VOLUME II: CHAPTER 4

PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

Final Report

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DISCLAIMER

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

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1

INTRODUCTION

The purposes of this document are to present general information on methodologies and/or approaches for estimating air emissions from equipment leaks in a clear and concise manner and to provide specific example calculations to aid in the preparation and review of emission inventories.

Because documents describing procedures for estimating emissions from equipment leaks are readily available, duplication of detailed information will be avoided in this document. The reader is referred to the following reports that were used to develop this document:

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

- Chemical Manufacturers Association (CMA). 1989. *Improving Air Quality: Guidance for Estimating Fugitive Emissions.* Second Edition. Washington, DC; and,

During the development of this guideline document, results of recent studies developed by the EPA for the petroleum industry were incorporated (Epperson, January, 1995). This information is available on the Office of Air Quality Planning and Standards (OAQPS) Technology Transfer Network (TTN) (under the Clearinghouse for Inventories and Emission Factors [CHIEF]).

Section 2 of this chapter contains a general description of the equipment leak sources, such as valves, pumps, and compressors and also includes information on equipment leak control techniques and efficiencies. Section 3 of this chapter provides an overview of available approaches for estimating emissions from equipment leaks. Four main approaches are discussed and compared in Section 3: (1) average emission factor; (2) screening ranges; (3) EPA correlation equation; and (4) unit-specific correlation equations. Also included in this section are descriptions of available procedures for collecting equipment leaks data and a comparison of available emission estimation approaches. Section 4 presents the preferred method for estimating emissions, while Section 5 presents alternative emission estimation methods. Quality assurance and control procedures are described in Section 6 and data coding procedures are discussed in Section 7. References are listed in Section 8.

Appendix A presents information on how to estimate the control effectiveness of leak detection and repair (LDAR) programs. Appendix B presents additional information on response factors (RFs) and some guidelines on how to evaluate whether an RF correction to a screening value should be made. Appendix C of this chapter presents general information on methods and calculation procedures for mass emissions sampling (bagging). Appendix D presents an example data collection form that can be used for gathering information to estimate fugitive emissions from equipment leaks.

2

GENERAL SOURCE CATEGORY DESCRIPTION

2.1 SOURCE CATEGORY DESCRIPTION

Emissions occur from process equipment whenever components in the liquid or gas stream leak. These emissions generally occur randomly and are difficult to predict. In addition, these emissions may be intermittent and vary in intensity over time. Therefore, measurements of equipment leak emissions actually represent a "snapshot" of the leaking process. There are several potential sources of equipment leak emissions. Components such as pumps, valves, pressure relief valves, flanges, agitators, and compressors are potential sources that can leak due to seal failure. Other sources, such as open-ended lines, and sampling connections may leak to the atmosphere for reasons other than faulty seals. The majority of data collected for estimating equipment leak emissions has been for total organic compounds and non-methane organic compounds. Equipment leak emission data have been collected from the following industry segments:

- Synthetic Organic Chemical Manufacturing Industry (SOCMI);
- Petroleum Refineries;
- Petroleum Marketing Terminals; and
- Oil and Gas Production Facilities.

Each of these emission sources is briefly described in this section. A more detailed discussion of these sources can be found in the *Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) and the *Equipment Leaks Enabling Document* (EPA, July 1992).

2.1.1 PUMPS

Pumps are used extensively in the petroleum and chemical industries for the movement of liquids. The centrifugal pump is the most widely used pump type in the chemical industry; however, other types, such as the positive displacement (reciprocating) pump, are also used. Chemicals transferred by pump can leak at the point of contact between the moving shaft and the stationary casing. Consequently, all pumps except the sealless type, such as canned-motor, magnetic drive, and diaphragm pumps, require a seal at the point where the shaft penetrates the housing in order to isolate the pumped fluid from the environment.

Two generic types of seals, packed and mechanical, are used on pumps. Packed seals can be used on both reciprocating and centrifugal pumps. A packed seal consists of a cavity ("stuffing box") in the pump casing filled with packing gland to form a seal around the shaft. Mechanical seals are limited in application to pumps with rotating shafts. There are single and dual mechanical seals, with many variations to their basic design and arrangement, but all have a lapped seal face between a stationary element and a rotating seal ring.

2.1.2 VALVES

Except for connectors, valves are the most common and numerous process equipment type found in the petroleum and chemical industries. Valves are available in many designs, and most contain a valve stem that operates to restrict or allow fluid flow. Typically, the stem is sealed by a packing gland or O-ring to prevent leakage of process fluid to the atmosphere. Emissions from valves occur at the stem or gland area of the valve body when the packing or O-ring in the valve fails.

2.1.3 COMPRESSORS

Compressors provide motive force for transporting gases through a process unit in much the same way that pumps transport liquids. Compressors are typically driven with rotating or reciprocating shafts. Thus, the sealing mechanisms for compressors are similar to those for pumps (i.e., packed and mechanical seals).

2.1.4 PRESSURE RELIEF DEVICES

Pressure relief devices are safety devices commonly used in petroleum and chemical facilities to prevent operating pressures from exceeding the maximum allowable working pressures of the process equipment. Note that it is not considered an equipment leak-type emission when a pressure relief device functions as designed during an over pressure incident allowing pressure to be reduced. Equipment leaks from pressure relief devices occur when material escapes from the pressure relief device during normal operation. The most common pressure relief valve (PRV) is spring-loaded. The PRV is designed to open when the operating pressure exceeds a set pressure and to reseat after the operating pressure has decreased to below the set pressure. Another pressure relief device is a rupture disk (RD) which does not result in equipment leak emissions. The disks are designed to remain whole and intact, and burst at a set pressure.

2.1.5 CONNECTORS AND FLANGES

Connectors and flanges are used to join sections of piping and equipment. They are used wherever pipes or other equipment (such as vessels, pumps, valves, and heat exchangers) require isolation or removal. Flanges are bolted, gasket-sealed connectors and are normally used for pipes with diameters of 2.0 inches or greater. The primary causes of flange leakage are poor installation, aging and deterioration of the sealant, and thermal stress. Flanges can also leak if improper gasket material is chosen.

Threaded fittings (connectors) are made by cutting threads into the outside end of one piece (male) and the inside end of another piece (female). These male and female parts are then screwed together like a nut and bolt. Threaded fittings are normally used to connect piping and equipment having diameters of 2.0 inches or less. Seals for threaded fittings are made by coating the male threads with a sealant before joining it to the female piece. The sealant may be a polymeric tape, brush-on paste, or other spreadable material that acts like glue in the joint. These sealants typically need to be replaced each time the joint is broken. Emissions can occur as the sealant ages and eventually cracks. Leakage can also occur as the result of poor assembly or sealant application, or from thermal stress on the piping and fittings.

In the 1993 petroleum industry studies, flanges were analyzed separately from connectors. Non-flanged connectors (or just connectors) were defined as plugs, screwed or threaded connectors, and union connectors that ranged in diameter from 0.5 to 8.0 inches, but were typically less than 3.0 inches in diameter. Flanged connectors (flanges) were larger, with diameters in some cases of 22.0 inches or more.

