-through method is especially preferable when measuring the leak rate from components with zero or very low screening values.)
- The blow-through method minimizes oxygen concentration in the bag (assuming air is not used as the carrier gas) and the risk of creating an explosive environment.
- In general, less equipment is required to set up the blow-through method sampling train.

However, the blow-through method does require a carrier gas source, and preferably the carrier gas should be inert and free of any organic compounds and moisture. The vacuum method does not require a special carrier gas.

Figures 4.C-3 and 4.C-4 present the calculation procedures for leak rates when using the vacuum and blow-through methods, respectively.

When choosing the bagging material, an important criteria is that it is impermeable to the specific compounds being emitted from the equipment piece.

Example 4.C-1, for the vacuum method, and Example 4.C-2, for the blow-through method, are presented in two parts. Part 1 shows the data sheets that were presented in Section 6 (Figures 4.6-2 and 4.6-3) filled out with the appropriate information, and Part 2 shows how that information is used to calculate the mass emission rates, using the equations shown in Figures 4.C-3 and 4.C-4.

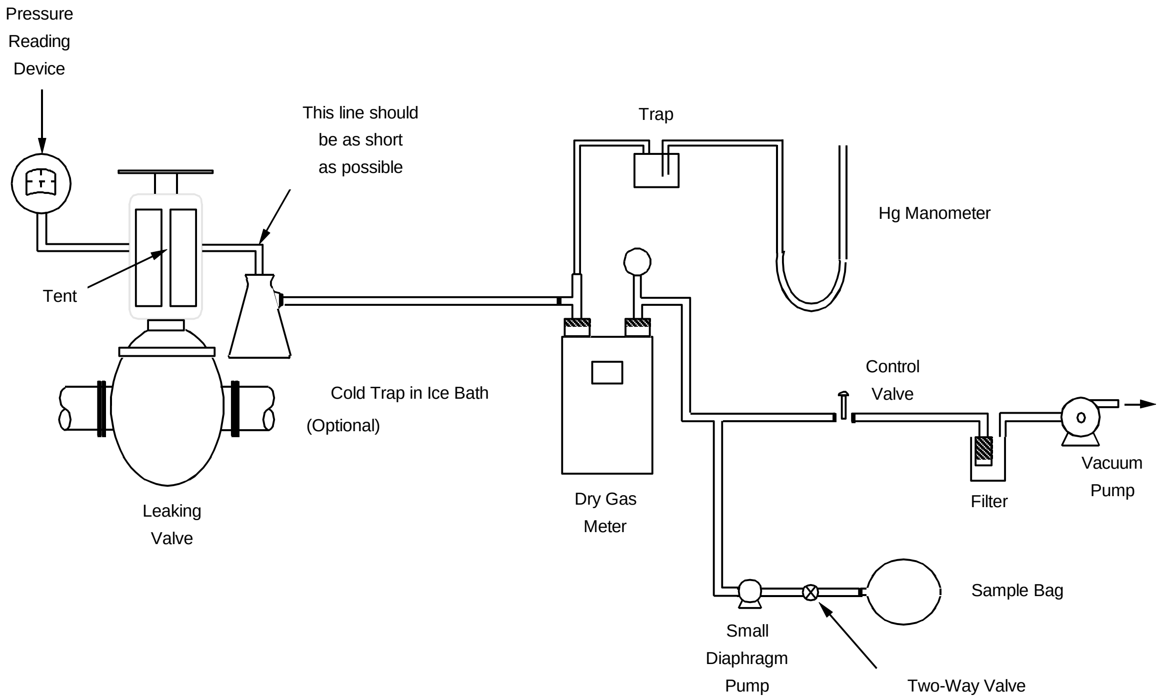

**FIGURE 4.C-1. SAMPLING TRAIN FOR BAGGING A SOURCE USING THE VACUUM METHOD**

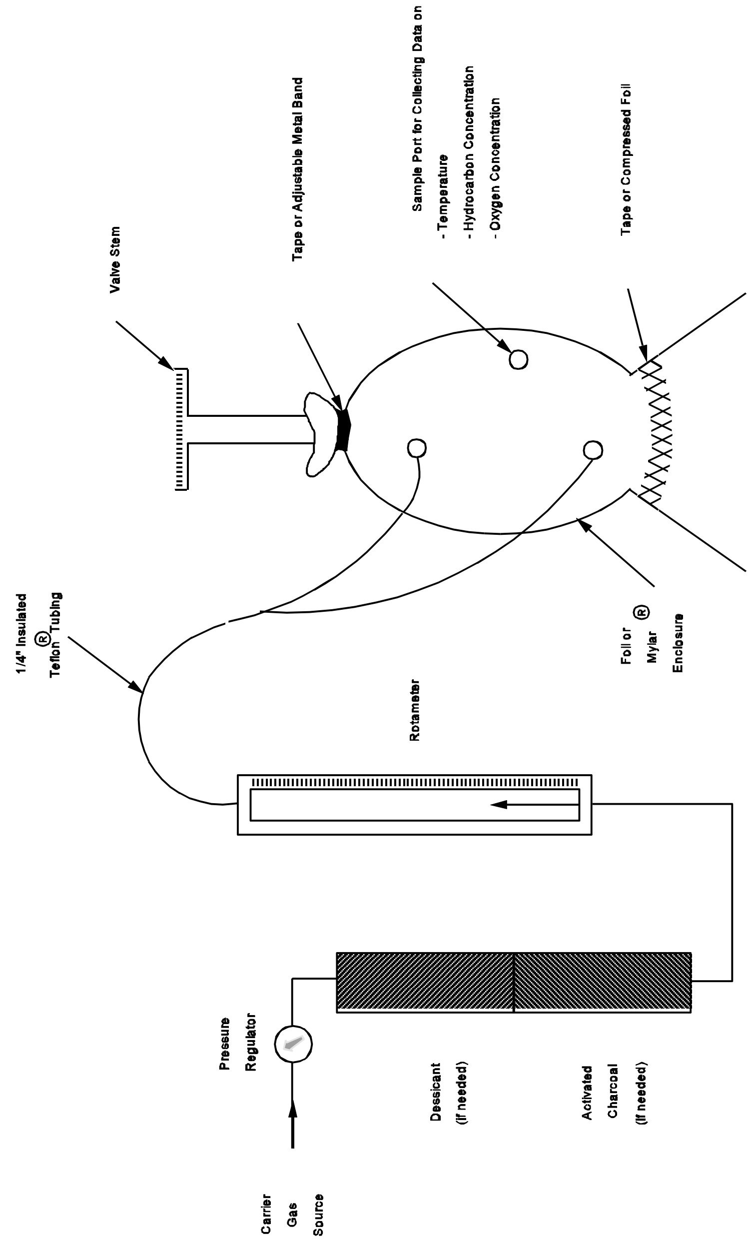

