
CALCULATING AIR EMISSIONS FOR THE MICHIGAN AIR EMISSIONS REPORTING SYSTEM (MAERS)

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INTRODUCTION

The all-important step in the completion of a facility's annual Michigan Air Emissions Reporting System (MAERS) report is the quantification of emissions of air contaminants from their various processes and activities. This document begins with an identification of the pollutants that must be reported in MAERS, and that is followed by a lengthy discussion of the three primary methods of calculating air contaminants: direct, mass balance, and emission factors and models.

Much of the discussion of emission factors and software contained within this document was taken from the U.S. Environmental Protection Agency's (EPA), Office of Planning & Standards' Technology Transfer Network (TTN). The TTN is a collection of technical web sites containing information on a number of air pollution topics including emission estimation.

WHAT POLLUTANTS MUST BE REPORTED IN MAERS?

Emissions for the following pollutants must be reported:

- Ammonia
- Carbon monoxide (CO);
- Nitrogen oxides (NO_x) expressed as NO₂;
- Particulate matter (PM);
- Particulate matter less than 10 microns (PM-10);
- Particulate matter less than 2.5 microns (PM-2.5)
- Sulfur oxides (SO_x) expressed as SO₂
- Volatile organic compounds (VOC); and
- Lead (Pb).

However, if the emission of one of the above pollutants from a source classification code (SCC) is less than 0.01 tons (20 pounds) per year, the emission does not have to be reported. Additional discussion of pollutant terminology and conventions begins on page 27.

Reporting Toxic Pollutants

Under MAERS, the reporting of approximately 240 toxic pollutants is optional. The Air Quality Division (AQD) of the Michigan Department of Environmental Quality (MDEQ) will analyze the emissions data submitted by each company and estimate the toxic air pollutant emissions from the information provided for the criteria pollutants. This includes activity information such as source classification codes and material throughput. Facilities submitting their MAERS report electronically will be able to view the estimation of toxics prior to submitting their report. The MAERS software is equipped with an emission calculator. If the emission estimates are in error, the Air Quality Division would appreciate the facility's help in correcting those estimates of toxic emissions.

Toxic Chemical Release Inventory (TRI) and MAERS

Section 313 of the federal Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986, also known as Title III of the Superfund Amendments and Reauthorization Act, requires certain facilities to report Toxic Chemical Release Inventory (TRI) information for any listed chemicals *manufactured, processed, or otherwise used* by the facility above specific thresholds.

Manufacture - produce, prepare, import, or compound an EPCRA Section 313 chemical.
Example: manufacturing benzene on-site for distribution and sale.

Process - prepare or process a listed toxic chemical for distribution in commerce. This is usually the incorporation of a toxic chemical into a product. An EPCRA Section 313 chemical is processed as a reactant, as a formulation or article component, repackaged, or as an impurity.
Example: process paint containing certain glycol ethers.

Otherwise use - use a listed toxic chemical that is not covered by the terms “manufacture” or “process.” EPCRA Section 313 chemicals are otherwise used as chemical processing or manufacturing aids, or for ancillary or other use. Example: using Freon 113 as a coolant in a closed-loop refrigerant system to cool process streams.

There are about 650 toxic chemicals and chemical categories covered by Section 313. A small number of these are identified as persistent, bioaccumulative and toxic (PBT). Activity thresholds for non-PBT chemicals are more than 25,000 pounds manufactured or more than 25,000 pounds processed or more than 10,000 pounds otherwise used. PBT chemical thresholds are significantly lower regardless of the activity – more than 10 pounds or 100 pounds depending on the chemical; for dioxin and dioxin-like compounds the activity threshold is more than 0.1 grams.

The EPA can add, remove, or modify the list of toxic chemicals that must be reported. Facilities should check each year for any changes to the Section 313 chemicals and chemical categories and reporting requirements.

Michigan has over 900 TRI facilities and almost 2,000 MAERS facilities. Although DEQ does not have an exact knowledge of how many facilities are filing both reports, it is estimated that well over half of the TRI facilities report under MAERS.

Facilities that report toxic pollutants under MAERS and are subject to EPCRA Section 313 TRI reporting requirements should develop a system that could satisfy both. This would eliminate the redundancy of calculations. The following outlines MAERS and TRI requirements.

- The reporting period for both MAERS and TRI is the calendar year. The initial submittal dates of the reports differ. MAERS forms are due March 15. TRI forms are due July 1.
- Under MAERS, facilities must estimate and report their releases of seven criteria air contaminants and may report an additional 240 toxic pollutants (80 requested by the Great Lakes Commission and 160 requested by the Toxics Unit of the Air Quality Division). All 188 Hazardous Air Pollutants (HAPs) are included in the list of 240 toxic pollutants. A majority of the MAERS toxic pollutants are included in one form or another on the list of TRI chemicals. Under EPCRA Section

313, facilities must estimate and report releases (including disposal) and other waste management activities for approximately 650 chemicals and chemical compound categories.

- The submittal of emission data collected by MAERS to EPA must be made on a process-by-process basis, as defined by EPA source classification codes (SCCs). In addition to emission estimates, several other parameters such as material throughput, operating schedules, stack parameters, and emission factors must be reported at the process level. EPCRA Section 313 requires facilities to report at the facility level.
- Under MAERS, facilities do not have to report an emission if it is less than 20 pounds per year for each activity (SCC process). EPCRA Section 313 has no minimum threshold for quantity released; once a facility meets the reporting threshold for chemical use mentioned above, it must submit a report, *even if* there are no releases.

A facility should consider developing an effective emission estimation system that can adequately address MAERS AND EPCRA Section 313 reporting requirements.

APPROACHES TO EMISSION ESTIMATION

There are numerous approaches to estimating emissions of air contaminants. Figure 1 depicts the various approaches to emission estimation that should be considered when analyzing the tradeoffs between cost of the estimates and quality of the resulting estimates. In this section, three approaches will be discussed including some examples on how to use them:

- direct measurement,
- mass balance, and
- emission factors and emission models.

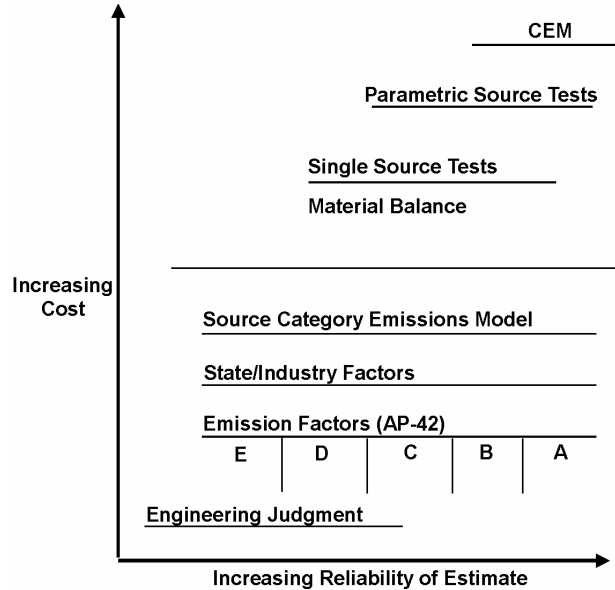


Figure 1. Approach to emission estimation.

Source: Compilation of Air Pollutant Emission Factors (AP-42), Fifth Edition, Volume I: Stationary Point and Area Sources, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

DIRECT MEASUREMENT

The most accurate way of estimating a source's emissions is directly measuring the concentration of air pollutants in the stack gas. Stack tests and continuous emission monitoring systems (CEMS) are two methods of collecting actual emission data. This section explains how source testing data from stack tests and CEMS can be used in the completion of a facility's Michigan Air Emission Reporting System (MAERS). The discussion will focus on the methodology to follow in converting data collected during source testing into a pollutant mass emission rate, i.e., tons of pollutant emitted per year. Albeit very important for compliance demonstration purposes, this discussion will not include comparison of stack testing and CEMS results, to all of the various air pollutant concentration limits contained within the state and federal air quality regulations.

The use of source test data reduces the number of assumptions regarding the applicability of emissions data to a source (a common consideration when emission factors are used); as well as the control device efficiency, equipment variations, and fuel characteristics. Even then, the results will be applicable only to the conditions existing at the time of the testing or monitoring. To provide the best estimate of longer-term (e.g., yearly or typical day) emissions, these operating conditions should be representative of the source's routine operations.

STACK TESTS

Stack tests provide a means to determine the concentration of emissions of an air pollutant at the point of release. These tests are conducted according to established procedures. Stack tests provide a snapshot of emissions during the period of the test. Samples are collected using probes inserted into the stack, then pollutants are collected in or on various media and sent to a laboratory for analysis or analyzed on-site by continuous analysis. Pollutant concentrations are obtained by dividing the amount of pollutant collected during the test by the volume of the air sampled. Only experienced stack testers should perform the stack tests.

CONTINUOUS EMISSION MONITORING SYSTEMS

Continuous emission monitoring systems (CEMS) involve the installation of monitoring equipment that accumulates data on a pre-determined time schedule in a stack or duct. The continuous measurements provide data under all operating conditions. Use of CEMS requires attention to detail and strict adherence to state and federal guidelines. Emissions data are available through direct measurement using continuous emissions monitors, usually located in the exhaust downstream of a combustion device. Information obtained from these devices can only be considered reliable if the devices are subject to a quality control/quality assurance (QA/QC) program that includes appropriate calibration. A CEMS provides a continuous record of emissions over an extended and uninterrupted period of time. Various principles are employed to measure the concentration of pollutants in the gas stream. These principles usually based upon photometric measurements. Instrument calibration drift can be problematic for CEMS. The owner is responsible for proper calibration, operation, and validation of the monitoring equipment and emission data.