2.1.6 AGITATORS

Agitators are used in the chemical industry to stir or blend chemicals. Four seal arrangements are commonly used with agitators: packed seals, mechanical seals, hydraulic seals, and lip seals. Packed and mechanical seals for agitators are similar in design and application to packed and mechanical seals for pumps. In a hydraulic seal, an annular cup attached to the process vessel contains a liquid that contracts an inverted cup attached to the rotating agitator shaft. Although the simplest agitator shaft seal, the hydraulic seal, is limited to low temperature/low pressure applications, and can handle only very small pressure changes. A lip seal consists of a spring-loaded, nonlubricated elastomer element, and is limited in application to low-pressure, top-entering agitators.

2.1.7 OPEN-ENDED LINES

Some valves are installed in a system so that they function with the downstream line open to the atmosphere. A faulty valve seat or incompletely closed valve on such an open-ended line would result in a leakage through the open end.

2.1.8 SAMPLING CONNECTIONS

Sampling connections are used to obtain samples from within the process. Emissions occur as a result of purging the sampling line to obtain a representative sample of the process fluid.

2.2 POLLUTANT COVERAGE

2.2.1 TOTAL ORGANIC COMPOUNDS

The majority of data collected for estimating equipment leaks within the petroleum and gas industries and the SOCMI has been for total organic compounds and non-methane organic compounds. Therefore, the emission factors and correlations developed for emission estimation approaches are intended to be used for estimating total organic compound (TOC) emissions.

2.2.2 SPECIATED ORGANICS/HAZARDOUS AND TOXIC AIR POLLUTANTS

Because material in equipment within a process unit is often a mixture of several chemicals, equipment leak emission estimates for specific volatile organic compounds (VOCs), hazardous air pollutants (HAPs), and/or pollutants under Section 112(r) of the Clean Air Act, as amended can be obtained by multiplying the TOC emissions from a particular equipment times the ratio of the concentration of the specific VOC/pollutant to the TOC concentration, both in weight percent. An assumption in the above estimation is that the weight percent of the chemicals in the mixture contained in the equipment will equal the weight percent of the chemicals in the leaking material. In general, this assumption should be accurate for single-phase streams containing any gas/vapor material or liquid mixtures containing constituents of similar volatilities. Engineering judgement should be used to estimate emissions of individual chemical species, in cases when:

- The material in the equipment piece is a liquid mixture of constituents with varying volatilities; or

- It is suspected that the leaking vapor will have different concentrations than the liquid.

2.2.3 INORGANIC COMPOUNDS

The emission estimation approaches developed for estimating TOC emissions may be used to estimate emissions of inorganic compounds--particularly for volatile compounds or those present as a gas/vapor. Also, in the event that there is no approach available to estimate the concentration of the inorganic compound at the leak interface, the average emission factors developed for organic compounds can be used; however, the accuracy of the emission estimate will be unknown.

2.3 ESTIMATION OF CONTROL EFFICIENCIES FOR EQUIPMENT LEAK CONTROL TECHNIQUES

Two primary techniques are used to reduce equipment leak emissions: (1) modifying or replacing existing equipment, and (2) implementing an LDAR program. Equipment modifications are applicable for each of the leaking equipment described in this section. An LDAR program is a structured program to detect and repair equipment that are identified as leaking; however, it is more effective on some equipment than others.

The use of equipment modifications and equipment included in an LDAR program are predicated by state and federal regulations that facilities/process units are required to meet. In most equipment leak regulations, a combination of equipment modifications and LDAR requirements are used. Table 4.A-1 in Appendix A of this chapter summarizes requirements in several federal equipment leak control regulations.

2.3.1 REPLACEMENT/MODIFICATION OF EXISTING EQUIPMENT

Controlling emissions by modifying existing equipment is achieved by either installing additional equipment that eliminates or reduces emissions, or replacing existing equipment with sealless types. Equipment modifications that can be used for each type of equipment described in this section, and their corresponding emission control efficiencies are presented in Table 4.2-1. A closed-vent system is a typical modification for pumps, compressors, and pressure relief devices. A closed-vent system captures leaking vapors and routes them to a control device. The control efficiency of a closed-vent system depends on the efficiency of the vapor transport system and the efficiency of the control device. A closed-vent system can be installed on a single piece of equipment or on a group of equipment pieces. A description of the controls by equipment type are briefly presented below.

Pumps

Equipment modifications that are control options for pumps include: (1) routing leaking vapors to a closed-vent system, (2) installing a dual mechanical seal containing a barrier fluid, or (3) replacing the existing pump with a sealless type. Dual mechanical seals and sealless pumps are discussed in detail in Chapter 5 of the *Equipment Leaks Enabling Document* (EPA, July 1992). The control efficiency of sealless pumps and a dual mechanical seal with a barrier fluid at a higher pressure than the pumped fluid is essentially 100 percent, assuming both the inner and outer seal do not fail simultaneously.

TABLE 4.2-1

SUMMARY OF EQUIPMENT MODIFICATIONS

Equipment Type	Modification	Approximate Control Efficiency (%)
Pumps	Sealless design	100[a]
	Closed-vent system	90[b]
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the pumped fluid	100
Valves	Sealless design	100[a]
Compressors	Closed-vent system	90[b]
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the compressed gas	100
Pressure relief devices	Closed-vent system	[c]
	Rupture disk assembly	100
Connectors	Weld together	100
Open-ended lines	Blind, cap, plug, or second valve	100
Sampling connections	Closed-loop sampling	100

[a] Sealless equipment can be a large source of emissions in the event of equipment failure.

[b] Actual efficiency of a closed-vent system depends on percentage of vapors collected and the efficiency of the control device to which the vapors are routed.

[c] Control efficiency of closed vent-systems installed on a pressure relief device may be lower than other closed-vent systems because they must be designed to handle both potentially large and small volumes of vapor.

Valves

Emissions from process valves can be eliminated if the valve stem can be isolated from the process fluid, (i.e., using sealless valves). Two types of sealless valves, diaphragm valves and sealed bellows, are available. The control efficiency of both diaphragm and sealed bellowed valves is essentially 100 percent.

Compressors

Emissions from compressors may be reduced by collecting and controlling the emissions from the seal using a closed-vent system or by improving seal performance by using a dual mechanical seal system similar to pumps. The dual mechanical seal system has an emissions control efficiency of 100 percent, assuming both the inner and outer seal do not fail simultaneously.

Pressure Relief Valves

Equipment leaks from pressure relief valves (PRVs) occur as a result of improper reseating of the valve after a release, or if the process is operating too close to the set pressure of the PRV and the PRV does not maintain the seal. There are two primary equipment modifications that can be used for controlling equipment leaks from pressure relief devices: (1) a closed-vent system, or (2) use of a rupture disk in conjunction with the PRV.

The equipment leak control efficiency for a closed-vent system installed on a PRV may not be as high as what can be achieved for other pieces of equipment because emissions from PRVs can have variable flow during an overpressure situation and it may be difficult to design a control device to efficiently handle both high and low flow emissions. Rupture disks can be installed upstream of a PRV to prevent fugitive emissions through the PRV seat. The control efficiency of a rupture disk/PRV combination is essentially 100 percent when operated and maintained properly.

Connectors and Flanges

In cases where connectors are not required for safety, maintenance, process modification, or periodic equipment removal, emissions can be eliminated by welding the connectors together.

Open-Ended Lines

Emissions from open-ended lines can be controlled by properly installing a cap, plug, or second valve to the open end. The control efficiency of these measures is essentially 100 percent.

Sampling Connections

Emissions from sampling connections can be reduced by using a closed-loop sampling system or by collecting the purged process fluid and transferring it to a control device or back to the process. The efficiency of a closed-loop system is 100 percent.