FIGURE 4.C-2. EQUIPMENT REQUIRED FOR THE BLOW-THROUGH SAMPLING TECHNIQUE

## CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE VACUUM METHOD

$$\underset{(\text{kg/hr})}{\text{Leak Rate}} = \frac{9.63 \times 10^{-10}(Q)(MW)(GC)(P)}{T + 273.15} + \frac{(\rho)(v_L)}{16.67(t)}$$

where:

$9.63 \times 10^{-10}$ = A conversion factor using the gas constant:

$$\frac{°K \times 10^6 \times \text{kg-mol} \times \text{min}}{L \times \text{hour} \times \text{mmHg}}$$

Q = Flow rate out of bag (L/min)
$MW^a$ = Molecular weight of organic compound(s) in the sample bag or alternatively in the process stream contained within the equipment piece being bagged (kg/kg-mol)
$GC^b$ = Sample bag organic compound concentration (ppmv) minus background bag organic compound concentration[c] (ppmv)
P = Absolute pressure at the dry gas meter (mmHg)
T = Temperature at the dry gas meter (°C)
$\rho$ = Density of organic liquid collected (g/mL)
$V_L$ = Volume of liquid collected (mL)
16.67 = A conversion factor to adjust term to units of kilograms per hour (g × hr)/(kg × min)
t = Time in which liquid is collected (min)

[a] For mixtures, calculate MW as:

$$\frac{\sum_{i=1}^{n} MW_i X_i}{\sum_{i=1}^{n} X_i}$$

where:

$MW_i$ = Molecular weight of organic compound "i"
$X_i$ = Mole fraction of organic compound i
n = Number of organic compounds in mixture.