Stack tests and CEMS directly measure two important values: the concentration of a specific air pollutant ([air pollutant]) in the stack gas and stack gas flow rate. Multiplying these two values together will equal a mass emission rate typically expressed as pounds of air pollutant per hour (see Equation 1 and Step 1). Once the hourly mass emission rate is calculated, it can be easily converted to a source specific emission factor by dividing the hourly mass emission rate by the hourly activity (i.e., hourly material throughput during the stack test or CEMS measurement, such as ton of coal combusted per hour [see Equation 2 and Step 2]). The annual emission rate of the air contaminant is simply the product of the source specific emission factor and annual activity (i.e., annual material throughput, such as tons of coal combusted during the year) (see Equation 3 and Step 3).

Equation (1) [air pollutant] * stack gas flow rate = hourly mass emission rate

Equation (2) hourly mass emission rate / hourly activity = source specific emission factor

Equation (3) source specific emission factor * annual activity = annual emission rate of air pollutant

STEP 1 - CALCULATING THE HOURLY MASS EMISSION RATE

According to Equation 1, the hourly mass emission rate is the concentration of air pollutant multiplied by the stack gas flow rate. The concentration of air pollutants and stack gas flow rate can be reported in a number of different ways or units, such as milligrams per cubic meter (mg/m^3) or pounds per standard cubic foot (lbs/scf). To correctly calculate the hourly emission rate, the concentration and gas flow rate must be in units that are compatible with each other.

CONCENTRATION OF AIR POLLUTANT IN THE STACK

The concentration of an air pollutant is calculated by dividing the mass of the air pollutant collected by the volume or mass of stack gas sampled (see Equation 4). During a stack test, most air pollutants are collected on some type of media. The type of media depends on the type of air contaminant being measured. For example, particulate matter and metals, which are solids, are collected on a filter. Benzene, which is in a gaseous state, is collected on a solid sorbent, such as charcoal. The total volume of stack gas sampled is typically measured by a dry gas meter. Continuous emission monitoring systems (CEMS) measure gaseous air pollutants directly by fluorescence (SO_2), infrared spectroscopy (CO), chemiluminescence (NO_x), and flame ionization detection (VOCs). Table 1 identifies the concentrations of the criteria air pollutants typically found in stack test and CEMS results. Concentrations can be reported on a mass or volume basis.

$$\text{Equation (4)} \quad \frac{\text{mass of air pollutant collected}}{\text{volume or mass of air (stack gas) sampled}} = \text{concentration}$$

Table 1 - Source Testing Results

Pollutant	Mass of Pollutant Collected	Volume of Stack Gas Sampled	Concentration of Pollutant in Stack Gas	Concentration Units
VOCS, SO ₂ , NO _x , CO, HCL				Ppmvd
PM, TOXICS	M(grams)	V _d (m ³ @ dry standard conditions)	$\frac{M * 1000\text{mg/g}}{V_d}$	mg/m³
PM	M(grams)	V _{dw} (scf)	$\frac{M * 1 \text{ lb}/453.59 \text{ grams}}{V_{dw}}$	lbs/scf
PM	M(grams)	V _d (dscf)	$\frac{M * 1 \text{ lb}/453.59 \text{ grams}}{V_d}$	lbs/dscf
PM	M(grams)	V _d (dscf)	$\frac{M * 15.432 \text{ grains/gram}}{V_d}$	grains/dscf
PM	M(grams)	V _{dw} (acf)	$\frac{M * 1 \text{ lb}/453.59 \text{ grams} * 1000}{V_{dw} * p_{dw}}$	lbs/1000 lbs (actual)
PM	M(grams)	V _d (dscf)	$\frac{M * 1 \text{ lb}/453.59 \text{ grams} * 1000}{V_d * p_d}$	lbs/1000 lbs (dry)

Table 2 - Nomenclature

acf	actual cubic feet
acfm	actual cubic feet per minute
[air pollutant]	concentration (mass of air pollutant/mass or volume of air)
dscf	dry standard cubic feet
dscfm	dry standard cubic feet per minute
F_d	fuel factor (dscfm/MMBtu)
ft^3	cubic feet
H_{in}	heat input rate (MMBtu/hr)
HHV	higher heating value (Btu/lb, Btu/gallon, or Btu/cubic feet)
lb	pounds
M	mass of air pollutant
m^3	cubic meters @ dry standard conditions
mg	milligrams
MW	molecular weight of the pollutant. The molecular weight of the air pollutant is the sum of the atomic weights of all atoms in the molecule. One mole of molecules contains 6.022×10^{23} molecules. The mass of one mole of pollutant is its molecular weight * lb/lb-mole.
P	pressure
ρ_{dw}	density of all sampled gas at standard conditions
ρ_d	density of dry gas at standard conditions
ppmvd	pollutant concentration expressed in units of parts per million volume dry. 1 ppmvd = 1 lb-mole of pollutant/ 10^6 lb-moles of air at dry conditions. Since ppmvd is a volume to volume ratio, it is independent of temperature and pressure.
Q	stack gas flow rate
R	mass fuel rate (lbs/hr)
scf	standard cubic feet
scfm	standard cubic feet per minute
STP	Standard temperature (70°F) and pressure (29.92 inches of Hg absolute) as defined in Michigan Rule 119(M).
T	temperature
V_d	volume of dry gas @ STP
V_w	volume of water vapor @ STP
V_{dw}	volume of all sampled gas @ STP
V_{ideal}	volume occupied by one lb-mole of ideal gas will occupy a volume of 386.5 ft ³ @ 70° F and 29.92 inches of Hg

Table 3 - Conversion Factors

1 gram/1000 milligram	60 minutes/hour	0.02832 m ³ /ft ³
1 gram/15.432 grains	1 lb/453.59 grams	1 lb/7000 grains

Combustion Sources: The stack gas leaving a combustion device (e.g. incinerator or boiler) contains certain levels of air pollutants which can be made to appear smaller if the total stack gas quantity is increased by adding non-pollutant gas to the stream. The volume fraction of any gas present in the stack gas can be reduced by dilution, i.e., adding air. It is for this reason that combustion equipment concentration emission standards are written with a specified amount of excess air (e.g., 0.08 grains/dscf corrected to 12% carbon dioxide). These excess air corrections are important when comparing stack test results to the emission standards but not when calculating the mass emission rate. No matter how much the stack gas is diluted, the mass emission rate will not change because the decrease in concentration will be offset by the increase in stack gas flow rate.

If concentrations from stack tests are corrected to 50% excess air, 7% CO₂, or 7% O₂, make sure the stack flow rate is in the same units when calculating the mass emission rate.

STACK GAS FLOW RATE

The second piece of information needed to calculate the hourly mass emission rate is the stack gas flow rate (see Equation 1). As one can see in Table 1, the concentrations are based upon volumes of air at actual or standard pressure and temperature, and dry or wet conditions. There it is necessary to know how to convert acfm to scfm and scfm to dscfm.

Flow rates can be determined using continuous volume flow rate monitor, stack sampling data or, for combustion sources, can be estimated based on heat input using fuel factors.

CONVERTING ACFM TO SCFM

The volume of a gas varies with changes in pressure and temperature. In order to simplify comparison of gases, chemists adopted a set of standard conditions of temperature and pressure. Accordingly, Rule 119(m) of the Michigan Administrative Rule for Air Pollution Control defines standard conditions as a gas temperature of 70° Fahrenheit (460 + 70° F = 530° R) and a gas pressure of 1 atmosphere (29.92 inches of mercury absolute).

The volume of a gas or volume flow rate of a gas at one temperature and pressure can be converted to its volume or volume flow rate at standard conditions by using the ideal gas equation which relates pressure, volume, and temperature.

According to the ideal gas law:

$$\text{Equation (5)} \quad Q_{\text{std}} = Q_o(T_{\text{std}}/T_o) (P_o/P_{\text{std}})$$

Where:

Q_{std} = gas flow rate at standard temperature and pressure

Q_o = gas flow rate at actual conditions

P_{std} = pressure at standard conditions is 29.92 inches Hg or 1 atmosphere

T_{std} = temperature at standard conditions is 70° F

P_o = pressure at actual conditions (inches Hg)

T_o = temperature at actual conditions (°F)

$$\text{Equation (6)} \quad Q_{\text{scfm}} = \frac{Q_{\text{acfm}} * (460 + 70^\circ \text{ F}) * P_o}{(460 + T_o) * P_s}$$

CONVERTING SCFM TO DSCFM

Certain processes will generate moisture in the stack gas

$$\text{Equation (7)} \quad Q_{\text{dscfm}} = Q_{\text{scfm}} * (1 - \% \text{ moisture})$$

This approach can only be used for exhaust flows < 5% moisture

For Combustion Sources: When direct measurements of stack gas flow rate are not available, Q can be calculated using fuel factors (F_d factors):

$$\text{Equation (8)} \quad Q_{\text{dscfm}} = \frac{F_d * 20.9 * H_{\text{in}}}{(20.9 - \%O_2) * 60 \text{ min/hr}}$$

Where:

F_d = fuel factor, dry basis

$\%O_2$ = measured oxygen concentration, dry basis expressed as a percentage

H_{in} = heat input rate in MMBtu/hr

$$\text{Equation (9)} \quad H_{\text{in}} = \frac{R * \text{HHV}}{10^6}$$

Where:

R = mass fuel rate in lbs/hr

HHV = higher heating value of the fuel in Btu/lb

The average F_d factors are provided in EPA Reference Test Method 19 for different fuels and are shown in Table 4. Also in Table 4 are the higher heating values (HHV) of fuel.