2.3.2 LEAK DETECTION AND REPAIR (LDAR) PROGRAMS

An LDAR program is a structured program to detect and repair equipment that is identified as leaking. A portable screening device is used to identify (monitor) pieces of equipment that are emitting sufficient amounts of material to warrant reduction of the emissions through simple repair techniques. These programs are best applied to equipment types that can be repaired on-line, resulting in immediate emissions reduction.

An LDAR program may include most types of equipment leaks; however, it is best-suited to valves and pumps and can also be implemented for connectors. For other equipment types, an LDAR program is not as applicable. Compressors are repaired in a manner similar to pumps; however, because compressors ordinarily do not have a spare for bypass, a process unit shutdown may be required for repair. Open-ended lines are most easily controlled by equipment modifications. Emissions from sampling connections can only be reduced by changing the method of collecting the sample, and cannot be reduced by an LDAR program. Safety considerations may preclude the use on an LDAR program on pressure relief valves.

The control efficiency of an LDAR program is dependent on three factors: (1) how a leak is defined, (2) the monitoring frequency of the LDAR program, and (3) the final leak frequency after the LDAR program is implemented. The leak definition is the screening value measured by a portable screening device at which a leak is indicated if a piece of equipment screens equal to or greater than that value. Screening values are measured as concentrations in parts per million by volume (ppmv). The leak definition is a given part of an LDAR program and can either be defined by the facility implementing the program or by an equipment standard to which the facility must comply. Table 4.A-1 in Appendix A of this document provides equipment leak screening values for several equipment leak control programs. The monitoring frequency is the number of times a year (daily, weekly, monthly, quarterly, yearly) that equipment are monitored with a portable screening device. The monitoring frequency may be estimated from the initial leak frequency before the LDAR program is implemented, and the final leak frequency after the LDAR program is implemented. The leak frequency is the fraction of equipment with screening values equal to or greater than the leak definition. The LDAR program control efficiency approach is based on the relationship between the percentage of equipment pieces that are leaking and the corresponding average leak rate for all of the equipment.

Most federal equipment leak control programs have quarterly or monthly monitoring requirements. However, the LDAR monitoring frequency and leak definitions at some state equipment leak control programs may be different from federal programs. During the planning of a LDAR program, it is recommended to contact the local environmental agency to find out about their LDAR program guidelines and/or requirements.

The EPA has developed control efficiencies for equipment monitored at specified leak definitions and frequencies. Tables 4.2-2 and 4.2-3 summarize the control efficiencies for equipment that are monitored quarterly and monthly at a leak definition of 10,000 ppmv, and equipment meeting the LDAR requirements of the National Emission Standard for Hazardous Air Pollutants (NESHAP) for hazardous organics known as the Hazardous Organic NESHAP (HON). Although it was developed for the SOCMI, it is the basis for most new equipment leak regulations for other industries. Appendix A presents information on how to develop process/facility-specific control efficiencies.

TABLE 4.2-2

CONTROL EFFECTIVENESS FOR AN LDAR PROGRAM AT A SOCMI PROCESS UNIT

	Control Effectiveness (%)		
Equipment Type and Service	**Monthly Monitoring 10,000 ppmv Leak Definition**	**Quarterly Monitoring 10,000 ppmv Leak Definition**	**HON[a]**
Valves - gas	87	67	92
Valves - light liquid	84	61	88
Pumps - light liquid	69	45	75
Compressors - gas	[b]	[b]	93
Connectors - gas and light liquid	[b]	33	[b]
Pressure relief devices - gas	[b]	44	[b]

[a] Control effectiveness attributed to the requirements of the HON equipment leak regulation is estimated based on equipment-specific leak definitions and performance levels.

[b] Data are not available to estimate control effectiveness.

TABLE 4.2-3

CONTROL EFFECTIVENESS FOR LDAR COMPONENT MONITORING FREQUENCIES FOR PETROLEUM REFINERIES

Equipment Type and Service	**Control Effectiveness (%)**		
	Monthly Monitoring 10,000 ppmv Leak Definition[a]	**Quarterly Monitoring 10,000 ppmv Leak Definition**[a,b]	**HON**[a,c]
Valves - gas	88	70	96
Valves - light liquid	76	61	95
Pumps - light liquid	68	45	88
Compressors - gas	[d]	33	[e]
Connectors - gas and light liquid	[f]	[f]	81
Pressure relief devices - gas	[d]	44	[e]

[a] Source: EPA, July 1992.

[b] Source: EPA, April 1982.

[c] Control effectiveness attributed to the requirements of the HON equipment leak regulation is estimated based on equipment-specific leak definitions and performance levels.

[d] Monthly monitoring of component is not required in any control program.

[e] Rule requires equipment modifications instead of LDAR.

[f] Information not available.

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3

OVERVIEW OF AVAILABLE METHODS

This section contains general information on the four basic approaches for estimating equipment leak emissions. The approach used is dependent upon available data, available resources to develop additional data, and the degree of accuracy needed in the estimate.

Regulatory considerations should also be taken into account in selecting an emission estimation approach. These considerations may include air toxic evaluations, nonattainment emission inventory reporting requirements, permit reporting requirements, and employee exposure concerns.

Each approach is briefly described including its corresponding data requirements. Since data collection procedures will impact the accuracy of the emission estimate, this section also includes a general description of the two variable procedures for collecting equipment leaks data, screening and bagging procedures, and available monitoring methods. Finally, a general description for estimating control efficiencies for equipment leak control techniques is presented. Table 4.3-1 lists the variables and symbols used in the following discussions on emissions estimates.

3.1 EMISSION ESTIMATION APPROACHES

There are four basic approaches for estimating emissions from equipment leaks in a specific processing unit. The approaches, in order of increasing refinement, are:

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

The approaches increase in complexity and in the amount of data collection and analysis required. All the approaches require some data collection, data analysis and/or statistical evaluation.

These approaches range from simply applying accurate equipment counts to average emission factors to the more complex project of developing unit-specific correlations of mass emission

TABLE 4.3-1

LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
TOC mass emissions	E_{TOC}	kg/hr of TOC
VOC mass emissions	E_{VOC}	kg/hr of VOC
Mass emissions of organic chemical x	E_x	kg/hr of organic chemical x
Concentration of TOCs	WP_{TOC}	weight percent of TOCs
VOC concentration	WP_{VOC}	weight percent of VOCs
Concentration of organic chemical x	WP_x	weight percent of organic chemical x
Average emission factor	F_A	typically, kg/hr per source
Emission factor for screening value ≥10,000 ppmv	F_G	kg/hr per source
Emission factor for screening value <10,000 ppmv	F_L	kg/hr per source
Concentration from screening value	SV	ppmv

rates and screening values. In general, the more refined approaches require more data and provide more accurate emission estimates for a process unit. Also, the more refined approaches, especially the unit-specific correlation approach which requires bagging data, require a larger budget to implement the program and develop the correlation equations.

Figure 4.3-1 shows an overview of the data collection and analysis required to apply each of the above approaches. All of the approaches require an accurate count of equipment components by the type of equipment (e.g., valves, pumps, connectors), and for some of the equipment types, the count must be further described by service (e.g., heavy liquid, light liquid, and gas).