[b] For mixtures, the value of GC is the total concentration of all the organic compounds in the mixture.

[c] Collection of a background bag is optional. If a bag of background air is not collected, assume the background concentration is zero.

FIGURE 4.C-3. CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE VACUUM METHOD

### CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE BLOW-THROUGH METHOD

$$\begin{array}{c}\text{Leak Rate}\\ \text{(kg/hr)}\end{array} = \left( \frac{1.219 \times 10^{-5}(Q)(MW)(GC)}{T + 273.15} + \frac{(\rho)(V_L)}{16.67(t)} \right) \times \left( \frac{10^6 \text{ ppmv}}{10^6 \text{ ppmv} - GC} \right)$$

where:

$1.219 \times 10^{-5}$ = A conversion factor taking into account the gas constant and assuming a pressure in the bag of 1 atmosphere:

$$\frac{°K \times 10^{6} \times \text{kg-mol}}{m^{3}}$$

Q = flow rate out of bag ($m^3$/hr);

$$= \frac{N_2 \text{ Flow Rate (L/min)}}{1 - [\text{Bag Oxygen Conc. (volume \%)}/21]} \times \frac{[0.06\ (m^3/\text{min})]}{(\text{L/hr})}$$

MW[a] = Molecular weight of organic compounds in the sample bag or alternatively in the process stream contained within the equipment piece being bagged (kg/kg-mol)

GC[b] = Sample bag organic compound concentration (ppmv), corrected for background bag organic compound concentration (ppmv)[c]

T = Temperature in bag (°C)

$\rho$ = Density of organic liquid collected (g/mL)

$V_L$ = Volume of liquid collected (mL)

16.67 = A conversion factor to adjust term to units of kilograms per hour (g × hr)/(kg × min)

t = Time in which liquid is collected (min)

**FIGURE 4.C-4. CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE BLOW-THROUGH METHOD**

## CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE BLOW-THROUGH METHOD (CONTINUED)

[a] For mixtures, calculate MW as:

$$\frac{\sum_{i=1}^{n} MW_i X_i}{\sum_{i=1}^{n} X_i}$$

where:

| | | |
|---|---|---|
| $MW_i$ | = | Molecular weight of organic compound "i" |
| $X_i$ | = | Mole fraction of organic compound i |
| n | = | Number of organic compounds in mixture |

[b] For mixtures, the value of GC is the total concentration of all the organic compounds in the mixture.

[c] Collection of a background bag is optional. If a bag of background air is not collected, assume the background concentration is zero. To correct for background concentration, use the following equation:

$$\underset{(\text{ppmv})}{GC} = SB - \left(\frac{BAG}{21} \times BG\right)$$

where:

| | | |
|---|---|---|
| SB | = | Sample bag concentration (ppmv); |
| BAG | = | Tent oxygen concentration (volume %); and |
| BG | = | Background bag concentration (ppmv) |

FIGURE 4.C-4. (CONTINUED)

## EXAMPLE 4.C-1: PART 1

## EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS BAGGING TEST (VACUUM METHOD)

Equipment Type ***Valve***
Equipment Category ________
Line Size ________
Stream Phase (G/V, LL, HL) ***LL***
Barometric Pressure ________
Ambient Temperature ________
Stream Temperature ________

Component ID ***V0101***
Plant ID ***P012***
Date ***10-15-95***
Analysis Team ________
Instrument ID ***I01***
Stream Pressure ________

Stream Composition (Wt. %) ***100% TOC MW = 25.4735 kg/kg-mol***
________, ________, ________

| Time | Bagging Test Measurement Data | |
|---|---|---|
| | Initial Screening (ppmv) Equipment Piece[a] ***450*** Bkgd. | ***9*** |
| | Background Bag Organic Compound Conc. (ppmv)[b] | |
| | Sample Bag 1 Organic Compound Conc. (ppmv) | ***268*** |
| | Dry Gas Meter Reading (L/min) | ***2.806*** |
| | Vacuum Check in Bag (Y/N) (Must be YES to collect sample.) | |
| | Dry Gas Meter Temperature[c] (°C) | ***17*** |
| | Dry Gas Meter Pressure[c] (mmHg) | ***668*** |
| | Sample Bag 2 Organic Compound Conc. (ppmv) | |
| | Dry Gas Meter Reading (L/min) | |
| | Vacuum Check in Bag (Y/N) (Must be YES to collect sample.) | |
| | Dry Gas Meter Temperature[c] (°C) | |
| | Dry Gas Meter Pressure[c] (mmHg) | |