Table 4 - Fuel Factors and Higher Heating Values

Fuel Type	F _d (dscf/MMBtu)	HHV(Btu)
Coal		
anthracite	10,100	12,300/lb
bituminous	9,780	13,000/lb
lignite	9,860	7,200/lb
Oil		
residual	9,190	150,000/gal
distillate	9,190	140,000/gal
Gas		
natural	8,710	1,050/scf
Wood	9,240/lb	5,200/lb
Wood Bark	9,600/lb	4,500/lb

EXAMPLE 1

Company A operates a distillate oil-fired boiler. The fuel rate is 20 gallons of oil per hour. The percent O₂ in their exhaust gas is 2.1%. Determine the stack gas flow rate Q_{dscfm}.

Step 1 - Calculate the heat input rate (H_{in}) MMBtu/hr

$$H_{in} = (R * HHV) / 10^6$$

$$H_{in} = (20 \text{ gal/hr} * 140,000 \text{ Btu/gal} * 1\text{MM}) / 10^6$$

$$H_{in} = 2.8 \text{ MMBtu/hr}$$

Step 2 - Calculate the stack gas flow rate Q_{dscfm}

From Table 4, the F_d factor for distillate oil is 9,190 dscf/MMBtu.

$$Q = F_d * ((20.9) / (20.9 - \%O_2)) * (H_{in} / 60)$$

$$Q = 9,190 * ((20.9) / (20.9 - 2.1)) * (2.8 / 60)$$

$$Q_{dscfm} = 477$$

CALCULATING HOURLY MASS EMISSION RATE

According to Equation 1 (see page 5), calculating the mass emission rate might appear to be quite simple; just multiply the stack gas concentration of air pollutant by the stack gas flow rate to get a mass emission rate. The trick in making this calculation is being sure the units of concentration of air pollutants are compatible with the units of the stack gas flow rate. The following equations will explain how the air pollutant concentrations reported in stack tests and CEMS data (see Table 1) can be converted to the hourly mass emission rate expressed in units of pounds per hour (lbs/hr).

CONVERTING PPMVD TO LBS/HR

$$\text{Equation (10)} \quad \frac{C_{\text{ppmvd}} * MW * Q_{\text{dscfm}} * 60 \text{ min/hr}}{V_{\text{ideal}} * 10^6} = \text{lbs/hr}$$

$$\frac{\text{lb-mole pollutant} * \text{lb pollutant} * \text{lb-mole air} * \text{ft}^3 \text{ air} * 60 \text{ min}}{\text{MM lb-mole air} * \text{lb-mole pollutant} * 386.5 \text{ ft}^3 \text{ air} * \text{min} * \text{hr}} = \text{lb/hr}$$

EXAMPLE 2

Company B operates a boiler equipped with a CEM for SO₂. According to the CEM, the in-stack concentration of SO₂ is 33 ppmvd. The stack gas flow rate Q_{dscfm} is 155,087. What is the emission rate of SO₂ in lbs/hr?

Using Equation 10 and the molecular weight of SO₂ is 64 (i.e., 32+(16 * 2)):

$$\frac{33 * 64 * 155,087 * 60}{386.5 * 10^6} = 51 \text{ lbs of SO}_2/\text{hr}$$

CONVERTING MG/M3 TO LBS/HR

The mass of air pollutant per volume of stack gas (mg/m³) is corrected to dry standard conditions. Thus, to calculate the mass emission rate, the concentration of air pollutant is multiplied by the stack gas flow rate, in units of dscfm.

$$\text{Equation (11)} \quad \frac{C_{\text{mg/m}^3} * V_{\text{dscfm}} * 60 \text{ min/hr} * 0.02832 \text{ m}^3/\text{ft}^3}{453.6 \text{ gram/lb} * 1000 \text{ mg/gram}} = \text{lbs/hr}$$

$$\frac{\text{mg} * \text{ft}^3 * \text{lb} * \text{min} * \text{m}^3 * \text{gram}}{\text{m}^3 * \text{min} * \text{gram} * \text{hr} * \text{ft}^3 * \text{mg}} = \text{lbs/hr}$$

CONVERTING LBS/SCF TO LBS/HR

$$\text{Equation (12)} \quad C_{\text{lb/scf}} * Q_{\text{scfm}} * 60 \text{ min/hr} = \text{lbs/hr}$$

$$\frac{\text{lb} * \text{ft}^3 * \text{min}}{\text{ft}^3 * \text{min} * \text{hr}} = \text{lbs/hr}$$

CONVERTING LBS/DSCF TO LBS/HR

$$\text{Equation (13)} \quad C_{\text{lb/dscf}} * Q_{\text{dscfm}} * 60 \text{ min/hr} = \text{lbs/hr}$$

$$\frac{\text{lb} * \text{ft}^3 * \text{min}}{\text{ft}^3 * \text{min} * \text{hr}} = \text{lbs/hr}$$

CONVERTING GRAINS/DSCF TO LBS/HR

Equation (14) $C_{\text{grains/dscf}} * 1 \text{ lb}/7000 \text{ grains} * Q_{\text{dscfm}} * 60 \text{ min/hr} = \text{lbs/hr}$

$$\frac{\text{grains} * \text{lb} * \text{ft}^3 * \text{min}}{\text{ft}^3 * \text{grains} * \text{min} * \text{hr}} = \text{lbs/hr}$$

CONVERTING LB/1,000 LBS (ACTUAL) TO LBS/HR

Equation (15) $\frac{\text{lb pollutant} * Q_{\text{acfm}} * 60 \text{ min/hr} * p_{\text{aw}}}{1000 \text{ lb air}} = \text{lbs/hr}$

$$\frac{\text{lb pollutant} * \text{ft}^3 * \text{min} * \text{lb air}}{\text{lb air} * \text{min} * \text{hr} * \text{ft}^3} = \text{lbs/hr}$$

CONVERTING LB/1,000 LBS (DRY) TO LB/HR

The density of air at dry standard conditions is 0.075 lbs/ft³

Equation (16) $\frac{\text{lb pollutant} * Q_{\text{dscfm}} * 60 \text{ min/hr} * 0.075 \text{ lb/ft}^3}{1000 \text{ lb air}} = \text{lbs/hr}$

$$\frac{\text{lb pollutant} * \text{ft}^3 * \text{min} * \text{lb air}}{\text{lb air} * \text{min} * \text{hr} * \text{ft}^3} = \text{lbs/hr}$$

STEP 2 - CALCULATING THE SOURCE SPECIFIC EMISSION FACTOR

The hourly mass emission rate determined from CEMS or stack test data (see Step 1) can be converted into a source specific emission factor. An emission factor is the amount of pollutant emitted per activity. Activities are typically expressed in terms of material usage, e.g., tons of coal or gallons of oil fired. The basic equation used in emission factor calculations is:

Equation (17) Emission Factor (EF) = $\frac{\text{Emission Rate (ER}_{\text{hourly}})}{\text{Activity (A}_{\text{hourly}})}$

$$\frac{\text{lb of pollutant emitted}}{\text{ton of material}} = \frac{\text{lb pollutant emitted} * \text{hr}}{\text{hr ton of material}}$$

See page 42 for additional discussion on source specific emission factors.

EXAMPLE 3

Company B operates a boiler that has an SO₂ emission rate (ER) of 51 lbs/hr. During the stack test, the coal firing rate (A) was 6.7 tons/year. Calculate the SO₂ emission factor (EF).

Using Equation 17:

$$EF_{SO_2} = \frac{51 \text{ lbs SO}_2/\text{hr}}{6.7 \text{ tons coal combusted/hr}}$$

$$EF_{SO_2} = 7.612 \text{ lbs SO}_2/\text{ton of coal}$$

For Combustion Sources: Often a stack test may report emissions in units of lbs/MMBtu. This is calculated by taking the lbs of pollutant/hr emission rate from the test and dividing by the heat input rate H_{in} (see Step 1 below). To convert lbs/MMBtu to an annual emission rate, use the fuel throughput and heating value of fuel (see Step 2 below).

$$(18) \quad \text{lbs pollutant/MMBtu} * \text{MMBtu/year} * \text{ton}/2000 \text{ lb} = \text{tons pollutant/yr}$$

Step 1 - Converting lbs/hr to lbs/MMBtu:

$$(\text{lbs pollutant/hr}) / H_{in} = \text{lbs pollutant/MMBtu}$$

Where: $H_{in} = \frac{R * HHV}{10^6}$

$$\frac{\text{lbs pollutant}}{\text{hr}} * \frac{\text{hr}}{\text{lbs fuel}} * \frac{\text{lbs fuel}}{\text{Btu}} * \frac{10^6}{1 \text{MM}} = \frac{\text{lbs pollutant}}{\text{MMBtu}}$$

Step 2 - Calculating MMBtu/year

$$HHV * \text{lbs fuel used/year} = \text{MMBtu/year}$$

$$\frac{\text{Btu}}{\text{lbs fuel}} * \frac{\text{lbs fuel}}{\text{year}} * \frac{\text{MM}}{10^6} = \frac{\text{MMBtu}}{\text{year}}$$

Step 3 - Converting lbs/MMBtu to tons/year

$$\frac{\text{lbs pollutant}}{\text{MMBtu}} * \frac{\text{MMBtu}}{\text{year}} * \frac{1 \text{ ton}}{2000 \text{ lbs}} = \frac{\text{tons pollutant}}{\text{year}}$$

STEP 3 - DETERMINING THE ANNUAL MASS EMISSION RATE

The annual mass emission rate is the product of the source specific emission factor (determined in Step 2) multiplied by an annual activity rate. Some examples of an annual activity rate are tons of coal combusted per year or gallons of paint applied per year.

$$(19) \text{ Annual Emission (ER}_{\text{annual}}) = \text{Emission Factor (EF)} * \text{Activity (A}_{\text{annual}})$$

$$\frac{\text{lb of pollutant emitted}}{\text{yr}} = \frac{\text{lb pollutant emitted}}{\text{ton of material}} * \frac{\text{ton of material}}{\text{yr}}$$

EXAMPLE 4

Company B burns 41,000 tons of coal during the year. What is the annual mass emission rate (ER) of SO₂?