The chemical industry has developed alternative methods for estimating equipment component count (CMA, 1989). One of the methods calls for an accurate count of the number of pumps in the process and the service of the pumps. Equipment components in the entire process are then estimated through use of the number of pumps. Another method calls for an accurate count of valves directly associated with a specific piece of equipment using process flow sheets; and then based on the number of valves, the number of flanges and fittings are estimated using ratios (e.g., flanges/valves) A careful selection/development of the methodology used to quantify the equipment component count should be made to accurately reflect the equipment leak emission estimates for any facilities and/or process units.

Except for the average emission factor approach, all of the approaches require screening data. Screening data are collected by using a portable monitoring instrument to sample air from potential leak interfaces on individual pieces of equipment. A screening value is a measure of the concentration of leaking compounds in the ambient air that provides an indication of the leak rate from an equipment piece, and is measured in units of parts per million by volume (ppmv). See "Source Screening" in this section for details about screening procedures.

In addition to equipment counts and screening data, the unit-specific correlation approach requires bagging data. Bagging data consist of screening values and their associated measured leak rates. A leak rate is measured by enclosing an equipment piece in a bag to determine the actual mass emission rate of the leak. The screening values and measured leak rates from several pieces of equipment are used to develop a unit-specific correlation. The resulting leak rate/screening value correlation predicts the mass emission rate as a function of the screening value. See "Mass Emissions Sampling (Bagging)" in this section for details about bagging procedures.

These approaches are applicable to any chemical- and petroleum-handling facility. However, more than one set of emission factors or correlations have been developed by the EPA and other regulatory agencies, depending upon the type of process unit being considered.

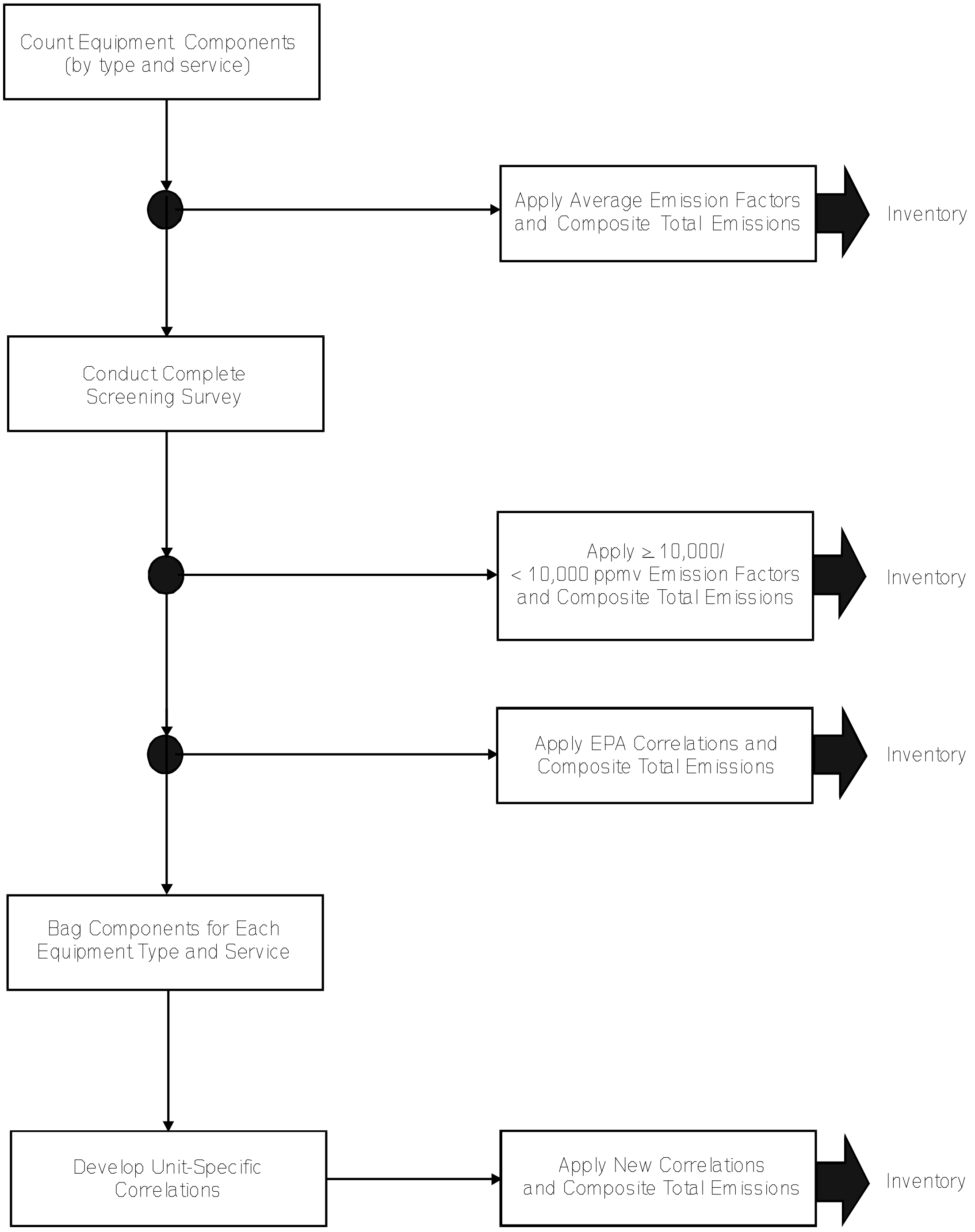


Figure 4.3-1. Overview of Data Collection and Analysis Approaches For Developing Equipment Leak Emissions Inventory

EPA data collection on emissions from equipment leaks in SOCMI facilities, refineries, oil and gas production operations, and marketing terminals has yielded emission factors and correlations for these source categories. Emission factors and correlations for oil and gas production facilities, including well heads, have also been developed by regulatory agencies and the American Petroleum Institute (CARB, August 1989; API, 1993).

For process units in source categories for which emission factors and/or correlations have not been developed, the factors and/or correlations already developed can be utilized. However, appropriate evidence should indicate that the existing emission factors and correlations are applicable to the source category in question. Criteria for determining the appropriateness of applying existing emission factors and correlations to another source category may include one or more of the following: (1) process design; (2) process operation parameters (i.e., pressure and temperature); (3) types of equipment used; and, (4) types of material handled. For example, in most cases, SOCMI emission factors and correlations are applicable for estimating equipment leak emissions from the polymer and resin manufacturing industry. This is because, in general, these two industries have comparable process design and comparable process operations; they use the same types of equipment and they tend to use similar feedstock with similar operations, molecular weight, density, and viscosity. Therefore, response factors should also be similar for screening values.

In estimating emissions for a given process unit, all equipment components must be screened for each class of components. However, in some cases, equipment is difficult or unsafe to screen or it is not possible to screen every equipment piece due to cost considerations. The latter is particularly true for connectors. The *Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) provides criteria for determining how may connectors must be screened to constitute a large enough sample size to identify the screening value distribution for connectors. However, if the process unit to be screened is subject to a standard which requires the screening of connectors, then all connectors must be screened. If the criteria presented in the *Protocol* document are met, the average emission rate for connectors that were connected can be applied to connectors that were not screened. For equipment types other than connectors, including difficult or unsafe-to-screen equipment, that are not monitored, the average emission factor approach or the average emission rate for the equipment components that were screened can be used to estimate emissions.

