

# Best Practices for Estimating Emissions Using Emissions Factors for Clean Air Act Permitting



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## What are emissions factors?

An emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. Such factors facilitate estimation of emissions from various sources of air pollution.

*The general equation for emissions estimation is:*

$$E = A \times EF \times (1-ER/100)$$

*where:*

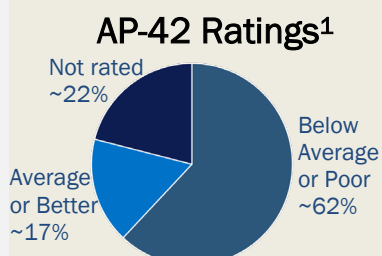
*E = emissions*

*A = activity rate*

*EF = emissions factor*

*ER = overall emission reduction efficiency, %*

ER is the product of the control device destruction or removal efficiency and the capture efficiency of the control system.



This document recommends practices that Clean Air Act (CAA) permitting authorities may use to ensure the most accurate emissions factors available are used to estimate emissions. Improperly using emissions factors in place of more representative source-specific emission values for CAA permitting and compliance demonstration purposes can be costly to businesses, inefficient, and in some circumstances, subject regulated entities to enforcement and penalties.

## Why emissions factors?

In CAA permitting, data from continuous emission monitoring systems (CEMS) or source-specific emission tests are usually preferred for estimating a source's emissions because those data provide the best representation of the tested source's emissions. However, CEMS and test data from individual sources are not always available and, even then, they may not reflect the variability of actual emissions over time. Thus, emissions factors are occasionally the best or only method available for estimating emissions despite their limitations. Emissions factors are often the basis for emission estimates used for developing control strategies, determining applicability of permitting and control programs, ascertaining the effects of sources and appropriate mitigation strategies, and many other related applications.

## Sources and Use of Emissions Factors

In its simplest form, an emissions factor is a ratio of the mass of pollutant emitted per unit of activity generating the emissions. Emissions factors for more complex processes or activities (e.g., paved and unpaved roads, and organic liquid storage tanks) are typically expressed using empirical equations that relate independent variables to the emissions. and typically provides for improved predictive accuracy when compared to a simple emissions factor.

Since 1972, EPA has published several compilations of available emissions factors. These publications include:<sup>3</sup>



## Order of Accuracy of Emissions Estimation Methods

1. CEMS
2. Stack testing
3. Vendor guarantees and stack test data from similar sources
4. Material balance calculations
5. Optical remote sensing
6. Emissions factors

*In many permitting situations, CEMS data are not available and emissions factors from stack testing or other available sources must be used to estimate emissions. When this happens, EPA recommends the CAA permit require source-specific testing to confirm the accuracy of the emissions estimates.*

- **AP-42, *Compilation of Air Pollutant Emissions Factors*.**<sup>2</sup> Developed and compiled from source test data, material balance studies, and engineering estimates, AP-42 contains emissions factors and process information for more than 200 air pollution source categories. The last hard-copy version of AP 42 (fifth edition) was published in 1995; although, EPA released six supplements (Supplements A through F) through the year 2000. Since 2001, updates to AP-42 were provided only electronically.
- ***Locating & Estimating (L&E)*** document series. Initiated in 1984, the L&E documents mostly focused on a specific pollutant (e.g., arsenic, benzene) or related group of pollutants (e.g., polycyclic organic matter). A total of 36 individual L&E documents were produced through 1998.
- The **Aerometric Information Retrieval System (AIRS) Facility Subsystem Emission Factors (AFSEF) and the Crosswalk/Air Toxics Emission Factors (XATEF)** databases. The AFSEF database documented all emissions factors for criteria pollutants that existed in the AIRS mainframe look-up tables as of March 1990. The XATEF database contained emissions factors for toxic air pollutants that were developed based upon data available to EPA through October 1990. EPA retired the AFSEF and XATEF databases in 1990 and created the Factor Information Retrieval (FIRE) Data System.
- **FIRE.** The FIRE database contains emissions factors from all AP 42 sections posted by September 1, 2004, the L&E document series and the retired AFSEF and XATEF databases.
- **Other.** Specialized studies have produced documents containing average emissions rates for various processes which have been posted on EPA's Clearinghouse for Inventories and Emissions Factors (CHIEF) website. These documents may still represent the most currently-available estimation tools for those processes.