Using Equation 19:

$$\text{ER}_{\text{annual}} = 7.612 \text{ lbs SO}_2/\text{ton of coal} * 41,000 \text{ tons coal/yr} * 1 \text{ ton}/2000 \text{ lbs}$$

$$\text{ER}_{\text{annual}} = 156 \text{ tons of SO}_2/\text{yr}$$

One final key point to consider when deriving an annual mass emission rate from source test data: Stack tests are generally only conducted over several hours or days at most. It's a snap shot of the emission unit's emissions. Over time, changes to the emission unit may occur that could result in emission rates that are different than those taken during the stack test. The facility may then have to conduct a new test to reflect these new operating conditions.

MASS BALANCE

Mass balance is a method that estimates emissions by analyzing inputs of raw materials to an emission unit and accounting for all of the various possible outputs of the raw materials in the form of air emissions, wastewater, hazardous waste, and/or the final product. As the term implies, one needs to account for all the materials going into and coming out of the process for such an emission estimation to be credible.

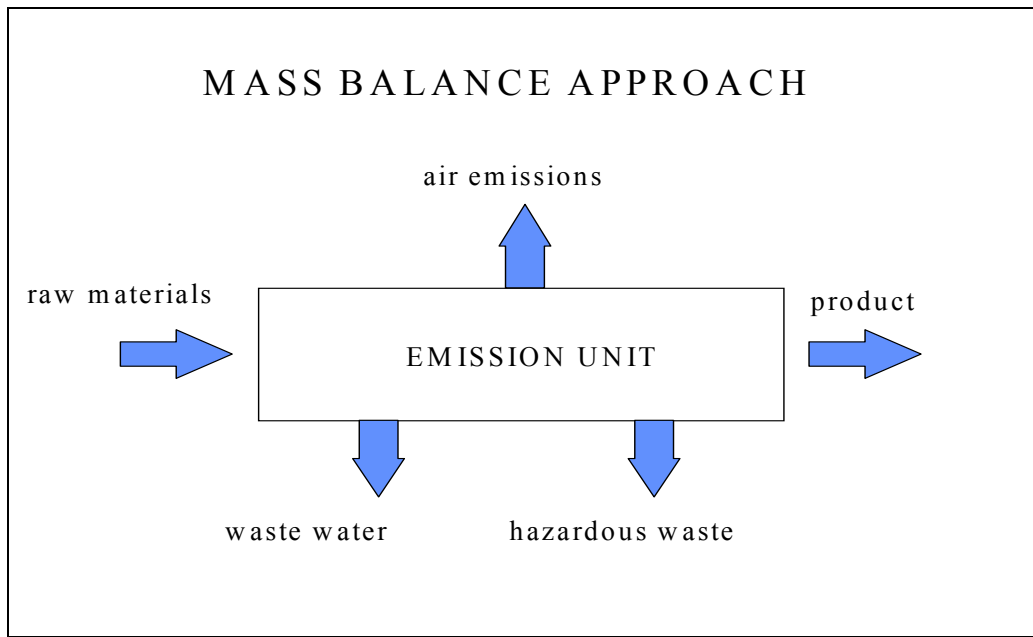


Figure 2. Mass Balance

A mass balance approach can provide reliable average emission estimates for specific emission units. For some emission units, a mass balance may provide a better estimate of emissions than an emission test would. In general, mass balances are appropriate for use in situations where a high percentage of material is lost to the atmosphere (e. g., sulfur in fuel, or solvent loss in an uncontrolled coating process).

The use of mass balance involves the examination of a process to determine whether emissions can be estimated solely on knowledge of operating parameters, material compositions, and total material usage. The simplest mass balance assumes that all solvent used in a process will evaporate to become air emissions somewhere at the facility. For instance, for many surface coating operations, it can be assumed that all of the solvent in the coating evaporates to the atmosphere during the application and drying processes. In such cases, emissions equal the amount of solvent contained in the surface coating plus any added thinners.

Mass balances are greatly simplified and very accurate in cases where all of the consumed solvent is emitted to the atmosphere. But many situations exist where a portion of the evaporated solvent is captured and routed to a control device such as an afterburner (incinerator) or condenser. In these cases, the captured portion must be measured or estimated by other means, and the disposition of any recovered material must be accounted for. As a second example, in degreasing operations, emissions will not equal solvent consumption if waste solvent is removed from the unit for recycling or incineration. A third example is where some fraction of the diluent (which is used to liquefy cutback asphalt, for example) is believed to be retained in the substrate (pavement) rather than evaporated after application. In these examples, a method of accounting for the non-emitted solvent is required to avoid an overestimation of emissions.

Mass balances may be inappropriate where material is consumed or chemically combined in the process, or where losses to the atmosphere are a small portion of the total process throughput. As an example, applying mass balances to petroleum product storage tanks is not generally feasible because the losses are too small relative to the uncertainty of any metering devices. In these cases, emission factors can be used.

EXAMPLE 3

Estimating Emissions Using Mass Balance with a Single Component

In one process, Company C uses a solvent bath to clean its product, widgets. The solvent density is 7.7 pounds per gallon. (The density of the solvent is used to convert from gallons of solvent to pounds of solvent in the emission calculation). Xylene is the only substance in the solvent for which emissions must be quantified, and it constitutes 87% of the solvent by weight. At the beginning of the year, Company C had 7,500 pounds of this solvent in storage and purchased another 9 tons over the year. At the end of the year, the facility had 10,000 pounds in storage.

- Assumptions:
- Xylene is a volatile organic compound and the total volume is usually emitted to the atmosphere. Thus, emissions equal amount of xylene used.
 - No control device is used to reduce the emissions of solvent.

Because emissions equal the amount of xylene used, emissions (ER) are determined using the following equation:

$$\text{Equation (20) } ER = (SB + SI - SE) * F$$

Where:

- ER = Annual emissions of xylene (lb/yr)
SB = Amount of solvent in storage at the beginning of the year (lb)
SI = Amount of solvent purchased during the year (lb)
SE = Amount of solvent left in storage at the end of the year (lb)
F = Fraction of xylene in the solvent, lb xylene/lb solvent

$$\begin{aligned} ER &= [7,500 \text{ lb} + (9 \text{ tons} \times 2,000 \text{ lb/ton}) - 10,000 \text{ lb}] * 0.87 \text{ lb xylene/lb solvent} \\ &= (15,500 \text{ lbs}) \times (0.87 \text{ lb xylene/lb solvent}) \\ &= 13,485 \text{ lbs of xylene emitted} \end{aligned}$$

CONSIDERATIONS WHEN CALCULATING VOC EMISSIONS

The VOC content of coating can be expressed in a number of different ways. For example, lbs of VOC/ gallon of coating or lbs of VOC/ gallon of coating minus water and exempt organic solvents. When calculating your annual emissions of VOC, make certain that the total gallons of coating used in a year is compatible with what is in the denominator of the VOC content of the coating.

EXAMPLE 4

Company D uses a coating that has a VOC content of 5.27 lb VOC /gal of coating minus water and exempt organic solvent. The company used 5, 452 gallons of coating in the year. The percent by volume of water and exempt organic solvents in the coating is 5 % and 15 %, respectively. Calculate their annual emissions of VOCs.

Step 1 - Determine volume of water and exempt organic solvents

5,452 gallons coating * (5% + 15%) = 1,090 gallons of water and exempt organic solvents

Step 2 - Determine gallons of coating minus water and exempt organic solvents

5,452 - 1,090 = 4,362 gallons of coating minus water and exempt organic solvents

Step 3 - Calculate annual emissions of VOC

5.27 lb VOC/gallons of coating minus water and exempt solvent *
4,362 gallons of coating minus water and exempt solvents/year =
22,989 lbs VOC/year

EMISSION CALCULATIONS USING FUEL ANALYSIS

Fuel analysis can be used to predict emissions based on the application of mass balance. The presence of certain elements in fuels may be used to predict their presence in emission streams. These include toxic elements such as metals found in coal; as well as other elements such as sulfur, that may be converted to other compounds during the combustion process.

The basic equation used in fuel analysis emission calculations is:

$$\text{Equation (21) } ER = R * PC * (MW_p/MW_f)$$

Where:

ER = pollutant emission rate

R = fuel flow rate (lb/hr)

PC = pollutant concentration in fuel (%/100)

MW_p = molecular weight of pollutant emitted (lb/lb-mole)

MW_f = molecular weight of pollutant in fuel (lb/lb-mole)

For example, SO₂ emissions from oil combustion can be calculated based on the concentration of sulfur in the oil. This approach assumes complete conversion of sulfur to SO₂. Therefore, for every pound of sulfur (MW = 32 g) burned, 2 lb of SO₂ (MW = 64 g) are emitted. The application of this emission estimation technique is shown in Example 5.