Also, screening data collected at several different times can be used for estimating emissions, as long as the elapsed time between values obtained is known. For example, if quarterly monitoring is performed on a valve, four screening values will be obtained from the valve in an annual period. The annual emissions from the valve should be calculated by determining the emissions for each quarter based on the operational hours for the quarter, and summing the quarterly emission together to get entire year emissions.

3.2 SPECIATING EMISSIONS

In some cases, it may be necessary to estimate emissions of a specific VOC in a mixture of several chemicals. The equations developed for each one of the approaches (see Sections 4 and 5) are used to estimate total VOC emissions; the following equation is used to speciate emissions from a single equipment piece:

$$E_x = E_{TOC} \times WP_x / WP_{TOC} \qquad (4.3\text{-}1)$$

where:

E_x = The mass emissions of organic chemical "x" from the equipment (kg/hr);
E_{TOC} = The TOC mass emissions from the equipment (kg/hr) calculated from either the Average Emission Factor, Screening Ranges, EPA Correlation, or Unit-Specific Correlation approaches;
WP_x = The concentration of organic chemical x in the equipment in weight percent; and
WP_{TOC} = The TOC concentration in the equipment in weight percent.

An assumption in the above equation is that the weight percent of the chemicals in the mixture contained in the equipment will equal the weight percent of the chemicals in the leaking material. In general, this assumption should be accurate for single-phase streams containing any gas/vapor material or liquid mixtures containing constituents of similar volatilities.

Engineering judgement should be used to estimate emissions of individual chemical species from liquid mixtures of constituents with varying volatilities or in cases where it is suspected that the leaking vapor has different concentrations than the liquid.

3.3 ORGANIC COMPOUND EMISSION ESTIMATES FROM EQUIPMENT CONTAINING NON-VOCS

A very similar approach to the one used to speciate emissions can be used to estimate organic compound emissions from equipment containing organic compounds not classified as VOCs. Because the concentrations of these compounds (such as methane or ethane) are included with VOC concentrations in the screening value, the emissions associated with the screening value will include emissions of the "non-VOCs."

Once TOC emissions have been estimated, the organic compound emissions from a group of equipment containing similar composition can be calculated using the equation:

$$E_{VOC} = E_{TOC} \times WP_{VOC}/WP_{TOC} \qquad (4.3\text{-}2)$$

where:

E_{VOC} = The VOC mass emissions from the equipment (kg/hr);
E_{TOC} = The TOC mass emissions from the equipment (kg/hr) calculated from either the Average Emission Factor, Screening Ranges, EPA Correlation, or Unit-Specific Correlation approaches;
WP_{VOC} = The concentration of VOC in the equipment in weight percent; and
WP_{TOC} = The TOC concentration in the equipment in weight percent.

3.4 INORGANIC COMPOUND EMISSION ESTIMATES

The emission factors and correlations presented in this document are intended to be applied to estimate emissions of total organic compounds. However, in some cases, it may be necessary to estimate equipment leak emissions of inorganic compounds, particularly for those existing as gas/vapor or for volatile compounds.

Equipment leak emission estimates of inorganic compounds can be obtained by the following methods:

- Develop unit-specific correlations;
- Use a portable monitoring instrument to obtain actual concentrations of the inorganic compounds and then enter the screening values obtained into the applicable correlations developed by the EPA;
- Use the screening values obtained above and apply the emission factors corresponding to that screening range; or
- Multiply the average emission factor by the component count to estimate the leak rate.

Also, surrogate measurements can be used to estimate emissions of inorganic compounds. For example, potassium iodide (KI) or a similar salt solution is an indicator for equipment leaks from acid (hydrochloric acid [HCl], hydrofluoric acid [HF]) process lines.

3.5 DESCRIPTION OF AVAILABLE PROCEDURES FOR COLLECTING EQUIPMENT LEAKS DATA

The *Protocol* document (EPA, November 1995) provides a consistent approach for collecting equipment leaks data, which will ensure the development of acceptable emission factors and/or correlation equations for emission estimation purposes. Recognizing the importance of the above statement, general information on the two available procedures for collecting equipment leaks data, screening and bagging, is presented in this section.

3.5.1 SOURCE SCREENING

This part of the section provides general information for conducting a screening program on-site and provides a short description of the type of portable analyzers that can be used when conducting screening surveys.

Source screening is performed with a portable organic compound analyzer (screening device). The *Protocol* document (EPA, November 1995) requires that the portable analyzer probe opening be placed at the leak interface of the equipment component to obtain a "screening" value. The screening value is an indication of the concentration level of any leaking material at the leak interface.

Some state and local agencies may require different screening procedures with respect to the distance between the probe and the leak interface. The reader should contact their state or local agency to determine the appropriate screening guidelines. However, use of the leak rate correlations require screening values gathered as closely as practicable to the leak interface.

The main objective of a screening program is to measure organic compound concentration at any potential leak point associated with a process unit. A list of equipment types that are potential sources of equipment leak emissions is provided in Table 4.3-2.

The first step is to define the process unit boundaries and obtain a component count of the equipment that could release fugitive emissions. A process unit can be defined as the smallest set of process equipment that can operate independently and includes all operations necessary to achieve its process objective. The use of a simplified flow diagram of the process is recommended to note the process streams. The actual screening data collection can be done efficiently by systematically following each stream.

The procedures outlined in EPA Reference Method 21 — *Determination of Volatile Organic Compound Leaks* (40 CFR 60, Appendix A) should be followed to screen each equipment type that has been identified. The *Protocol* document (EPA, November 1995) describes the location on each type of equipment where screening efforts should be concentrated. For equipment with no moving parts at the leak interface, the probe should be placed directly on

TABLE 4.3-2

EQUIPMENT LEAK EMISSION SOURCES

Equipment Types
Pump seals
Compressor seals
Valves
Pressure relief devices
Flanges
Connectors
Open-ended lines
Agitator seals
Other[a]
Services
Gas/vapor
Light liquid
Heavy liquid

[a] Includes instruments, loading arms, stuffing boxes, vents, dump lever arms, diaphragms, drains, hatches, meters, polished rods, and vents.

the leak interface (perpendicular, not tangential, to the leak potential interface). On the other hand, for equipment with moving parts, the probe should be placed approximately 1 centimeter off from the leak interface (EPA, November 1995). The Chemical Manufacturers Association has also made some suggestions to maintain good screening practices (CMA, 1989). Recent ongoing efforts by the American Petroleum Institute have also been focused on increasing the accuracy of screening readings.

Various portable organic compound detection devices can be used to measure concentration levels at the equipment leak interface. Any analyzer can be used provided it meets the specifications and performance criteria set forth in EPA Reference Method 21.

Reference Method 21 requires that the analyzer meet the following specifications:

- The VOC detector should respond to those organic compounds being processed (determined by the response factor [RF]);
- Both the linear response range and the measurable range of the instrument for the VOC to be measured and the calibration gas must encompass the leak definition concentration specified in the regulation;
- The scale of the analyzer meter must be readable to ±2.5 percent of the specified leak definition concentration;
- The analyzer must be equipped with an electrically driven pump so that a continuous sample is provided at a nominal flow rate of between 0.1 and 3.0 liters per minute;
- The analyzer must be intrinsically safe for operation in explosive atmospheres; and
- The analyzer must be equipped with a probe or probe extension for sampling not to exceed 0.25 inch in outside diameter, with a single end opening for admission of sample.

Note that the suction flow rate span allowed by Reference Method 21 is intended to accommodate a wide variety of instruments, and manufacturers guidelines for appropriate suction flow rate should be followed.