Historically, EPA's emissions factors have been graded as A, B, C, D, etc, with "A"-rated emissions factors being of the highest quality. However, future emissions factors will be assigned numerical ratings which are either "highly representative," "poorly representative," or "moderately representative" of the source category.<sup>3</sup>

While emissions factors may be used as an option for calculating emissions from regulated sources, caution should be exercised when using emissions factors for establishing source-specific permit limits or for determining compliance. Because emissions factors represent an average of a range of emissions rates, approximately half of the subject sources will have emission rates greater than the emissions factor and the other half will have emission rates less than the factor. As such, a permit limit using an emissions factor could result in half of the sources being in noncompliance. Where representative source-specific data cannot be obtained, and emissions factors are the only source of emissions information, EPA recommends the CAA permit require source-specific testing to confirm the accuracy of the selected emissions factor.



## Historical Ratings of AP-42 Emissions Factors<sup>2, 3</sup>

A = Excellent. Factor is developed from tests conducted with sound, or generally sound, methodology.

B = Above average. Factor is developed from tests conducted with sound, or generally sound, methodology from a “reasonable number” of facilities. The facilities tested may or may not represent a random sample of the industry.

C = Average. Same as “B,” but the factor can be developed from an unproven or new methodology. The facilities tested may or may not represent a random sample of the industry.

## Other Sources of Emissions Factors

Besides emissions factors retrieved through FIRE, other sources of emissions information include:

- Source test data at the source.
- Equipment vendors, such as emission performance guarantees.
- Source test data from similar equipment at the source.
- Source test data from similar equipment at another source.

## Hierarchy of Emissions Estimation Methods

EPA recommends the following emissions estimation methods, in order of accuracy:<sup>2</sup>

- **Continuous Emissions Monitoring System (CEMS)** – A CEMS offers a highly accurate source-specific method that continuously monitors the emissions coming out of a particular stack.
- **Stack Testing** – Like a CEMS, source-specific data are generated at a particular stack but emissions are only measured for a specific time, typically for a few hours during normal operations.
- **Vendor Guarantees and Stack Test Data from Similar Facilities** – If representative source-specific data cannot be obtained, emissions information from equipment vendors, particularly emission performance guarantees or actual test data from similar equipment, is a better source of information for permitting decisions than an AP-42 emissions factor.
- **Material Balance Calculations** – While material balance calculations are not generally considered as accurate as direct measurements, they may provide more reliable average emission estimates for certain sources where a high percentage of material is lost to the atmosphere (e.g., solvent VOC emissions). This method works well for materials and processes that are well understood (e.g., all material inputs and outputs can be accurately characterized and quantified).
- **Optical Remote Sensing** – Measurement techniques involving differential absorption light detection and ranging (known as DIAL) and solar occultation flux (SOF) can be used to measure emissions from sources such as coke ovens, storage tanks, wastewater treatment plants, and process units that are otherwise difficult to measure by other means.
- **AP-42 Emissions Factors** – When source-specific emissions or other more reliable approaches are unavailable, AP-42 emissions factors may be the only way to estimate emissions. AP-42 emissions factors should only be used as a last resort.



D = Below average. Same as “C,” but test data are from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population.

E = Poor. Factor is developed from: (1) tests based on an unproven or new methodology, or tests that may be lacking a significant amount of background information, or (2) tests based on a generally unacceptable method, but the method may provide an “order of magnitude” value for the source. Facilities tested may not represent a random sample of the industry and there is evidence of variability within the source category population.

# Best Practices

## 1. Carefully review all emissions estimation methods available for the source, in order of accuracy.

For any permitting situation, the decision on emissions estimation methods should account for the specific circumstances of the source being evaluated. For example, CEMS data from a non-quality assured nor properly maintained CEMS may not provide the most reliable emissions information in some cases while “A”-rated AP-42 emissions factors may, in some cases, be more reliable than source test data from a different but similar source. The permitting authority should sufficiently explain in the permit record why more reliable emissions estimation methods were not selected. The record should also explain the types of safeguards incorporated into the permit to ensure the emissions factors can be confirmed and emissions limits are not violated (e.g., source testing, continuous monitoring, etc.).

## 2. Consider and communicate the risk of using emissions factors.

EPA recognizes that in many permitting situations, CEMS data are not available and emissions factors from stack testing or other available sources are the only source of information on emissions. However, in such situations, EPA recommends the CAA permit require source-specific testing to confirm the accuracy of the emissions estimates. This could help protect the facility from potential enforcement penalties and may ensure the permitting authority meets its environmental protection targets. In each permitting situation, the environmental and financial risk of using emissions factors should be carefully considered.

## 3. Ensure the permit application contains documentation sufficiently demonstrating that emissions factors accurately represent the source’s activities.

