Best Practices for Sources with Volatile Organic Compound Fugitive Emissions

Introduction

January 2024

The U.S. Environmental Protection Agency is issuing this technical resource for addressing fugitive volatile organic compound (VOC) emissions at facilities located in EPA Region 5. This document may assist air permit writers and applicants in developing and applying best practices in construction and operating air permits for sources with fugitive emissions of VOCs and hazardous air pollutants (HAPs) to comply with Clean Air Act (CAA) requirements.

Where do fugitive VOC emissions come from?

Fugitive VOC Emissions come from components such as:

- **Valves**
- **Connectors**
- **Pumps**

Leaks from these components may result from seal or gasket failures due to normal wear, poor design, improper maintenance.

In a typical facility that is a source of fugitive VOC emissions, most of the emissions come from components such as valves and connectors since these are the most prevalent components and number in the thousands. The major cause of emissions from valves and connectors is stem seal or gasket failure due to normal wear, poor design, or improper maintenance.

Previous EPA studies have estimated that valves and connectors account for more than 90% of emissions from leaking equipment, with valves being the most significant source. New information suggests that open-ended lines and sampling connections may account for as much as 10% of total VOC emissions from equipment leaks.

Other sources of fugitive VOC emissions include, but are not limited to, emissions from storage tanks, wastewater treatment systems, cooling towers, loading operations, coaters, drum washing operations. This document focuses primarily on VOC leaks from components.

Why are fugitive VOC emissions a concern?

Facilities emit a significant amount of VOCs as fugitive emissions that may be unaccounted for when their total estimated air emissions are calculated. When fugitive emissions are not monitored, facilities may be unwittingly out of compliance with its permit terms and applicable requirements.

Additionally, the EPA has found widespread noncompliance with Leak Detection and Repair (LDAR) regulations; specifically, noncompliance with Method 21 testing requirements. In 1999, the EPA estimated that, as a result of such noncompliance, an additional 40,000 tons of VOCs are emitted annually from valves at petroleum refineries in the United States alone. A typical refinery or chemical plant can emit between 600 and 700 tons of VOCs per year from leaking equipment, such as valves, connectors, pumps, sampling connections, compressors, pressure-relief devices, and open-ended lines.

Major/Minor Source Applicability

Title V Major Source Thresholds and Area Sources

A source that emits or has the potential to emit at or above the major source threshold for an air pollutant would be considered a major source for purposes of Title V permit applicability. The major source threshold for any air pollutant in an attainment area is 100 tons/year. Lower thresholds apply in non-attainment areas for the pollutants for which the area is in non-attainment. The fugitive emissions of a source are a component of a facility's calculation of its potential to emit (PTE) if the facility belongs to one of the 28 source categories listed in the EPA's Prevention of Significant Deterioration regulations. Major source thresholds for HAPs are 10 tons/year for a single HAP or 25 tons/year for any combination of HAPs. Fugitive emissions of HAPs must be considered when calculating a facility's PTE, regardless of source category.

Sources that choose to limit their potential to emit pollutants to avoid Title V applicability must be subject to legally and practicably enforceable limitations to ensure their emissions are less than major source thresholds. Also, sources that choose to limit their HAP emissions below major source thresholds are classified as "area sources." However, depending on the source category, some of those area sources could still be subject to applicable area source National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements and are therefore subject to Title V applicability if they meet a particular standard that applies in 40 CFR Part 63.

Major MACT-to-Area Source (MM2A)

In 2020, the EPA finalized amendments to the General Provisions of the NESHAP regulations in 40 CFR part 63, Subpart A, to implement the plain language reading of the "major source" and "area source" statutory definitions of section 112 of the CAA. The amendments provide that a major source can be reclassified to area source status at any time upon reducing its emissions and PTE, as defined in 40 CFR § 63.2, to below the major source thresholds of 10 tpy of any single HAP and 25 tpy of any combination of HAP.