In addition to the specifications for analyzers, each analyzer must meet instrument performance criteria, including instrument response factor, instrument response time, and calibration precision. Table 4.3-3 presents the performance criteria requirements that portable organic compound detectors must meet to be accepted for use in a screening program.

TABLE 4.3-3

EPA REFERENCE METHOD 21 PERFORMANCE CRITERIA FOR PORTABLE ORGANIC COMPOUND DETECTORS[a]

Criteria	Requirement	Time Interval
Instrument response factor[b]	Must be <10 unless correction curve is used	One time, before detector is put in service.
Instrument response time[c]	Must be ≤30 seconds	One time, before detector is put in service. If modification to sample pumping or flow configuration is made, a new test is required.
Calibration precision[d]	Must be ≤10 percent of calibration gas value	Before detector is put in service and at 3-month intervals or next use, whichever is later.

[a] Source: 40 CFR Part 60, Appendix A, EPA Reference Method 21. These performance criteria must be met in order to use the portable analyzer in question for screening.

[b] The response factor is the ratio of the known concentration of a VOC to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the applicable regulation.

[c] The response time is the time interval from a step change in VOC concentration at the input of the sampling system to the time at which 90 percent of the corresponding final value is reached as displayed on the instrument readout meter.

[d] The precision is the degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration; i.e., between two meter readings of a sample of known concentration.

Table 4.3-4 lists several portable organic compound detection instruments, their manufacturers, model number, pollutants detected, principle of operation, and range. Figure 4.3-2 shows the HW-101 (HNU Systems, Inc.) instrument, Figure 4.3-3 shows the Foxboro OVA-108, and Figure 4.3-4 shows the Foxboro TVA-1000. When a monitoring device does not meet all of the EPA Reference Method 21 requirements, it can still be used for the purpose of estimating emissions if its reliability is documented. For information on operating principles and limitations of portable organic compound detection devices, as well as specifications and performance criteria, please refer to the *Protocol for Equipment Leak Emission Estimates* document (EPA, November 1995).

Data loggers are available for use with portable organic compound detection devices to aid in the collection of screening data and in downloading the data to a computer. Database management programs are also available to aid in screening data inventory management and compiling emissions. Contact the American Petroleum Institute or state and local agencies for more information about data loggers and database management programs.

As mentioned earlier, screening values are obtained by using a portable monitoring instrument to detect TOCs at an equipment leak interface. However, portable monitoring instruments used to detect TOC concentrations do not respond to different organic compounds equally. To correct screening values to compensate for variations in a monitor's response to different compounds, response factors (RFs) have been developed. An RF relates measured concentrations to actual concentrations for specific compounds using specific instruments.

Appendix B of this chapter presents additional information on response factors and includes some guidelines on how to evaluate whether an RF correction to a screening value should be made.

3.5.2 MASS EMISSIONS SAMPLING (BAGGING)

An equipment component is bagged by enclosing the component to collect leaking vapors. A bag (or tent) made of material that is impermeable to the compound(s) of interest is constructed around the leak interface of the piece of the equipment.

A known rate of carrier gas is introduced into the bag. A sample of the gas from the bag is collected and analyzed to determine the concentration (in parts per million by volume [ppmv]) of leaking material. The concentration is measured using laboratory instrumentation and procedures. The use of analytical instrumentation in a laboratory is critical to accurately estimate mass emissions. A gas chromatograph (GC) equipped with a flame ionization detector or electron capture detector is commonly used to identify individual constituents of a sample (EPA, November 1995).

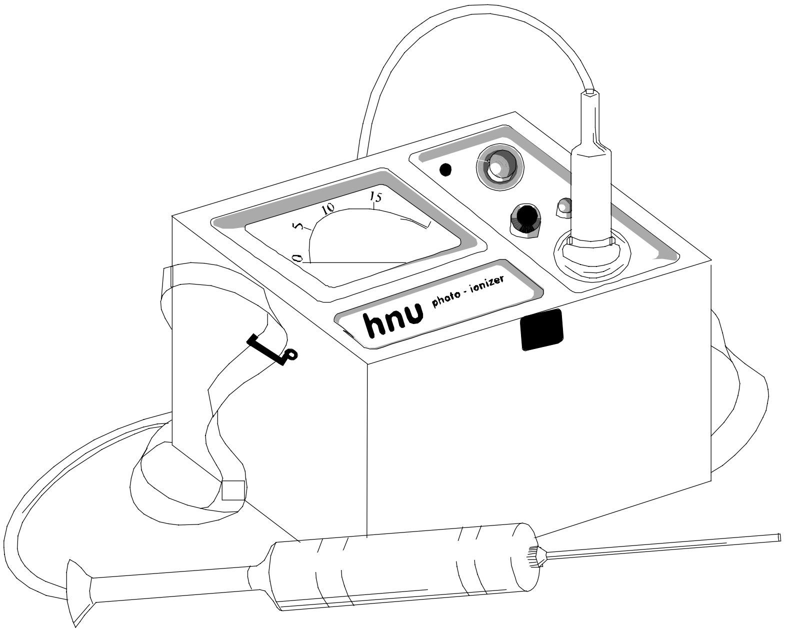
Appendix C of this chapter presents general information on the methods generally employed in sampling source enclosures (vacuum and blow-through methods) and presents the

TABLE 4.3-4

PORTABLE ORGANIC COMPOUND DETECTION INSTRUMENTS

Manufacturer	Model Number	Pollutant(s) Detected	Detection Technique	Range
Bacharach Instrument Co., Santa Clara, California	L	Combustible gases	Catalytic combustion	0 - 100% LEL[a]
	TLV Sniffer	Combustible gases	Catalytic combustion	0 - 1,000 and 0 - 10,000 ppm
Foxboro S. Norwalk, Connecticut	OVA-128	Most organic compounds	FID/GC[b]	0 - 1,000 ppm
	OVA-108	Most organic compounds	FID/GC	0 - 10,000 ppm
	Miran IBX	Compounds that absorb infrared radiation	NDIR[c]	Compound specific
	TVA-1000	Most organic and inorganic compounds	Photoionization and FID/GC	0.5-2,000 ppm (photoionization) 1-50,000 ppm (FID/GC)
Health Consultants	Detecto- PAK III	Most organic compounds	FID/GC	0 - 10,000 ppm
HNU Systems, Inc. Newton Upper Falls, Massachusetts	HW-101	Chlorinated hydrocarbons, aromatics, aldehydes, ketones, any substance that ultraviolet light ionizes	Photoionization	0 - 20, 0 - 200 and 0 - 2,000 ppm
Mine Safety Appliances Co., Pittsburgh, Pennsylvania	40	Combustible gases	Catalytic combustion	0 - 10% and 0 - 100% LEL
Survey and Analysis, Inc., Northboro, Massachusetts	On Mark Model 5	Combustible gases	Thermal conductivity	0 - 5% and 0 - 100% LEL
Rae Systems Sunnyvale, California	MiniRAE PGM-75K	Chlorinated hydrocarbons, aromatics, aldehydes, ketones, any substance that ultraviolet light ionizes	Photoionization	0 - 1,999 ppm

[a] LEL = Lower explosive limit.
[b] FID/GC = Flame ionization detection/gas chromatography.
[c] NDIR = Nondispersive infrared analysis.



950236-LN-CRTP

FIGURE 4.3-2. HW-101 PORTABLE ORGANIC COMPOUND DETECTION INSTRUMENT (HNU SYSTEM, INC.)