EXAMPLE 5

Calculate the SO₂ emissions from the combustion of oil based on fuel analysis results and the fuel flow information.

fuel flow rate R = 46,000 lbs/hr
percent sulfur (% S) in fuel = 1.17

$$\begin{aligned}ER &= R * PC * (MW_p/MW_f) \\ &= (46,000) * (1.17/100) * (64/32) \\ &= 1,076 \text{ lbs SO}_2/\text{hr}\end{aligned}$$

EMISSION FACTORS AND EMISSION MODELS

WHAT ARE EMISSION FACTORS?

An emission 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. An emission factor is a ratio of the amount of a pollutant emitted per throughput of material (for example, pounds of NO_x per gallon of residual oil burned). Emission factors are founded on the premise that there exists a linear relationship between the emissions of air contaminant and the activity level. A wide variety of sources can use emission factors to estimate their emissions.

The general equation for calculating uncontrolled emissions using an emission factor is:

$$\text{Equation (22) } ER_A = EF_A * CF_1 * CF_2 * A_1 * A_2 * (100-EC/100)$$

Where:

ER_A = emissions of pollutant A

EF_A = emission factor of pollutant A

CF = 1 or more conversion factors (if necessary)

A = 1 or more activity values

EC = overall emission control efficiency (%) (if controlled).

Activity data (A) quantify the activities associated with a given emission factor (examples include tons of raw material burned, processed, handled, charged, and received). The conversion factors (CF) are those factors needed to apply the emission factor to the activity data. This includes factors such as the heat content of fuel expressed in Btu's per ton of fuel.

The following are examples of emission factor calculations.

- Calculation for fuel combustion requiring a single conversion factor and a single activity value:

$$ER = EF (\#benzene / MMBtu\ heat) \times CF (MMBtu\ heat / ton\ coal) \times A (ton\ coal)$$

- Calculation of dust from hauling dirt requires two activity values:

$$ER = EF (\#PM / yard^3 - mile\ dirt\ hauled) \times A1 (yard^3\ dirt) \times A2 (miles\ hauled)$$

LIMITATIONS OF EMISSION FACTORS

Data from source-specific stack tests or continuous emission monitoring systems are usually preferred for estimating a source's emissions because those data provide the best representation of the tested source's emissions. However, test data from individual sources are not always available and, even then, they may not reflect the variability of actual emissions over time. Thus, emission factors are frequently the best or only method available for estimating emissions, in spite of their limitations.

Average emissions differ significantly from source to source and, therefore, emission factors frequently may not provide adequate estimates of the average emissions for a specific source. The extent of between-source variability that exists, even among similar individual sources, can be large depending on process, control system, and pollutant. Although the causes of this variability are considered in emission factor development, this type of information is seldom included in emission test reports used to develop emission factors. As a result, some emission factors are derived from tests that may vary by an order of magnitude or more. Even when the major process variables are accounted for, the emission factors developed may be the result of averaging source tests that differ by factors of five or more.

Air pollution control devices also may cause differing emission characteristics. The design criteria of air pollution control equipment affect the resulting emissions. Design criteria include such items as the type of wet scrubber used, the pressure drop across a scrubber, the plate area of an electrostatic precipitator, and the alkali feed rate to an acid gas scrubber. Often, design criteria are not included in emission test reports (at least not in a form conducive to detailed analysis of how varying process parameters can affect emissions) and therefore may not be accounted for in the resulting factors.

Before simply applying emission factors to predict emissions from new or proposed sources, or to make other source-specific emission assessments, the user should review the latest literature and technology to be aware of circumstances that might cause such sources to exhibit emission characteristics different from those of other, typical existing sources. Care should be taken to assure that the subject source type and design, controls, and raw material input are those of the source(s) analyzed to produce the emission factor. This fact should be considered, as well as the age of the information and the user's knowledge of technology advances.

EMISSION FACTORS PROVIDED WITH MAERS

The MAERS software includes a look-up table of emission factors that can be used in completing the report. The emission factors contained in the table are based upon those listed in the *Factor Information REtrieval (FIRE)* Data System. The Air Quality Division, in developing the look-up table of emission factors, edited and removed certain emission factors from *FIRE*. See the discussion beginning on page 37 on how the MAERS look-up table differs from the emission factors contained in *FIRE*.

Even though facilities are encouraged to utilize the emission factors contained in the MAERS look-up table, it is important for them to have an understanding of who develops emission factors and what other emission estimation tools are available.

OVERVIEW OF EMISSION FACTOR DISCUSSION

Following this brief introduction to emission factors, the governmental agencies that are taking the lead in emission factor and emission inventory development will be discussed. The agencies have made emission factors accessible to sources through an Internet web site known as CHIEF - Clearinghouse for Inventories and Emission Factors. CHIEF is one of sixteen programs that comprise U.S. Environmental Protection Agency's Technology Transfer Network (TTN). An explanation of all the emission factor tools located in CHIEF will be provided. These tools include, emission factor documents including *the Compilation of Air Pollution Emission Factors, AP-42*, and computer models that can provide emission data for specific emission units. In short, CHIEF is the supermarket of emission factor information.

EMISSION FACTOR RESOURCES

EMISSION FACTOR AND INVENTORIES GROUP (EFIG)

www.epa.gov/oar/oaqps/organization/emad/efig.html

The Emission Factor and Inventories Group (EFIG) is part of the Emissions, Modeling, and Analysis Division of EPA's Office of Air Quality Planning and Standards. The program is located at EPA's facility in Research Triangle Park, North Carolina. The EFIG provides leadership in the development and use of emission factors through: preparation and dissemination of technical guidance and information; enhancements to and maintenance of reference guides (*Compilation of Air Pollutant Emission Factors, AP-42*); technical information dissemination tools (e.g., *Fax CHIEF, Air CHIEF*, and the CHIEF web site); training; and conferences.

EMISSION INVENTORY IMPROVEMENT PROGRAM (EIIP)

www.epa.gov/ttn/chief/eiip

The Emission Inventory Improvement Program (EIIP) is a jointly sponsored effort of the State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officials (STAPPA/ALAPCO) and EPA. The EIIP Steering Committee and technical committees are composed of state, local, industry, and EPA representatives. The goal of EIIP is to provide cost-effective, reliable emission inventories that are an aggregation of emission data from specific sources of air pollution. State regulatory agencies use emission inventories in tracking trends in air releases and the development of new regulations. Since reliable emission inventories must be built upon the latest emission factors, the EIIP has developed some important emission factor tools that facilities subject to MAERS should consult. Methods for estimating air emissions from various industrial processes are available at www.epa.gov/ttn/chief/eiip/techreport/volume02/index.html.

CLEARINGHOUSE FOR INVENTORIES & EMISSION FACTORS (CHIEF)

www.epa.gov/ttn/chief

All of the latest information on air emission inventories and factors developed by the EFIG and EIIP are organized on the CHIEF web site which is one of 16 web sites of the Technology Transfer Network (TTN) (see Figure 3). The TTN Web is a computer system administered by the Office of Air Quality Planning and Standards (OAQPS), U.S. EPA consisting of a collection of air quality related web sites. Each web site focuses on a different aspect of air quality or the Clean Air Act. The various sites contain on-line databases, downloadable computer programs, newsletters, and regulatory information. Because of the available functionality, the TTN Web is being touted as a primary communication and outreach vehicle by the OAQPS. Many of the reports and information found in the TTN are in Adobe® Acrobat® Reader 3.0 which can be viewed or printed.



Figure 3. CHIEF

In addition to CHIEF, there is one other TTN web site containing emission factor information: Clean Air Technology Center (CATC). This web site (www.epa.gov/ttn/catc) offers free engineering assistance, a hotline, and technical guidance to state and local air pollution control agencies in implementing air pollution control programs.

Figure 4 (following) is an overview of all the components of CHIEF.