Thus, major sources that reclassify to area source status at any time, including after the first substantive compliance date of an applicable major NESHAP, will no longer be subject to CAA section 112 major source NESHAP requirements and will be subject to any applicable area source NESHAP requirements. Similar to the discussion above, a source taking facility-wide emission restrictions in order to reclassify as an area source must take legally and practicably enforceable limitations to ensure their emissions remain under major source thresholds.

Limits on PTE Must be Legally and Practicably Enforceable

Any limitations on PTE must be both legally and practicably enforceable.

Limitations on PTE, whether by permit or other mechanism, must include sufficient terms and conditions to ensure that compliance can be determined and verified. The permit must clearly specify how emissions will be measured or determined for purposes of demonstrating compliance with the limit, including monitoring, recordkeeping, and reporting requirements that adequately enable regulators and citizens to determine whether the source can truly comply with the established limits, as well as for purposes of appropriate enforcement. Furthermore, to effectively restrict a facility's PTE, a permit's emission limits must apply at all times, and all actual emissions must be considered in determining compliance with the respective limits.

Three criteria apply to practically and legally enforceable PTE limits: (1) a technically accurate limitation along with specification of the portions of the source subject to the limitation; (2) the time period for the limitation (e.g., hourly, daily, monthly); and (3) a method to determine compliance, coupled with monitoring, recordkeeping, and reporting.

Emissions from all emission units that are part of the stationary source's physical and operational design must be included in calculating PTE for purposes of restricting major source applicability. Emissions from those units also need to be accurately calculated when determining compliance with the source-wide PTE limit. This includes fugitive VOC and HAP emissions from fugitive leaks. Emissions coming from sources of leaks must be accounted for when calculating PTE as well as properly monitored to ensure the source does not exceed the limitations established in the permit. This document includes references to EPA resources that may assist in the estimation and monitoring of VOC and HAP emissions from equipment leaks.

Fugitive Emission Estimation and Equipment Monitoring Guidance

Protocol for Equipment Leak Emission Estimates - 1995 Protocol

The EPA's Protocol for Equipment Leak Emission Estimates, issued in 1995, developed emission factors from experimental data collected on leak emissions of organic compounds from several different equipment fittings and connectors in refineries, marketing terminals, oil and gas production operations, and synthetic organic chemical manufacturing Industry process units. Emission factors and correlations have been developed for the following equipment types: valves, pumps, compressors, pressure relief valves, connectors, flanges, and open-ended lines.

Emissions Estimation Protocol for Petroleum Refineries - April 2015

The EPA's Emissions Estimation Protocol for Petroleum Refineries, issued in 2015 and sometimes referred to as the Refinery Emissions Protocol, is intended to provide guidance and instructions to petroleum refinery owners and operators, and to federal, state, and local agencies for the purpose of improving emission inventories within the petroleum refining industry.

2006 International Workshop

In 2006, EPA held an international workshop studying VOC Fugitive Losses discussing findings including data from IR video camera methods, differential absorption light detection and ranging (DIAL) spectroscopy, and radial-plume mapping spectroscopy.

LDAR Guide and Best Practices – October 2007

The EPA's best practices guide is intended for use by regulated entities, as well as compliance inspectors. The guide details some of the problems identified with LDAR programs. It focuses on Method 21 requirements and describes the practices that can be used to increase the effectiveness of an LDAR program.

Examples of Leak Detection in Consent Agreements

In order to address violations of the CAA at facilities that experience fugitive emissions, the EPA has entered into consent agreements or decrees with sources to implement LDAR requirements. The LDAR programs were either newly established under the orders, or improved where existing LDAR programs already existed for the facilities. These example approaches can be used to incorporate an LDAR program in permits, especially where limits are established and where a permitting authority must establish a corresponding means of demonstrating compliance with those permit limits in a manner that ensures practical enforceability.