Condensate Accumulation: Starting Time ______ Final Time ________

Organic Condensate Collected (mL) ________

Density of Organic Condensate (g/mL) ________

________ Final Screening (ppmv) Equip. Piece[a] ***450*** Bkgd. ***9***

[a] The vacuum method is not recommended if the screening value is approximately 10 ppmv or less.
[b] Collection of a background bag is optional.
[c] Pressure and temperature are measured at the dry gas meter.

# EXAMPLE 4.C-1: PART 2

## EQUATION FOR CALCULATING THE LEAK RATE USING THE DATA FROM PART 1

$$\text{Leak Rate} = \left( \frac{9.63\text{E}-10\ (Q)(MW)(GC)(P)}{T + 273.15} \right)$$

$$= \left( 9.63\text{E}-10\ \frac{°\text{K} \times 10^{6} \times \text{kg-mol} \times \text{min}}{\text{L} \times \text{hr} \times \text{mmHg}} \right) \left( 2.806\ \frac{\text{L}}{\text{min}} \right) \left( 25.4735\ \frac{\text{kg}}{\text{kg-mol}} \right)$$

$$\left( \frac{(268\ \text{ppmv})(668\ \text{mmHg})}{(17 + 273.15)°\text{K}} \right)$$

$$= 4.25\text{E}-05\ \text{kg/hr}$$

# EXAMPLE 4.C-2: PART 1

## EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS BAGGING TEST (BLOW-THROUGH METHOD)

Equipment Type ***Valve***

Equipment Category

Line Size

Stream Phase (G/V, LL, HL) ***LL***

Barometric Pressure

Ambient Temperature

Stream Temperature

Component ID ***V0102***

Plant ID ***P012***

Date ***10-15-95***

Analysis Team

Instrument ID ***I01***

Stream Pressure

Stream Composition (Wt. %) ***100% TOC MW=28.12 kg/kg-mol***

| Time | Bagging Test Measurement Data | |
|---|---|---|
| | Initial Screening (ppmv) Equipment Piece ***8*** Bkgd. | ***4*** |
| | Background Bag Organic Compound Conc. (ppmv)[a] | |
| | Sample Bag 1 Organic Compound Conc. (ppmv) | ***29.3*** |
| | Dilution Gas Flow Rate (L/min) | ***5.21*** |
| | $O_2$ Concentration (volume %) | ***2.55*** |
| | Bag Temperature (°C) | ***23.89*** |
| | Sample Bag 2 Organic Compound Conc. (ppmv) | |
| | Dilution Gas Flow Rate (L/min) | |
| | $O_2$ Concentration (volume %) | |
| | Bag Temperature (°C) | |

Condensate Accumulation: Starting Time Final Time

Organic Condensate Collected (mL)

Density of Organic Condensate (g/mL)

Final Screening (ppmv) Equipment Piece ***8*** Bkgd. ***4***

---

[a] Collection of a background bag is optional. However, it is recommended in cases where the screening value is less than 10 ppmv and there is a detectable oxygen level in the bag.

## EXAMPLE 4.C-2: PART 2

## EQUATION FOR CALCULATING THE LEAK RATE USING THE DATA FROM PART 1

$$Q = \frac{\text{Dilution Gas Flow Rate}}{\left(1 - \dfrac{\text{Bag } O_2 \text{ conc (vol\%)}}{21\%}\right)} \times \frac{\left[0.06 \ m^3/\text{min}\right]}{\text{L/hr}}$$

$$= \frac{5.21 \ \dfrac{\text{L}}{\text{min}}}{1 - \left(\dfrac{2.55\%}{21\%}\right)} \times \frac{\left[\ 0.06 \ m^3/\text{min}\right]}{\text{L/hr}}$$

$$= 0.36 \ m^3/\text{hr}$$

$$\text{Leak Rate} = \left(\frac{1.219\text{E}-05 \ (Q) \ (MW) \ (GC)}{T + 273.15}\right) \times \left(\frac{10^6}{10^6 - GC}\right)$$