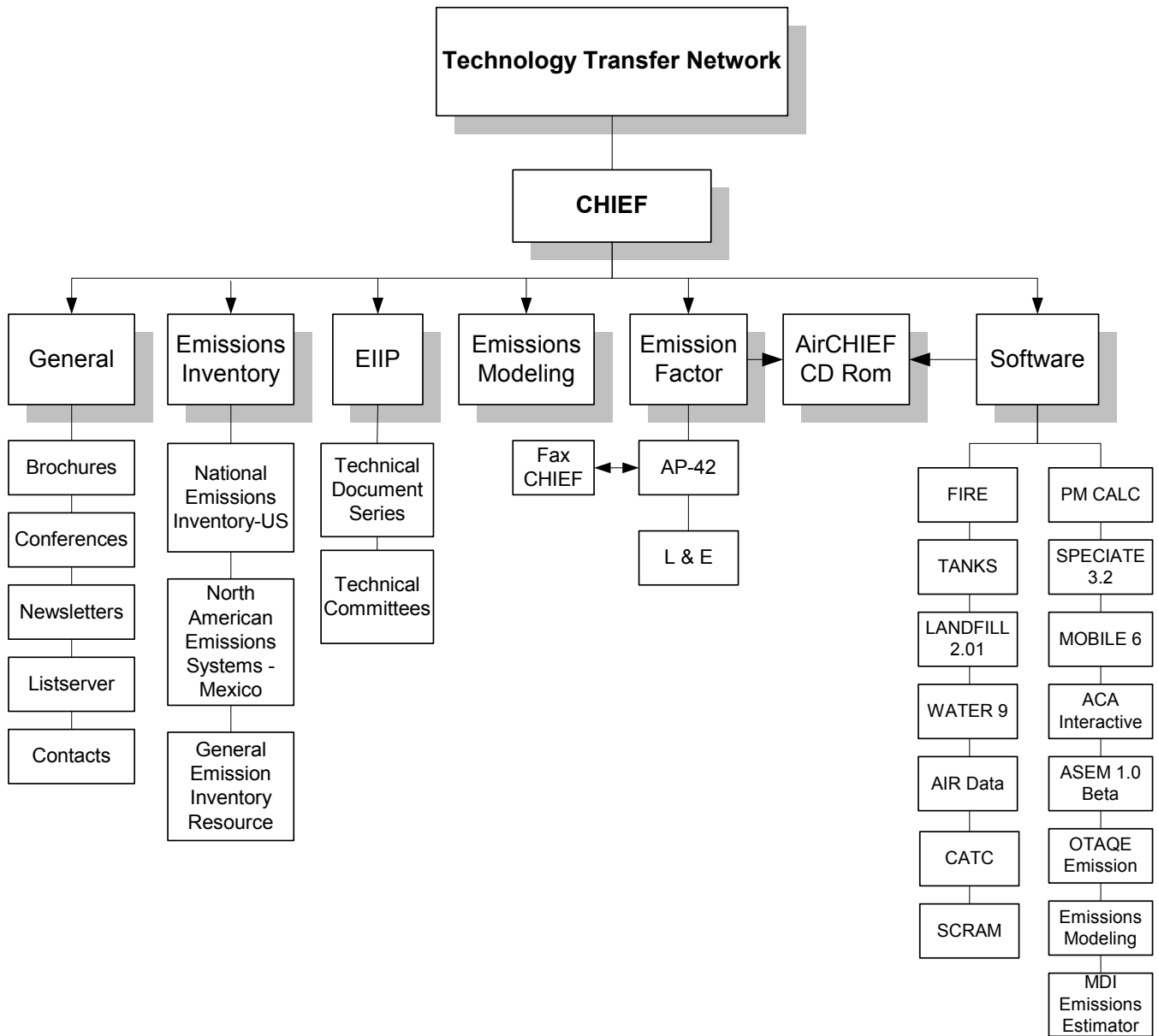


Figure 4. Overview of CHIEF

EMISSION FACTOR PUBLICATIONS

There are three major publications containing criteria and toxic air pollutant emission factor information:

1. *Compilation of Air Pollutant Emission Factors*
AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources and Supplements A, B, C, D, E & F,
2. *EIIP Technical Report Series, Volumes I - Point Sources and Volume II - Area Sources, and*
3. *Locating and Estimating (L&E) Air Toxic Emissions Document Series.*

Each of these publications is available from the CHIEF web site.

Compilation of Air Pollutant Emission Factors (AP-42)

www.epa.gov/ttn/chief/ap42/index.html

The Fifth Edition of the *Compilation of Air Pollutant Emission Factors (AP-42), Volume I*, compiles emission factors and descriptions of activities that produce criteria and toxic pollutant emissions for most stationary point and area sources. The emissions data in the *AP-42* document have been gathered from source tests, material balance studies, and engineering estimates. *AP-42* is divided into an introduction, 14 chapters and 5 appendices (see Table 5 below). Each chapter covers a different major industry or source category, and contains at least one section describing a specific operation with common products or similar process methodologies. *Volume II of AP-42* deals with mobile sources.

Since the February 1995 release of the Fifth Edition of *AP-42*, additions and changes to the emission factors have been placed in supplements. For the latest updates of the *AP-42* emission factors, Supplements A-F should be reviewed in their entirety. The supplements are found in CHIEF at www.epa.gov/ttn/chief/ap42/ap42supp.html

The fact that an emission factor for a pollutant or process is not available from EPA does not imply that the EPA believes the source does not emit that pollutant or that the source should not be inventoried, it is only that EPA does not have enough data to provide any advice.

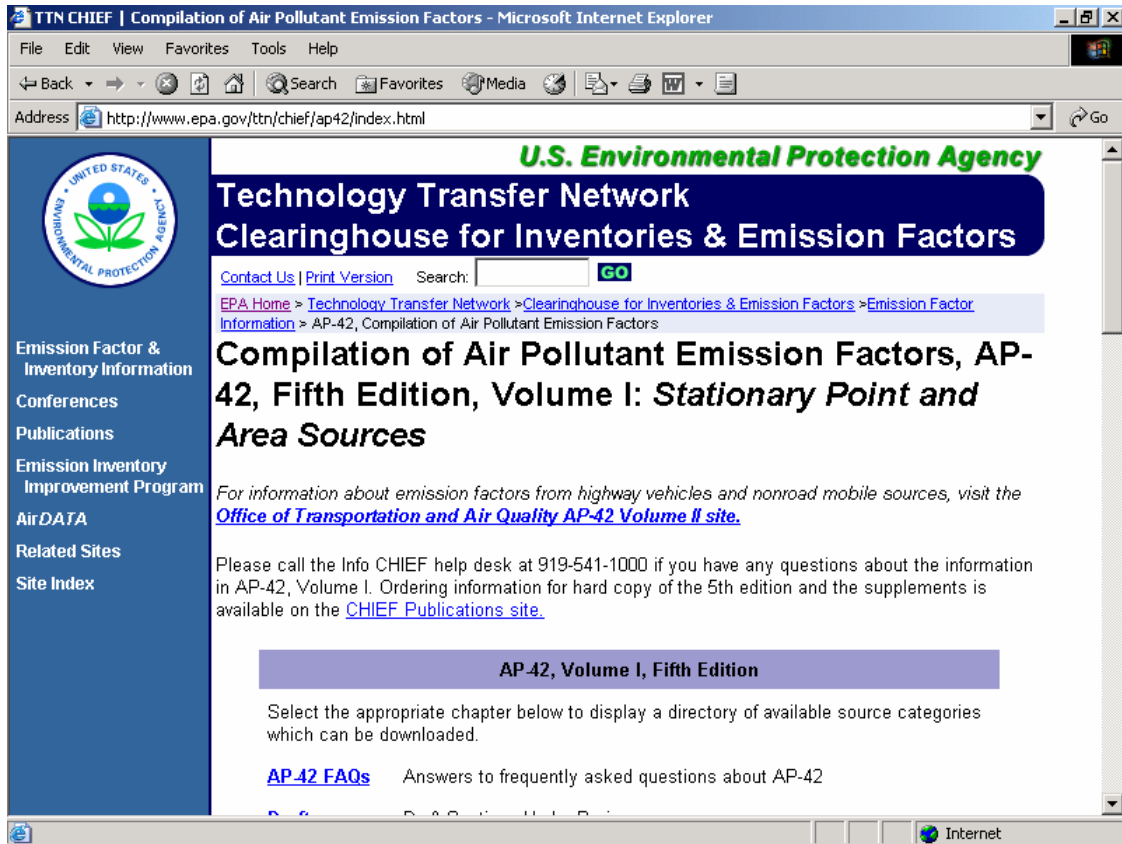


Figure 6. AP-42

Table 5 - AP-42 Table of Contents

Chapter 1	External Combustion Sources
Chapter 2	Solid Waste Disposal
Chapter 3	Stationary Internal Combustion Sources
Chapter 4	Evaporation Loss Sources
Chapter 5	Petroleum Industry
Chapter 6	Organic Chemical Process Industry
Chapter 7	Liquid Storage Tanks
Chapter 8	Inorganic Chemical Industry
Chapter 9	Food and Agricultural Industries
Chapter 10	Wood Products Industry
Chapter 11	Mineral Products Industry
Chapter 12	Metallurgical Industry
Chapter 13	Miscellaneous Sources
Chapter 14	Greenhouse Gas Biogenic Sources

Pollutant Terminology and Conventions In AP-42

The need for clearly and precisely defined terms in *AP-42* should be evident to all. The factors in this document represent units of pollutants (or for ozone, precursors) for which there are National Ambient Air Quality Standards (NAAQS). These are often referred to as "criteria" pollutants. Factors may be presented also for hazardous air pollutants (HAPs) designated in the Clean Air Act and for other regulated and unregulated air pollutants. If the pollutants are volatile organic compounds or particulate matter, additional species or analytical information may be needed for specific applications.

Many pollutants are defined by their chemical names, which often may have synonyms and trade names. Trade names are often given to mixtures to obscure proprietary information, and the same components may have several trade names. For assurance of the use of the proper chemical identification, the Chemical Abstract Service (CAS) number for the chemical should be consulted along with the list of synonyms. The pollutant terminology and conventions currently used in *AP-42* are discussed below.

Particulate Matter

There are a number of terms commonly associated with the general pollutant, "particulate matter" (PM). They include three different particle size forms, and four different composition forms:

Particle Size Forms

- PM (particulate matter – all sizes)
- PM-10 (particulate matter less than 10 microns in diameter)
- PM-2.5 (particulate matter less than 2.5 microns in diameter)

Composition Forms

- PRIMARY (sum of filterable particulate and condensable particulate)
- TOTAL (same as PRIMARY, but both form names are currently being used)
- FILTERABLE (that portion of the particulate which is collected on a filter)
- CONDENSABLE (that portion of the particulate which is collected in impingers after passing through a filter)

Within a stack sampling train there are two locations where particulate matter is collected. In the front half of the train, particulate matter is collected on a filter. EPA Method 5 is used to determine the mass of this filterable particulate. In the back half of the sampling train, particulate matter is condensed in the sampling train impingers. EPA Method 202 is used to determine this condensable particulate.