The level of documentation would vary depending on the level of risk associated with the specific emissions estimation methodology. While AP-42 typically contains documentation and references for the emissions factors listed in that publication, the permitting authority should document why the specific AP-42 emissions factors selected are

appropriate for the source’s activities. For example, the applicant may describe any source-specific testing or monitoring conducted by the source that has confirmed the appropriateness of the proposed emissions factors. While it may not be necessary or practical to review each individual data source that was relied upon in developing the emissions factors, such review may be appropriate in cases where EPA or other entities have reported significant source-to-source variability in the measured emission rates. In addition, because AP-42 emissions factors represent an average of emissions from various sources within a source category, it is possible that





## Best Practices

1. *Carefully review all emissions estimation methods available for the source, in order of accuracy.*
2. *Consider and communicate the risk of using emissions factors.*
3. *Ensure the permit application contains documentation sufficiently demonstrating that emissions factors accurately represent the source's activities.*
4. *Consider source-specific testing to confirm the accuracy of emissions factors.*
5. *Where source testing to confirm emissions factors is not practical, evaluate other methods for quantifying emissions.*
6. *Where emissions factors are extremely source-specific, or source testing to confirm or establish new emissions factors is deemed not practical, consider adding emissions factors into the permit.*

some of the sources evaluated by EPA have significantly different emissions characteristics than the source being evaluated. The applicant should review the latest literature and technology to be aware of circumstances that might cause its source to exhibit emissions characteristics different from those of other, typical existing sources.

### 4. Consider source-specific testing to confirm the accuracy of emissions factors.

As a general matter, whether source testing to confirm emissions estimates should be required in a permit depends on the specific circumstances of the source, and such decisions are best made on a case-by-case basis. For example, the permitting authority may determine that other provisions of the permit, such as any required continuous parametric monitoring and add-on control devices, sufficiently limit emissions such that it would be impractical to violate emissions limits without also violating those requirements. While the need to require source testing should always be carefully considered, it is particularly necessary where emissions factors are used to project emissions.

EPA recommends that creators and users of emissions factors conduct periodic retesting to confirm or revise (as necessary) the emissions factor. A good practice is to determine the appropriate frequency of such retesting based on the rating of the emissions factor used, with poor-rated emissions factors receiving more frequent testing than higher-rated emissions factors.

### 5. Where source testing to confirm emissions factors is not practical, evaluate other methods for quantifying emissions.

Except in limited circumstances, a CAA permit will typically include an emissions limit. Under the CAA, the permit must include methods for demonstrating compliance with all permit conditions, including any emissions limits. As already discussed, where emissions factors are used to estimate emissions, we recommend the permit include a means to verify the appropriateness of the emissions factor. Where such verification cannot be achieved through source testing (e.g., if emissions from the source are mostly fugitive emissions that cannot be collected to enable a stack test), other emissions quantification methods should be considered and evaluated. These methods may include:

- an engineering study by the source or independent entity to evaluate emissions from the affected activities,
- theoretical calculations from chemical equations published in literature,
- theoretical calculations from engineering first principles,
- other methods as appropriate.

### 6. Where emissions factors are extremely source-specific, or source testing to confirm or establish new emissions factors is deemed not practical, consider adding emissions factors into the permit.

## 7. *Submit stack test and CEMS data electronically to EPA.*

Factors to consider when determining whether emissions factor validation testing is appropriate:

- Variability of emissions from the unit in question.
- The likelihood of a violation of the requirements.
- Whether add-on controls will be used.
- The type and reliability of other data collected for the emission unit.
- Whether validation testing can safely and practically be done.
- Consequences of excess emissions on health or environmental effects, or regulatory applicability.

In some cases, emissions factors may be very source-specific because they were developed from unique characteristics of a particular source or source category. For example, emissions factors for hazardous air pollutants and volatile organic compounds from hogged fuel boilers and other wood combustion devices may be based on a custom mix of wood varieties that are expected to be burned in the devices. In this case, continuous emissions monitoring and source testing would confirm the emissions factors, or could lead to a revision of the emissions factors and the accompanying emissions estimates. However, if such testing or continuous emissions monitoring is deemed to be impractical, it may be appropriate to specify in the permit the emissions factors and assumptions used to calculate emissions and to monitor compliance with emissions limits. To ensure transparency and enforceability of permit conditions, it may be appropriate to specify emissions factors in permits even in situations where the source can be tested. However, in all cases, the permit must be clear about how any emissions factors specified in the permit would be revised based on new information that becomes available regarding emissions from the source (e.g., from future source tests or other information sources).