Chemical Solvents, Inc. Consent Decree (2019):

The consent decree requires a facility-wide LDAR plan and includes LDAR monitoring at the following frequency: Valves – Quarterly; (2) Connectors – Annually; (3) Pumps / Agitators – Monthly; and (4) Open-Ended Lines – Quarterly. The consent decree requires the use of a Toxic Vapor Analyzer 2020 Flame Ionization Detector ("FID"), or equivalent monitoring device, to monitor and record TOC concentrations. The consent decree requires the source to quantify emissions from the components in accordance with the *Protocol for Equipment Leak Emission Estimates -1995 Protocol* (1995 Protocol) to demonstrate compliance with the limits established in the permit.

Kalsec, Inc. Administrative Consent Order (2020):

The Administrative Consent Order (ACO) provided that the source would avoid major source NESHAP requirements by seeking to establish enforceable emissions limits in a state operating permit. Additionally, the ACO requires the establishment and use of an LDAR program. The ACO specifies that the LDAR will consist of quarterly inspection of process vessels and equipment that are in HAP service using audio, visual, and olfactory (AVO) detection methods. Otherwise, the source is required to use Method 21 on an annual basis with a leak definition of 500 ppmv. The source is required to use the 1995 Protocol for calculating emissions as part of the requirements.

Altivia Petrochemicals LLC, Haverhill, Ohio Consent Decree:

The consent decree encompasses various work practices used by industry to reduce fugitive emissions from a facility. The terms of the consent decree include the following: development of a facility-wide LDAR plan, lower leak definition, more frequent monitoring (including monitoring of the closure device of OELs), drill-and-tap as a repair attempt for valves, use of low-emissions valves for new and existing valves, management of change to track addition and removal of LDAR components, quality assurance of LDAR data, and third-party auditing.

Best Practices Recommended for Air Permits

Installing Leakless Valves

Emissions from pumps and valves can be reduced through the use of "low-emission" or "leakless" valves and "sealless" pumps. Low-emission valves are common and commercially available for most valve types and come with a warranty or performance guarantee to perform below 100 ppm for at least 5 years. The American Petroleum Institute (API) has memorialized the low-emissions into their established industry standards since at least 2015, and suggest the use of these standards whenever a facility replaces an existing valve or installs a new valve. It is highly recommended that they are used when replacing individual, chronic leaking components since they are effective in reducing fugitive emissions, as well as preventing additional loss in product.

Incorporating an LDAR program

LDAR is a work practice designed to identify leaking equipment so that emissions can be reduced through repairs. A component that is subject to LDAR requirements must be monitored at specified, regular intervals to determine whether or not it is leaking. Any leaking component must then be repaired or replaced within a specified time frame. As discussed above, LDAR programs are required by many federal standards as well as other state or local requirements. An effective LDAR program entails implementation of Method 21.

Optical Gas Imaging (OGI) Cameras

An OGI or handheld thermal infrared imaging camera can rapidly scan an area of concern for leaks. The camera is not able to speciate or quantitate a plume; however, the camera can more easily and efficiently identify leaks compared with other types of VOC instrument detectors such as handheld photoionization sampling probe detectors. Use of these cameras can provide an initial check on components and inform facilities that further investigation is required. OGI cameras do have limitations as they generally are not able to detect releases at or under 500 ppm. They are, however, still effective for safety checks, large leak detection, or hard to access fugitive emission components. Since it is easier and more efficient to use, an OGI camera can be used in combination with other methods at a more frequent rate to find leaks in between times of more involved methods of leak detection (such as annual Method 21 monitoring).

In addition, the General Provisions of NSPS at 40 C.F.R. 60, Subpart A provide an alternative work practice (AWP) for monitoring equipment for leaks. As described in 40 C.F.R. § 60.18(g) through (i), an owner or operator may use an optical gas imaging instrument to identify leaking equipment instead of a Method 21 instrument (e.g., flame ionization and photoionization VOC instrument detectors). This AWP standard is available to all subparts in 40 C.F.R. parts 60, 61, 63, and 65 that require monitoring of equipment with a 40 CFR part 60, appendix A-7, Method 21 monitor. The protocol for the use of OGI cameras for leak detection was finalized as appendix K to 40 CFR part 60.