The inorganic gas, AMMONIA (NH₃) is considered as a haze precursor and, as such, is being added to the list of criteria pollutants. Reporting began with the 2002 emissions inventory.

For MAERS reporting, the particulate matter form and AMMONIA, if present, are required to be reported and are shown with their emission factors, in the color blue at the bottom of the E-101 Emissions form within the software.

Organic Compounds

Precursors of the criteria pollutant "ozone" include organic compounds. "Volatile organic compounds" (VOCs) are required in a State Implementation Plan (SIP) emission inventory. VOCs have been defined by EPA (40 CFR 51.100, February 3, 1992) as "any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric chemical reactions." There are a number of compounds deemed to have "negligible photochemical reactivity", and these are therefore exempt from the definition of VOC.

Toxic, Hazardous, and Other Noncriteria Pollutants

Hazardous Air Pollutants are defined for EPA regulatory purposes in Title III of the Clean Air Act Amendment (CAAA). However, many states and other authorities designate additional toxic or hazardous compounds, organic or inorganic, that can exist in gaseous or particulate form. Also, as mentioned, compounds emitted as VOCs may be of interest for their participation in photochemical reactivity. Few EPA Reference Test Methods exist for these compounds, which may come from the myriad of sources covered in this document. However, test methods are available to allow reasonable reliable quantification of many compounds, and adequate test results are available to yield estimates of sufficient quality to be included in this document. Where such compounds are quantified herein with emission factors, they represent the actual mass of that compound emitted. Totals for PM or VOC, as appropriate, are inclusive of the component species unless otherwise noted. There are a limited number of gaseous hazardous or toxic compounds that may not be VOCs, and whenever they occur they will be identified separately.

The Emission Inventory and Improvement Group (EIIP) produces a separate series of reports that focus on a number of the more significant HAPs and related sources. The title of these documents begin with "Locating And Estimating Emissions From Sources of . . . (Substance)." See page 33 for a description of these publications.

Emission Factor Ratings

Each *AP-42* emission factor is given a rating from A through E and U, with A being the best. The factor's rating is a general indication of the reliability of that factor. This rating is based on the estimated eligibility of the tests used to develop the factor and on both the amount and the representative characteristics of those data. In general, factors based on many observations, or on more widely accepted test procedures, are assigned higher rankings. The factors are determined by *AP-42* authors and reviewers. Because emission factors can be based on source tests, modeling, mass balance, or other information, factor ratings can vary greatly.

Test data quality is rated A through D, and ratings are thus assigned:

A = Tests are performed by a sound methodology and are reported in enough detail for adequate validation.

B = Tests are performed by a generally sound methodology, but lacking enough detail for adequate validation.

C = Tests are based on an unproven or new methodology, or are lacking a significant amount of background information.

D = Tests are based on a generally unacceptable method, but the method may provide an order-of-magnitude value for the source.

The AP-42 emission factor rating is an overall assessment of the reliability of a factor. It is based on both the quality of the test(s) or information that is the source of the factor and on how well the factor represents the emission source. Higher ratings are for factors based on many unbiased observations, or on widely accepted test procedures. For example, ten or more source tests on different randomly selected plants would likely be assigned an "A" rating if all tests are conducted using a single valid reference measurement method. Likewise, a single observation based on questionable methods of testing would be assigned an "E", and a factor extrapolated from higher-rated factors for similar processes would be assigned a "D" or an "E".

AP-42 emission factor quality ratings are thus assigned:

A Excellent. Factor is developed from A- and B-rated source test data taken from many randomly chosen facilities in the industry population. The source category population is sufficiently specific to minimize variability.

B Above Average. Factor is developed from A- or B-rated test data from a "reasonable number" of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with an A rating, the source category population is sufficiently specific to minimize variability.

C Average. Factor is developed from A-, B-, and/or C-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A rating, the source category population is sufficiently specific to minimize variability.

D Below Average. Factor is developed from A-, B- and/or C-rated test data 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 population.

E Poor. Factor is developed from C- and D-rated test data, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population.

U Unranked Too little data to rank.

Other Ways To Obtain AP-42 Information And Updates

In addition to downloading all or part of *AP-42* from the CHIEF web site, the emission factors in the *AP-42* are in the *Air CHIEF CD* (see page 40) and in the *Factor Information REtrieval System (FIRE)* (see page 34).

The following paper copies of *Volume I of AP-42* and three supplements are available from the Government Printing Office:

AP-42 5 TH Volume 1	(Stock Number: 055-000-00500-1)	\$72
Supplement A	(Stock Number: 055-000-00551-6)	\$32
Supplement B	(Stock Number: 055-000-00565-6)	\$47.50
Supplement C	(Stock Number: 055-000-00587-7)	\$11
Supplement D	(not available from GPO)	
Supplement E	(not available from GPO)	
Supplement F	(not available from GPO)	

To order, visit the Government Printing Office web site at: <http://bookstore.gpo.gov>

GPO Access User Support Team contacts: Ph: (202) 512-1530
Toll Free: (888) 293-6498
Fax: (202) 512-1262
e-mail: gpoaccess@gpo.gov

Emission Inventory Improvement Program (EIIP) Preferred And Alternative Methods For Estimating Air Emissions
www.epa.gov/ttn/chief/eiip/techreport/index.html

EIIP focuses on producing documents that maximize the use of existing emission estimation information. EIIP documents present preferred and alternative methods for collecting data and calculating emissions from point, area, mobile, and biogenic source categories. For each document, EIIP assembles all available emissions and source activity data information for a specific source category. A committee of technical experts (from EPA, state and local agencies, and industry) then chooses the most appropriate procedures, standardizes their presentation, and describes the circumstances in which to best use the information.

The EIIP guidance development process does not develop new emission factors, nor will EIIP documents replace AP-42. EIIP relies on emission factors from AP-42. Users of EIIP documents are referred to the appropriate sections(s) of AP-42 for selection of emission factors or for more detailed process information. EIIP guidance and AP-42 have a complementary relationship. Table 6 below contains the table of contents.

Table 6**Table of Contents of the Preferred and Alternative Methods For Estimating Air Emissions**

www.epa.gov/ttn/chief/eiip/techreport/index.html

Volume I: Introduction

www.epa.gov/ttn/chief/eiip/techreport/volume01/index.html

Introduction and Use of EIIP Guidance for Emissions Inventory Development.

Volume II: Point Sources

www.epa.gov/ttn/chief/eiip/techreport/volume02/index.html

- Chapter 1: Introduction to Stationary Point Source Emission Inventory Development.
- Chapter 2: Preferred and Alternative Methods for Estimating Air Emissions from Boilers.
- Chapter 3: Preferred and Alternative Methods for Estimating Air Emissions from Hot Mix Asphalt Plants.
- Chapter 4: Preferred and Alternative Methods for Estimating Air Emissions from Equipment Leaks.
- Chapter 5: Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment.
- Chapter 6: Preferred and Alternative Methods for Estimating Air Emissions from Semiconductors.
- Chapter 7: Preferred and Alternative Methods for Estimating Air Emissions from Surface Coating Operations.
- Chapter 8: Preferred and Alternative Methods for Estimating Air Emissions from Paint and Ink Manufacturing.
- Chapter 9: Preferred and Alternative Methods for Estimating Air Emissions from Secondary Metal Processing.
- Chapter 10: Preferred and Alternative Methods for Estimating Air Emissions from Oil and Gas Field Production and Processing Operations.
- Chapter 11: Preferred and Alternative Methods for Estimating Air Emissions from Plastic Products Manufacturing.
- Chapter 12: How to Incorporate Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates.
- Chapter 13: Preferred and Alternative Methods for Estimating Air Emissions From Stone Mining and Quarrying Operations.
- Chapter 14: Uncontrolled Emission Factor Listing for Criteria Air Pollutants
- Chapter 15: Preferred and Alternative Methods for Estimating Air Emissions from the Printing, Packaging, and Graphic Arts Industry

Table 6 - Continued

Volume III: Area Sources

www.epa.gov/ttn/chief/eiip/techreport/volume03/index.html

Chapter 1:	Introduction to Area Source Emission Inventory Development
Chapter 2:	Residential Wood Combustion
Chapter 3:	Architectural Surface Coating
Chapter 4:	Dry Cleaning
Chapter 5:	Consumer and Commercial Solvent
Chapter 6:	Solvent Cleaning
Chapter 7:	Graphics Arts
Chapter 8:	Industrial Surface Coating
Chapter 9:	Pesticides - Agricultural and Nonagricultural
Chapter 10:	<i>Not Yet Available</i>
Chapter 11:	Gasoline Marketing Draft 1999 National VOC Inventory for Gasoline Distribution (<i>addition</i>)
Chapter 12:	Marine Vessel Loading, Ballasting and Transit
Chapter 13:	Autobody Refinishing
Chapter 14:	Traffic Paints
Chapter 15:	Municipal Landfills
Chapter 16:	Open Burning
Chapter 17:	Asphalt Paving
Chapter 18:	Structure Fires
Chapter 24:	Conducting Surveys For Area Source Inventories
Volume IV:	Mobile Sources
Volume V:	Biogenic Sources
Volume VI:	Quality Assurance Procedures and DARS Software
Volume VII:	Data Management Procedures
Volume VIII:	Estimating Greenhouse Gas Emissions
Volume IX:	Particulate Emissions
Volume X:	Emission Projections

Other Ways To Obtain Information and Updates

Volumes I through VII were printed in July 1997. In addition to being printed from the web site, they are available in hardcopy by calling the Info CHIEF Help Desk. The phone number (919) 541-1000 or fax (919) 541-5680

Locating and Estimating (L&E) Document Series

www.epa.gov/ttn/chief/le/index.html

The *L&E* documents are the result of an EPA program to compile and publish information on specific toxic air pollutants and the source categories from which these emissions are expected. These documents are pollutant- or source-specific. Each of the *L&Es* identifies and quantifies emissions from specific source categories and includes general process descriptions, potential release points, and emission factors.