## 7. Submit stack test and CEMS data to EPA.

If you conduct stack testing or operate CEMS, EPA recommends the stack test or CEMS data be electronically submitted to EPA using the WebFIRE Import Spreadsheet available at: <https://www.epa.gov/electronic-reporting-air-emissions/electronic-reporting-tool-ert#WebFIRE>, and the complete test report should be sent by e-mail to Chief\_Info@epa.gov.

# Who do I contact for more information?

## United States Environmental Protection Agency

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

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



## State/Tribal/Local Permitting Authorities

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

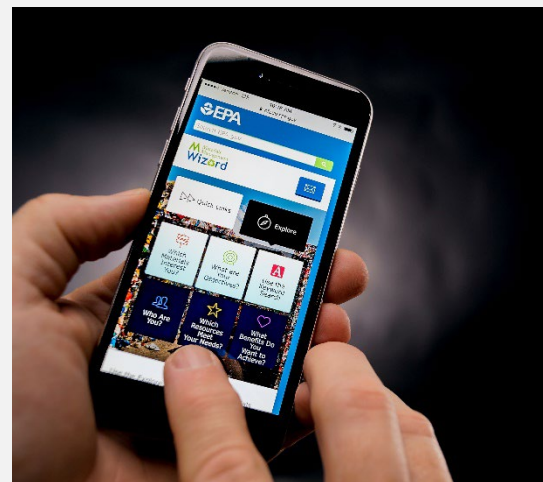
- Illinois: <https://www2.illinois.gov/epa/Pages/default.aspx>
- Indiana: <https://www.in.gov/idem/airquality/index.htm>
- Michigan: <https://www.michigan.gov/egle/>
- Minnesota: <https://www.pca.state.mn.us/>
- Ohio: <https://www.epa.ohio.gov/>
- Wisconsin: <https://dnr.wisconsin.gov/>





# Useful Resources

1. “Emission factors used to paint a broad picture of air quality often underestimate pollution, evidence shows,”  
<https://publicintegrity.org/environment/most-of-the-epas-pollution-estimates-are-unreliable-so-why-is-everyone-still-using-them/>
2. AP-42, Fifth Edition, Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources. Introduction.  
<https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors>.
3. Recommended Procedures for Development of Emissions Factors and Use of the WebFIRE Database, EPA-453/D-13-001, August 2013. <https://www.epa.gov/sites/default/files/2020-09/documents/procedures81213.pdf>
4. EPA Reminder About Inappropriate Use of AP-42 Emission Factors:  
<https://www.epa.gov/sites/production/files/2021-01/documents/ap42-enforcementalert.pdf>
5. In the Matter of U.S. Steel Granite City Works CAAPP Permit No. 96030056, EPA Order on Petition No. V -2009-03, January 31, 2011: [https://www.epa.gov/sites/production/files/2015-08/documents/uss\\_response2009.pdf](https://www.epa.gov/sites/production/files/2015-08/documents/uss_response2009.pdf)
6. In the Matter of U.S. Steel Granite City Works CAAPP Permit No. 96030056, EPA Order on Petition No. V-2011-2, December 3, 2012: [https://www.epa.gov/sites/production/files/2015-08/documents/uss\\_2nd\\_response2009.pdf](https://www.epa.gov/sites/production/files/2015-08/documents/uss_2nd_response2009.pdf)
7. In the Matter of Tesoro Refining and Marketing Co, Martinez, California Facility, EPA Order on Petition No. IX-2004-6, March 15, 2005: [https://www.epa.gov/sites/production/files/2015-08/documents/tesoro\\_decision2004.pdf](https://www.epa.gov/sites/production/files/2015-08/documents/tesoro_decision2004.pdf)
8. In the Matter of Cargill, Inc. Title V Permit No. 2075-139-0002-V-01-1, EPA Order on Petition No. IV-2003-7 (Amended Order), October 19, 2004: [https://www.epa.gov/sites/production/files/2015-08/documents/cargillamendment\\_decision2003.pdf](https://www.epa.gov/sites/production/files/2015-08/documents/cargillamendment_decision2003.pdf)
9. In re: Peabody Western Coal Co., CAA Appeal No. 04-01, Environmental Appeals Bard Order Denying Review, February 18, 2005:  
[https://yosemite.epa.gov/oa/EAB\\_Web\\_Docket.nsf/ef8da29510bd7a78852570000042db69/de9ba2fa4dabe5148525706c0045c6c11OpenDocument](https://yosemite.epa.gov/oa/EAB_Web_Docket.nsf/ef8da29510bd7a78852570000042db69/de9ba2fa4dabe5148525706c0045c6c11OpenDocument)
10. Procedures for Preparing Emission Factor Documents, EPA-454/R-95-015, November 1997.



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