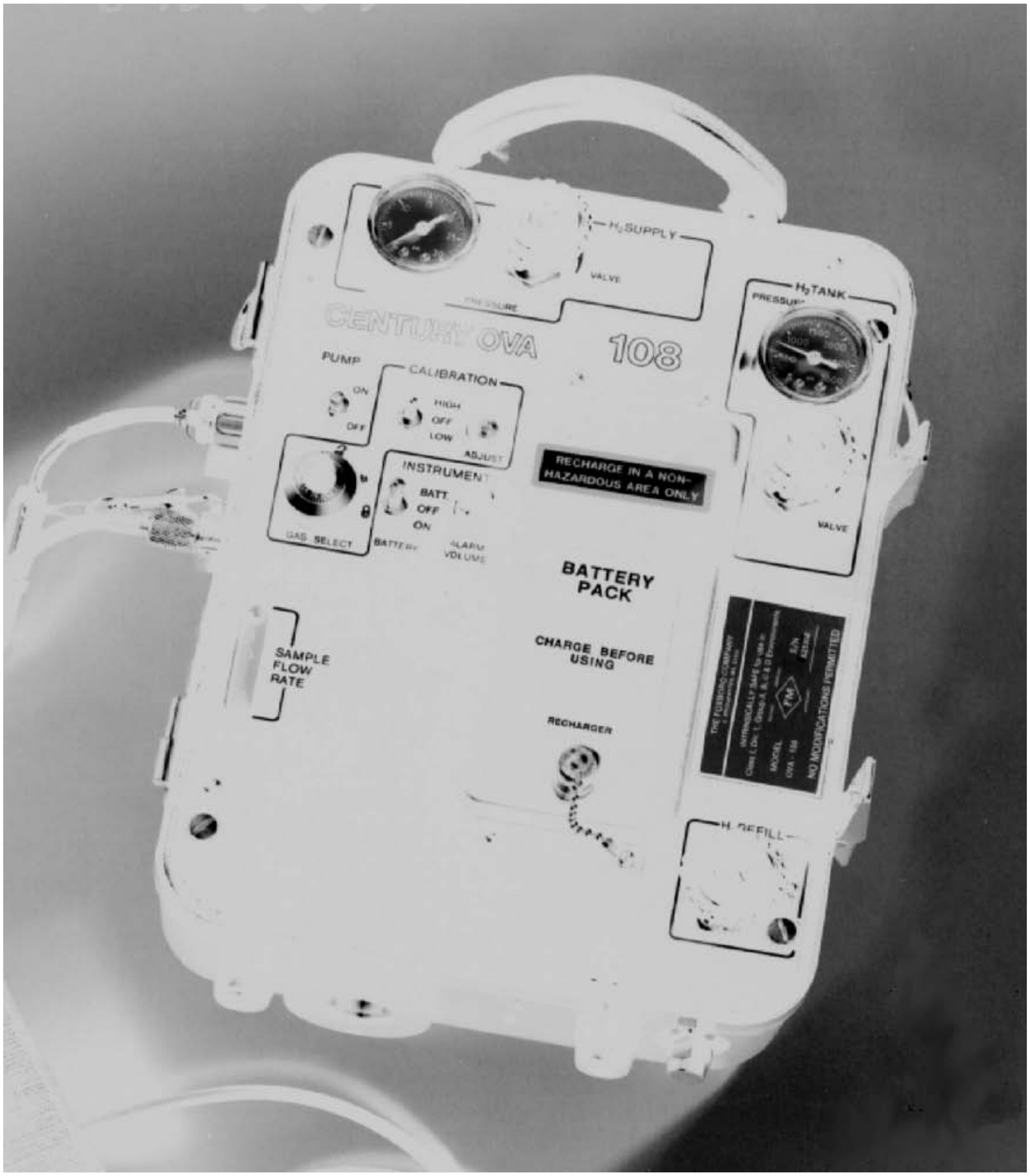


FIGURE 4.3-3. OVA-108 PORTABLE ORGANIC COMPOUND DETECTION INSTRUMENT (FOXBORO)

FIGURE 4.3-4. TVA-1000 PORTABLE ORGANIC/INORGANIC COMPOUND DETECTION INSTRUMENT (FOXBORO)

calculation procedures for leak rates when using both methods.

The *Protocol for Equipment Leak Emission Estimates* document provides detailed information on sampling methods for bagging equipment, considerations for bagging each equipment type and analytical techniques (EPA, November 1995).

3.6 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES/APPROACHES

Table 4.3-5 identifies the preferred and alternative emission estimation approaches for equipment leaks, and presents their advantages and disadvantages. All four emission estimation approaches presented are more appropriately applied to the estimation of emissions from equipment population rather than individual equipment pieces.

The preferred approach for estimating fugitive emissions from equipment leaks is to use the EPA correlation equations that relate screening values to mass emission rates. The selection of the preferred method for emission estimation purposes is based on the degree of accuracy obtained and the amount of resources and cost associated with the method.

Because the equipment leak emissions may occur randomly, intermittently, and vary in intensity over time, the "snapshot" of emissions from a given leak indicated by screening and/or bagging results, which are used either to develop or apply all of the approaches, may or may not be representative of the individual leak. However, by taking measurements from several pieces of a given equipment type, the snapshots of individual deviations from the actual leaks offset one another such that the ensemble of leaks should be representative. All of these approaches are imperfect tools for estimating fugitive emissions from equipment leaks; however, they are the best tools available. The best of these tools, the preferred method, can be expected to account for approximately 50 to 70 percent of the variability of the snapshot ensemble of equipment leak emissions.

TABLE 4.3-5

SUMMARY OF THE ADVANTAGES AND DISADVANTAGES OF PREFERRED AND ALTERNATIVE EMISSION ESTIMATION APPROACHES FOR EQUIPMENT LEAKS

Preferred Emission Estimation Approach	Alternative Emission Estimation Approach	Advantages	Disadvantages
EPA Correlation Equations		Provides a refined emission estimate when actual screening values are available. Provides a continuous function over the entire range of screening values instead of discrete intervals.	Screening value measurements used with these correlations should have the same format as the one followed to develop the correlations (OVA[a]/methane). The development of an instrument response curve may be needed to relate screening values to actual concentration.
	Average Emission Factors	In the absence of screening data, offers good indication of equipment leak emission rates from equipment in a process unit.	They are not necessarily an accurate indication of the mass emission rate from an individual piece of equipment. Average emission factors do not reflect different site-specific conditions among process units within a source category. May present the largest potential error (among the other approaches) when applied to estimate emissions from equipment populations.
	Screening Ranges	Offers some refinement over the Average Emission Factor approach. Allows some adjustment for individual unit conditions and operation.	Available data indicate that measured mass emission rates can vary considerably from the rates predicted by the use of these emission factors.
	Process-Unit Specific Correlation	The correlations are developed on a process unit basis to minimize the error associated with different leak rate characteristics between units.	High cost.

[a] Organic vapor analyzer.