$$= \frac{\left(1.219\text{E}-05 \ \dfrac{°K \times 10^6 \times \text{kg-mol} \times \text{min}}{m^3}\right)\left(0.36 \ \dfrac{m^3}{\text{hr}}\right)\left(28.12 \ \dfrac{\text{kg}}{\text{kg-mol}}\right)(29.3\text{ppmv})}{(23.89+273.15)°K} \times \left(\frac{10^6}{10^6 - 29.3}\right)$$

$$= 1.22\text{E}-05 \ \text{kg/hr}$$

# APPENDIX D

# EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

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# EXAMPLE DATA COLLECTION FORM INSTRUCTIONS

## GENERAL

- This form may be used as a worksheet to aid in collecting the information/data necessary to estimate HAP and VOC emissions from equipment leaks.
- The form is divided into five sections: General Information; Stream Composition Data; Equipment Counts; Screening Data; and Equipment Leaks Controls.
- Some of the sections require entry on a stream basis; for these, a separate copy of the section will need to be made for each stream in the process unit.
- If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the CHIEF bulletin board system (BBS) of the OAQPS TTN.

## STREAM COMPOSITION DATA SECTION

- Weight percents may not need to be provided for constituents present in concentrations less than 1.0 weight percent.
- In the row labelled "OTHER," identify total weight percent of all constituents not previously listed. The total weight percent of constituents labelled as "OTHER" must not exceed 10 percent. Total weight percent of all constituents in the stream must equal 100 percent.

## SCREENING DATA SECTION

- Complete the information/data for each screened stream.

## EQUIPMENT COUNT SECTION

- Complete each blank form for each stream in the facility.
- The LDAR trigger concentration refers to the concentration level that the component is considered to be leaking.
- Enter the control parameters for each component type in the stream. Provide the percent of the total equipment type in the stream that has the controls listed in the attached table.
- If other controls are used, specify what they are in the space left of the slash. Specify the percent of each component type in the stream that use the other control in the space to the right of the slash.
- Indicate any secondary control devices to which the closed vent system transports the process fluid.

Example 4.D-1 shows how all of the sections of this form would be filled out for the example presented in Section 4 (Tables 4.4-1 and 4.4-2) for a hypothetical chemical processing facility, which is subject to an LDAR program.

**Note**: Complete this form for each type of fuel used and for each unit.

## EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

| GENERAL INFORMATION |
|---|
| Process Unit Capacity (lb/yr) |
| Portable VOC Monitoring Instrument Used[a] |
| Calibration Gas of Monitoring Instrument[a] |

| STREAM COMPOSITION DATA | | | | | | |
|---|---|---|---|---|---|---|
| CAS Number | Chemical Name | Concentration (wt.%) | | | | |
| | | Stream 1 | Stream 2 | Stream 3 | Stream 4 | Stream 5 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| -- | OTHER | | | | | |
| -- | Total HAPs | | | | | |
| -- | Total VOCs | | | | | |
| -- | Source[c] | | | | | |
| Amount of Time Fluid in Stream (hr/yr) | | | | | | |

[a] Collect information if screening data have been gathered at the process unit.

[b] CAS = Chemical Abstract Service.

[c] EJ = Engineering judgement; TD = Test data; LV = Literature values.

# EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

| EQUIPMENT COUNTS | | | | | |
|---|---|---|---|---|---|
| Component | Service | Count Source[b] | Stream 1 (A) | Stream 2 (B) | Stream 3 (C) |
| Valves | gas/vapor | | | | |
| | light liquid | | | | |
| | heavy liquid | | | | |
| Connectors | all | | | | |
| Pumps | light liquid | | | | |
| | heavy liquid | | | | |
| Compressor | gas/vapor | | | | |
| Open Lines | all | | | | |
| Sample Connections | all | | | | |
| Pressure Relief Valve | gas/vapor | | | | |

[a] Do not include equipment in vacuum service.

[b] D = Design specifications; I = Inspection and maintenance tags; C = Actual count; and R = Ratio; if ratio, specify (i.e., 25 valves per pump).

## EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

| | |
|---|---|
| SCREENING DATA | |
| Stream ID: | Component Type: |
| Date Components Screened: | Total Number of Components Screened |
| Component ID | Screening Value (ppmv) |
| | |
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# EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

## EQUIPMENT LEAKS CONTROLS

Stream ID:

Is the equipment in this stream subject to a LDAR program? (Yes/No)

Type of Monitoring System[a]:

| | Leak Detection and Repair Parameters | | | | Control Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Equipment | Quantity in Program | LDAR Trigger Conc. | Monitoring Frequency | Response Time[b] | Percent with Control A[c] | Percent with Control B[c] | Percent with Control C[c] | Other | Closed Vent Secondary Control |
| Valves | | | | | | | NA[d] | / | |
| Pumps | | | | | | | | / | |
| Compressors | | | | | | | NA | / | |
| Connectors | | | | | | NA | NA | / | |
| Open-ended lines | | | | | | | NA | / | |
| Sampling Connections | NA | NA | NA | NA | | | | / | |
| Pressure Relief Valves | | | | | | | NA | / | |

[a] V = Visual; P = Portable; F = Fixed point; If other, please specify.

[b] IM = Immediately; D = 1 day; D3 = 3 days; W = 1 week; W2 = 2 weeks; and M = 1 month.

[c] See attached table, Controls by Equipment Type.

[d] NA = Not applicable.

## EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

### TABLE OF CONTROLS BY EQUIPMENT TYPE

| Control Option | Equipment | Controls |
|---|---|---|
| A | All | Closed vent system |
| B | Valves | Sealless |
| | Pumps | Dual mechanical seal with barrier fluid |
| | Compressors | Mechanical seals with barrier fluid |
| | Open-ended lines | Capped, plugged, blind-flagged |
| | Sampling Connections | *In-situ* sampling |
| | PRVs | Rupture disk |
| C | Pumps | Sealless |
| | Sampling connections | Closed loop sampling |

# EXAMPLE 4.D-1

## EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT FROM EQUIPMENT LEAKS

### GENERAL INFORMATION

Process Unit Capacity (lb/yr) ***800,000***

Portable VOC Monitoring Instrument Used[a] Foxboro OVA Model ***108***

Calibration Gas of Monitoring Instrument[a] ***Methane***

### STREAM COMPOSITION DATA

| CAS Number | Chemical Name | Concentration (wt%) | | | | |
|---|---|---|---|---|---|---|
| | | Stream 1 (A) | Stream 2 (B) | Stream 3 (C) | Stream 4 | Stream 5 |
| ***140885*** | ***ETHYL ACRYLATE*** | ***80*** | ***10*** | ***65*** | | |
| ***100425*** | ***STYRENE*** | | ***90*** | | | |
| ***74840*** | ***ETHANE*** | | | ***25*** | | |
| ***7732185*** | ***WATER*** | ***20*** | | ***10*** | | |
| | | | | | | |
| -- | OTHER | | | | | |
| -- | Total HAPs | ***80*** | ***100*** | ***65*** | | |
| -- | Total VOCs | ***80*** | ***100*** | ***90*** | | |
| -- | Source[b] | ***TD*** | ***TD*** | ***TD*** | | |
| Amount of Time Fluid in Stream (hr/yr) | | ***8760*** | ***4380*** | ***8760*** | | |

[a] Collect information if screening data have been gathered at the process unit.

[b] EJ = Engineering judgement; TD = Test data; LV = Literature values.

# EXAMPLE 4.D-1

## (CONTINUED)

| EQUIPMENT COUNTS | | | | | |
|---|---|---|---|---|---|
| Component | Service | Count Source[b] | Stream 1 (A) | Stream 2 (B) | Stream 3 (C) |
| Valves | gas/vapor | ***C*** | | | ***40*** |
| | light liquid | | | | |
| | heavy liquid | | | | |
| Connectors | all | | | | |
| Pumps | light liquid | ***C*** | ***15*** | ***12*** | |
| | heavy liquid | | | | |
| Compressor | gas/vapor | | | | |
| Open Lines | all | | | | |
| Sample Connections | all | | | | |
| Pressure Relief Valve | gas/vapor | | | | |

[a] Do not include equipment in vacuum service.

[b] D = Design specifications; I = Inspection and maintenance tags; C = Actual count; and R = Ratio; if ratio, specify (i.e., 25 valves per pump).