Proactive Maintenance for Chronic Leakers

If a valve leaks above 500 ppm, it is generally a good practice to repack or replace that valve with a low-emissions or leakless valve due to the increased probability that it will leak again. However, at a minimum, facilities should review leak data for repeat leakers (i.e. "chronic leaker") if they leak above 500 ppm twice within a period of five years of monitoring. Following the identification of a repeat leaker valve, a source should replace or repack the valve within 30 days. A source should consider using the drill and tap method along with the use of a low-emission injectable that would convert the valve to a low-emission performing valve.

AVO Surveys

For sources that have a low potential for leaks and that have a larger margin of compliance, permitting authorities may consider the use of AVO (audible, visual and olfactory) surveys for monitoring compliance with fugitive leaks prevention requirements from those sources. AVO surveys are inspections where inspectors listen, look and smell for leaks. The surveys are used as a means of demonstrating compliance with requirements in many NSPS and NESHAP standards. The simplicity of the survey provides for ease of inspections and can be done as frequently as monthly. AVO surveys can also be used in conjunction with other best practices listed above to provide additional layers of leak detection. AVO surveys can easily be built into regular maintenance activities that are designed to keep the equipment at a facility site in good working order.

Who do I contact for more information?

U.S. Environmental Protection Agency

Region 5
Air & Radiation Division (AR-18J)
77 West Jackson Blvd
Chicago, Illinois 60604-3590
(312) 353-2000
R5AirPermits@epa.gov

https://www.epa.gov/caa-permitting/caa-permitting-epas-great-lakes-region

State/Local Permitting Authorities

EPA has approved or delegated authority for the following Region 5 states and other jurisdictions to issue certain CAA permits:

- Illinois: https://www2.illinois.gov/epa/Pages/default.aspx
- Indiana: https://www.in.gov/idem/airquality/index.htm
- Michigan: https: //www.michigan.gov/egle/
- Minnesota: https://www.pca.state.mn.us/
- Ohio: https://www.epa.ohio.gov/
- Wisconsin: https://dnr.wisconsin.gov/

***DISCLAIMER**: This document aims to explain the application of certain EPA regulatory provisions using plain language. Nothing in this document revises or replaces any regulatory provisions, any other part of the Code of Federal Regulations, the Federal Register, or the Clean Air Act. Following the best practices contained herein does not equate to or guarantee compliance with the Clean Air Act, its implementing regulations, and associated state/local requirements. For more information, visit: https://www.epa.gov/caa-permitting.*

Appendix A Federal Regulations That Require a Formal LDAR Program With Method 21

40 CFR		Regulation Title
Part	Subpart	
60	VV	SOCMI VOC Equipment Leaks NSPS
60	DDD	Volatile Organic Compound (VOC) Emissions from the Polymer Manufacturing Industry
60	GGG	Petroleum Refinery VOC Equipment Leaks NSPS
60	KKK	Onshore Natural Gas Processing Plant VOC Equipment Leaks NSPS
61	J	National Emission Standard for Equipment Leaks (Fugitive Emission Sources) of Benzene
61	V	Equipment Leaks NESHAP
63	H	Organic HAP Equipment Leak NESHAP (HON)
63	I	Organic HAP Equipment Leak NESHAP for Certain Processes
63	J	Polyvinyl Chloride and Copolymers Production NESHAP
63	R	Gasoline Distribution Facilities (Bulk Gasoline Terminals and Pipeline Breakout Stations)
63	CC	Hazardous Air Pollutants from Petroleum Refineries
63	DD	Hazardous Air Pollutants from Off-Site Waste and Recovery Operations
63	SS	Closed Vent Systems, Control Devices, Recovery Devices and Routing to a Fuel Gas System or a Process
63	TT	Equipment Leaks – Control Level 1
63	UU	Equipment Leaks – Control Level 2
63	YY	Hazardous Air Pollutants for Source Categories: Generic Maximum Achievable Control Technology Standards
63	GGG	Pharmaceuticals Production
63	III	Hazardous Air Pollutants from Flexible Polyurethane Foam Production
63	MMM	Hazardous Air Pollutants for Pesticide Active Ingredient Production
63	FFFF	Hazardous Air Pollutants: Miscellaneous Organic Chemical Manufacturing
63	GGGGG	Hazardous Air Pollutants: Site Remediation
63	HHHHH	Hazardous Air Pollutants: Miscellaneous Coating Manufacturing
65	F	Consolidated Federal Air Rule – Equipment Leaks
264	BB	Equipment Leaks for Hazardous Waste TSDFs
265	BB	Equipment Leaks for Interim Status Hazardous Waste TSDFs