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

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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:

$$E_{TOC} = F_A \times WF_{TOC} \times N \qquad (4.5\text{-}1)$$

$$E_{TOC} = F_A \times \frac{WF_{TOC}}{WF_{TOC} - WF_{methane}} \times WF_{TOC} \times N \qquad (4.5\text{-}2)$$

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)

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

Component ID ____________
Plant ID ____________
Date ____________
Analysis Team ____________
____
Instrument ID ____________
Stream Pressure____________

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 ______________________ Component ID ______________________
Equipment Category ______________________ Plant ID ______________________
Line Size ______________________ Date ______________________
Stream Phase (G/V, LL, HL)______________________ Analysis Team ______________________
Barometric Pressure ______________________ ______________________
Ambient Temperature ______________________ Instrument ID ______________________
Stream Temperature ______________________ 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 CHIEF 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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EPA. April 1980. *Assessment of Atmospheric Emissions from Petroleum Refining: Volume 3. Appendix B*. U.S. Environmental Protection Agency, 600/2-80-075c. Research Triangle Park, North Carolina.

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.

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

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.

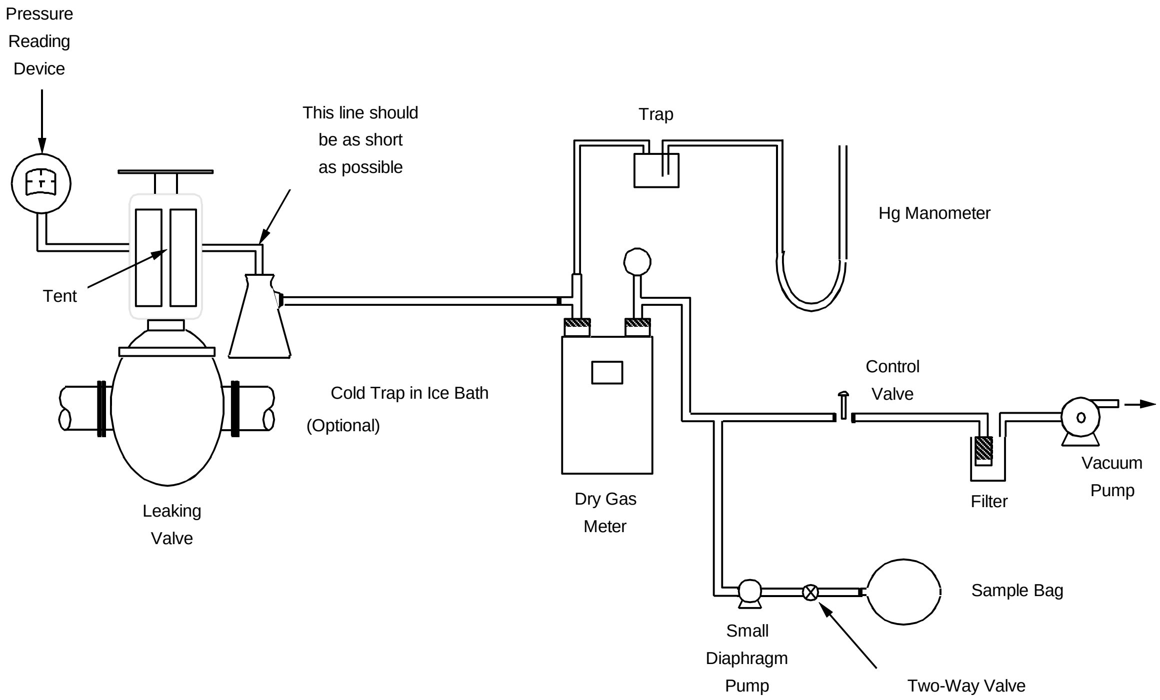

FIGURE 4.C-1. SAMPLING TRAIN FOR BAGGING A SOURCE USING THE VACUUM METHOD

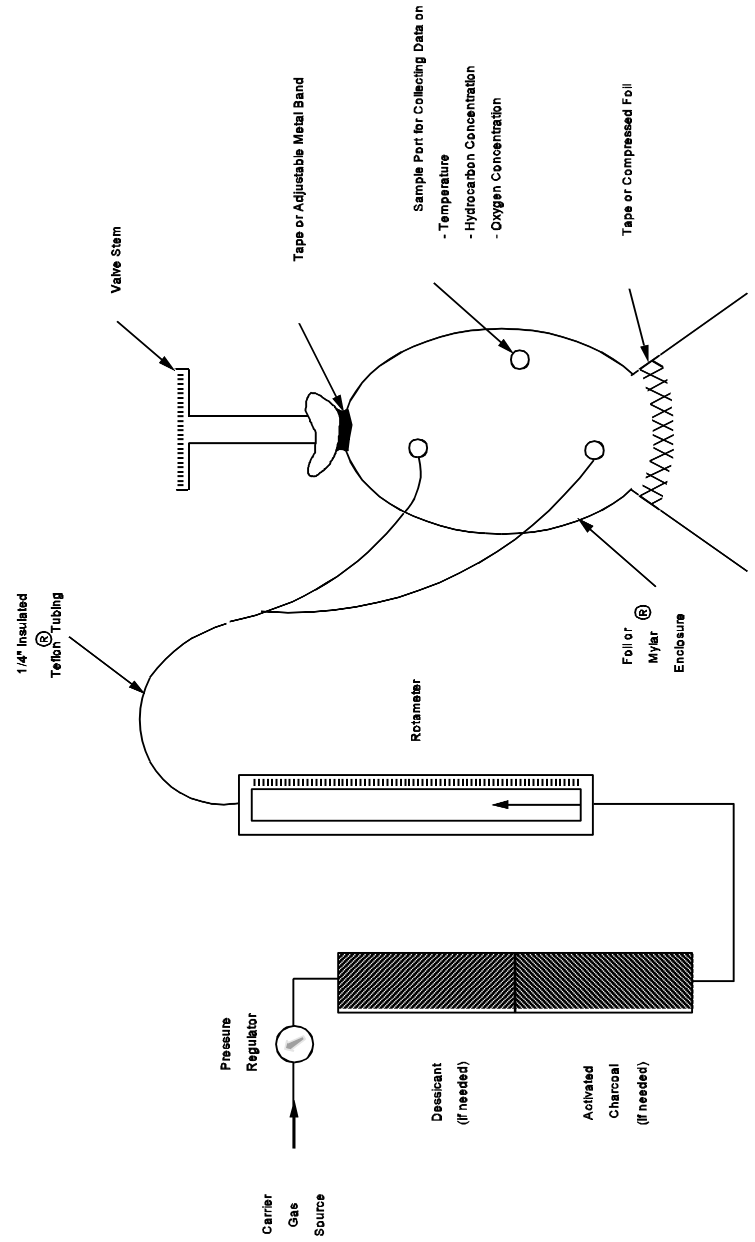

FIGURE 4.C-2. EQUIPMENT REQUIRED FOR THE BLOW-THROUGH SAMPLING TECHNIQUE

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:

9.63×10^{-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)
ρ = 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:

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

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

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)

ρ = 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***	Component ID ***V0102***
Equipment Category ______	Plant ID ***P012***
Line Size ______	Date ***10-15-95***
Stream Phase (G/V, LL, HL) ***LL***	Analysis Team ______
Barometric Pressure ______	______
Ambient Temperature ______	Instrument ID ***I01***
Stream Temperature ______	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

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

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

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

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

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

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

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 system 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)

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 Pumps Compressors Open-ended lines Sampling Connections PRVs	Sealless Dual mechanical seal with barrier fluid Mechanical seals with barrier fluid Capped, plugged, blind-flagged *In-situ* sampling Rupture disk
C	Pumps Sampling connections	Sealless 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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