# EXAMPLE 4.D-1

## (CONTINUED)

SCREENING DATA

| | |
|---|---|
| Stream ID: ***A*** | Component Type: ***Light Liquid Pump*** |
| Date Components Screened: ***7-15-95*** | Total Number of Components Screened: ***15*** |

| Component ID | Screening Value (ppmv) |
|---|---|
| ***A-1*** | ***0*** |
| ***A-2*** | ***0*** |
| ***A-3*** | ***0*** |
| ***A-4*** | ***0*** |
| ***A-5*** | ***0*** |
| ***A-6*** | ***20*** |
| ***A-7*** | ***50*** |
| ***A-8*** | ***50*** |
| ***A-9*** | ***100*** |
| ***A-10*** | ***100*** |
| ***A-11*** | ***200*** |
| ***A-12*** | ***400*** |
| ***A-13*** | ***1000*** |
| ***A-14*** | ***2000*** |
| ***A-15*** | ***5000*** |

## EXAMPLE 4.D-1

## (CONTINUED)

| SCREENING DATA | |
|---|---|
| Stream ID: ***B*** | Component Type: ***Light Liquid Pump*** |
| Date Components Screened: ***7-15-95*** | Total Number of Components Screened: ***11*** |
| Component ID | Screening Value (ppmv) |
| ***B-1*** | ***0*** |
| ***B-2*** | ***0*** |
| ***B-3*** | ***0*** |
| ***B-4*** | ***10*** |
| ***B-5*** | ***30*** |
| ***B-6*** | ***250*** |
| ***B-7*** | ***500*** |
| ***B-8*** | ***2000*** |
| ***B-9*** | ***5000*** |
| ***B-10*** | ***8000*** |
| ***B-11*** | ***25,000*** |

# EXAMPLE 4.D-1

## (CONTINUED)

| SCREENING DATA | |
|---|---|
| Stream ID: ***C*** | Component Type: ***Gas/Vapor Valve*** |
| Date Components Screened: ***7-15-95*** | Total Number of Components Screened: ***40*** |
| Component ID | Screening Value (ppmv) |
| ***C-1*** | ***0*** |
| ***C-2*** | ***0*** |
| ***C-3*** | ***0*** |
| ***C-4*** | ***0*** |
| ***C-5*** | ***0*** |
| ***C-6*** | ***0*** |
| ***C-7*** | ***15*** |
| ***C-8*** | ***20*** |
| ***C-9*** | ***20*** |
| ***C-10*** | ***35*** |
| ***C-11*** | ***50*** |
| ***C-12*** | ***50*** |
| ***C-13*** | ***120*** |
| ***C-14*** | ***150*** |
| ***C-15*** | ***200*** |

## EXAMPLE 4.D-1

## (CONTINUED)

SCREENING DATA

| | |
|---|---|
| Stream ID: ***C*** | Component Type: ***Gas/Vapor Valve*** |
| Date Components Screened: ***7-15-95*** | Total Number of Components Screened: ***40*** |

| Component ID | Screening Value (ppmv) |
|---|---|
| ***C-16*** | ***500*** |
| ***C-17*** | ***550*** |
| ***C-18*** | ***575*** |
| ***C-19*** | ***600*** |
| ***C-20*** | ***610*** |
| ***C-21*** | ***700*** |
| ***C-22*** | ***800*** |
| ***C-23*** | ***1010*** |
| ***C-24*** | ***1200*** |
| ***C-25*** | ***1500*** |
| ***C-26*** | ***1550*** |
| ***C-27*** | ***1700*** |
| ***C-28*** | ***2000*** |
| ***C-29*** | ***5000*** |
| ***C-30*** | ***5100*** |

## EXAMPLE 4.D-1

## (CONTINUED)

SCREENING DATA

| | |
|---|---|
| Stream ID: ***C*** | Component Type: ***Gas/Vapor Valve*** |
| Date Components Screened: ***7-15-95*** | Total Number of Components Screened: ***40*** |

| Component ID | Screening Value (ppmv) |
|---|---|
| ***C-31*** | ***6100*** |
| ***C-32*** | ***7000*** |
| ***C-33*** | ***8000*** |
| ***C-34*** | ***8100*** |
| ***C-35*** | ***8150*** |
| ***C-36*** | ***8300*** |
| ***C-37*** | ***9000*** |
| ***C-38*** | ***10,000*** |
| ***C-39*** | ***15,000*** |
| ***C-40*** | ***50,000*** |