Note: Many of these regulations have identical requirements, but some have different applicability and control requirements.

Appendix B Federal Regulations That Require the Use of Method 21 But Do Not Require a Formal LDAR Program

40 CFR		Regulation Title
Part	Subpart	
60	XX	Bulk Gasoline Terminals
60	QQQ	VOC Emissions from Petroleum Refinery Wastewater Systems
60	WWW	Municipal Solid Waste Landfills
61	F	Vinyl Chloride
61	L	Benzene from Coke By-Products
61	BB	Benzene Transfer
61	FF	Benzene Waste Operations
63	G	Organic Hazardous Air Pollutants from SOCMI for Process Vents, Storage Vessels, Transfer Operations, and Wastewater
63	M	Perchloroethylene Standards for Dry Cleaning
63	S	Hazardous Air Pollutants from the Pulp and Paper Industry
63	Y	Marine Unloading Operations
63	EE	Magnetic Tape Manufacturing Operations
63	GG	Aerospace Manufacturing and Rework Facilities
63	HH	Hazardous Air Pollutants from Oil and Gas Production Facilities
63	OO	Tanks – Level 1
63	PP	Containers
63	QQ	Surface Impoundments
63	VV	Oil/Water, Organic/Water Separators
63	HHH	Hazardous Air Pollutants from Natural Gas Transmission and Storage
63	JJJ	Hazardous Air Pollutant Emissions: Group IV Polymers and Resins
63	VVV	Hazardous Air Pollutants: Publicly Owned Treatment Works
65	G	CFAR – Closed Vent Systems
264	AA	Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities - Process Vents
264	CC	Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities - Tanks, Surface Impoundments, Containers
265	AA	Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities – Process Vents
265	CC	Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities - Tanks, Surface Impoundments, Containers
270	B	Hazardous Waste Permit Program – Permit Application
270	J	Hazardous Waste Permit Program – RCRA Standardized Permits for Storage Tanks and Treatment Units

References

1. Protocol for Equipment Leak Emission Estimates (November 1995) - 1995 Protocol for Equipment Leak Emission Estimates. https://www3.epa.gov/ttnchie1/efdocs/equiplks.pdf

2. VOC Fugitive Losses: New Monitors, Emission Losses, and Potential Policy Gaps - 2006 INTERTATIONAL WORKSHOP. https://www3.epa.gov/ttn/chief/efpac/documents/wrkshop_fugvocemissions.pdf

3. Leak Detection and Repair – A Best Practices Guide. https://www.epa.gov/compliance/leak-detection-and-repair-best-practices-guide

4. Emissions Estimation Protocol for Petroleum Refineries – April 2015. https://www3.epa.gov/ttn/chief/efpac/protocol/Protocol%20Report%202015.pdf

5. Consent Decree in United States, et al. v. Chemical Solvents. https://www.justice.gov/enrd/consent-decree/file/1201701/download

6. Administrative Consent Order - In the Matter of: Kalsec, Inc. https://www.deq.state.mi.us/aps/downloads/SRN/A1991/A1991_ACO_20200909.pdf

7. Consent Decree in United States, et al. v. Altivia Petrochemicals, LLC. (2022) https://www.justice.gov/enrd/consent-decree/file/1537461/download