# EXAMPLE 4.D-1

## (CONTINUED)

### EQUIPMENT LEAKS CONTROLS

Stream ID: ***A***

Is the equipment in this stream subject to a LDAR program? (Yes/No) ***Yes***

Type of Monitoring System[a]: ***P***

| | Leak Detection and Repair Parameters | | | | Control Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Equipment | Quantity in Program | LDAR Trigger Conc. | Monitoring Frequency | Response Time[b] | Percent with Control A[c] | Percent with Control B[c] | Percent with Control C[c] | Other | Closed Vent Secondary Control |
| Valves | | | | | | | NA[d] | / | |
| Pumps | ***15*** | ***10,000 ppm*** | ***monthly*** | ***W*** | ***53%*** | ***7%*** | ***40%*** | / | |
| Compressors | | | | | | | NA | / | |
| Connectors | | | | | | NA | NA | / | |
| Open-ended lines | | | | | | | NA | / | |
| Sampling Connections | NA | NA | NA | NA | | | | / | |
| Pressure Relief Valves | | | | | | | NA | / | |

[a] V = Visual; P = Portable; F = Fixed point; If other, please specify.
[b] IM = Immediately; D = 1 day; D3 = 3 days; W = 1 week; W2 = 2 weeks; and M = 1 month.
[c] See attached table, Controls by Equipment Type.
[d] NA = Not applicable.

## EXAMPLE 4.D-1

## (CONTINUED)

### EQUIPMENT LEAKS CONTROLS

Stream ID: ***B***

Is the equipment in this stream subject to a LDAR program? (Yes/No) ***Yes***

Type of Monitoring System[a]: ***P***

| | Leak Detection and Repair Parameters | | | | Control Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Equipment | Quantity in Program | LDAR Trigger Conc. | Monitoring Frequency | Response Time[b] | Percent with Control A[c] | Percent with Control B[c] | Percent with Control C[c] | Other | Closed Vent Secondary Control |
| Valves | | | | | | | NA[d] | / | |
| Pumps | ***12*** | ***10,000 ppm*** | ***monthly*** | ***W*** | ***67%*** | ***33%*** | ***0%*** | / | |
| Compressors | | | | | | | NA | / | |
| Connectors | | | | | | NA | NA | / | |
| Open-ended lines | | | | | | | NA | / | |
| Sampling Connections | NA | NA | NA | NA | | | | / | |
| Pressure Relief Valves | | | | | | | NA | / | |

[a] V = Visual; P = Portable; F = Fixed point; If other, please specify.
[b] IM = Immediately; D = 1 day; D3 = 3 days; W = 1 week; W2 = 2 weeks; and M = 1 month.
[c] See attached table, Controls by Equipment Type.
[d] NA = Not applicable.

## EXAMPLE 4.D-1

## (CONTINUED)

| EQUIPMENT LEAKS CONTROLS |
|---|
| Stream ID: ***C*** |
| Is the equipment in this stream subject to a LDAR program? (Yes/No) ***Yes*** |
| Type of Monitoring System[a]: ***P*** |

| | Leak Detection and Repair Parameters | | | | Control Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Equipment | Quantity in Program | LDAR Trigger Conc. | Monitoring Frequency | Response Time[b] | Percent with Control A[c] | Percent with Control B[c] | Percent with Control C[c] | Other | Closed Vent Secondary Control |
| Valves | ***40*** | ***10,000 ppm*** | ***monthly*** | ***W*** | ***50%*** | ***50%*** | NA[d] | / | |
| Pumps | | | | | | | | / | |
| Compressors | | | | | | | NA | / | |
| Connectors | | | | | | NA | NA | / | |
| Open-ended lines | | | | | | | NA | / | |
| Sampling Connections | NA | NA | NA | NA | | | | / | |
| Pressure Relief Valves | | | | | | | NA | / | |

[a] V = Visual; P = Portable; F = Fixed point; If other, please specify.
[b] IM = Immediately; D = 1 day; D3 = 3 days; W = 1 week; W2 = 2 weeks; and M = 1 month.
[c] See attached table, Controls by Equipment Type.
[d] NA = Not applicable.

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