L&Es are hazardous air pollutant (HAP) specific reports that present emission factors and process flow diagrams. Emission factors from the *L&Es* are not subject to the same strict development guidelines required for *AP-42* and consequently, may be of lower quality.

CHIEF SOFTWARE

www.epa.gov/ttn/chief/software/index.html

Emission models or software have been developed by EPA to estimate emissions for a limited number of processes. These models are generally more accurate than an emission factor used in a linear equation. All of the models may be downloaded from the TNN Web (see Figure 7).

The screenshot shows a web browser window with the address <http://www.epa.gov/ttn/chief/software/index.html>. The page header features the U.S. Environmental Protection Agency logo and the text "U.S. Environmental Protection Agency Technology Transfer Network Clearinghouse for Inventories & Emission Factors". Below the header is a search bar with a "GO" button and a breadcrumb trail: "EPA Home > Technology Transfer Network > Clearinghouse for Inventories & Emission Factors > CHIEF Software and Tools". The main content area is titled "Software and Tools" and contains a table of CHIEF Software models:

CHIEF Software		
Air CHIEF	FIRE	PM Calculator
SPECIATE 3.2	TANKS	Area Source Emission Model (ASEM) version 1.0.92 BETA
National Emissions Inventory Input Format (NIF) & the National Emissions Inventory Quality Assurance / Quality Control Software		
Explanation of File Formats		

Below the table is a section for "EPA Related Software and Tools". The left sidebar contains navigation links: "Emission Factor & Inventory Information", "Conferences", "Publications", "Emission Inventory Improvement Program", "AirDATA", "Related Sites", and "Site Index".

Figure 7. Models Available From CHIEF

Factor Information Retrieval (FIRE) Data System www.epa.gov/ttn/chief/software/fire/index.html

Emission factors are available from the *Factor Information REtrieval (FIRE)* Data System (see Figure 8). *FIRE* is a database management system containing over 18,500 emission factors to estimate the emission of criteria and hazardous air pollutants from stationary, area, and mobile sources. *FIRE* allows easy access to criteria and hazardous air pollutant emission factors obtained from the *Compilation of Air Pollutant Emission Factors (AP-42)*, *Locating and Estimating (L&E)* series documents, factors derived from state-reported test data, and factors taken from literature searches.

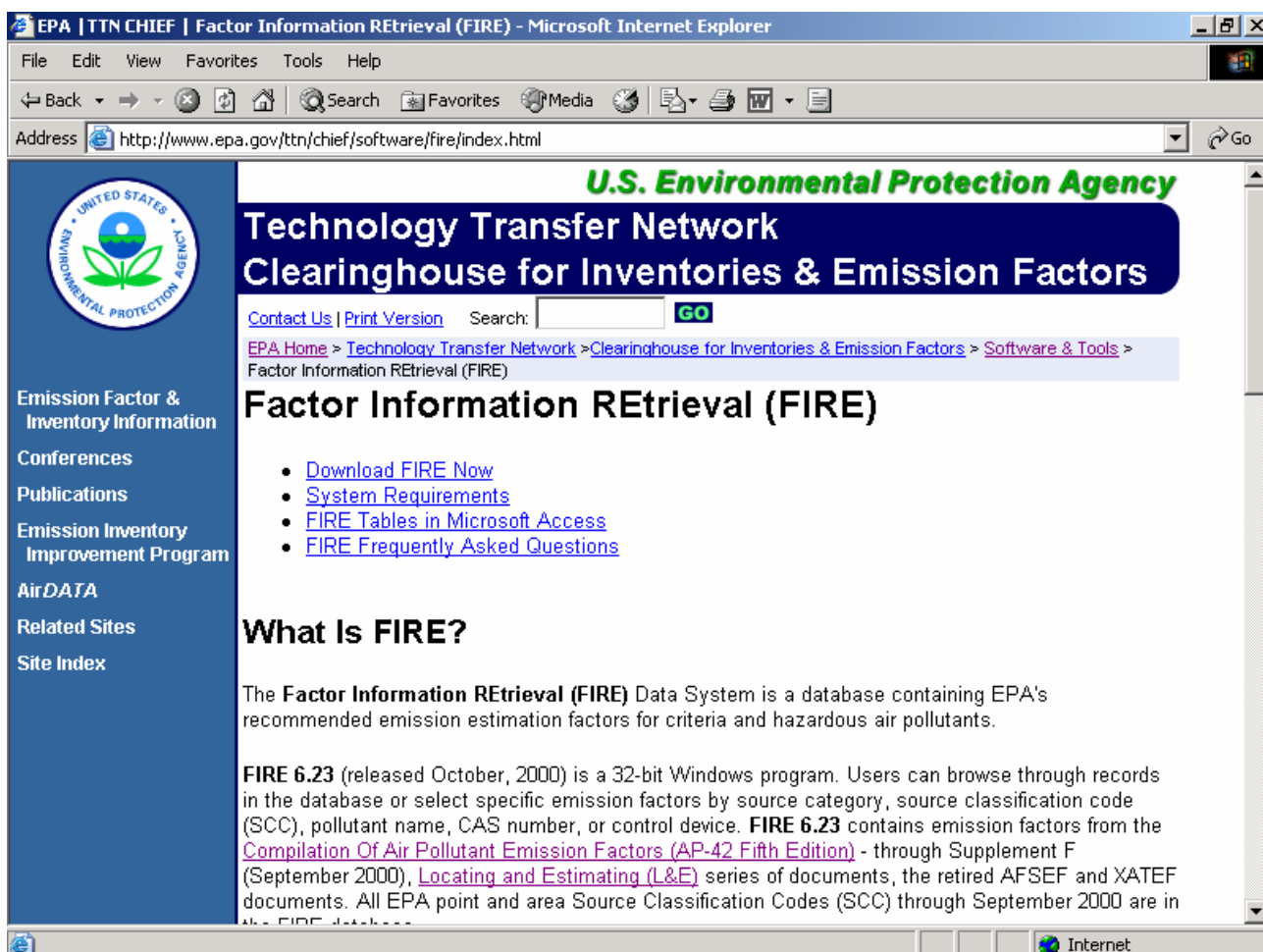


Figure 8. FIRE

Some of the emission factor data in the air toxics module of the *FIRE* tool come from a number of emissions source testing reports developed under the California Air Resources Board (CARB) air regulatory initiative (AB-2588). Some of these CARB data are of particularly high quality because they are derived from pooled source tests of similar sources within an industry in California. Sources in the CARB pooled emissions source testing include oil and gas production, asphalt production, petroleum refining, and fuel combustion.

Each emission factor in *FIRE* also includes information about the pollutant (Chemical Abstract Service [CAS] numbers and chemical synonyms) and about the source (Standard Industrial Classification [SIC] codes and descriptions, and SCCs and descriptions). Each emission factor entry includes comments about its development in terms of the calculation methods and/or source conditions, as well as the references where the data were obtained. The emission factor entry also includes a data quality rating.

FIRE Version 6.23 (released October 2000) is a user-friendly, menu-driven Windows® program that can run under Windows® 95/98 or Windows® NT. Users can browse through records in the database or can select specific emission factors by source category name or source classification code (SCC), by pollutant name or CAS number, or by control device type or code. *FIRE 6.23* contains emission factors from *AP-42* through *Supplement F*.

How MAERS Look-up Emission Factor Table and FIRE Differ

The Air Quality Division has installed an edited version of *FIRE 6.23* in the MAERS software referred to as the look-up table of emission factors. Below is an explanation of how *FIRE* was edited.

- All *FIRE* emission factors that are identified as “less than or equal to” or as a “range” have been changed to “equal to” or “mean” factors. Emission ranges are not accepted by MAERS.
- When *FIRE* identifies more than one emission factor for a pollutant for one SCC code, only one emission factor appears in the MAERS look-up table. For example, a SCC code in *FIRE* may display emission factors for SO₂ and SO_x. Only one of these emission factors will appear in MAERS.
- Some *FIRE* emission factors have been replaced with Michigan emission factors. They primarily involve surface coating operations and were part of the old Michigan Air Pollution Reporting (MAPR) system.

As a reminder, the emission factors contained in the MAERS look-up table are provided for reference and should not be used if more accurate information is available.

TANKS

www.epa.gov/ttn/chief/software/tanks/index.html

TANKS is a Windows-based computer software program that estimates volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions from fixed- and floating-roof storage tanks. *TANKS* is based on the emission estimation procedures from Chapter 7 of EPA's *Compilation of Air Pollutant Emission Factors, AP-42*. The user's manual, available in Adobe Acrobat format and WordPerfect, explains the many features and options of *TANKS*. The program includes on-line help for every screen.

TANKS uses chemical, meteorological, roof fitting, and rim seal data to generate emissions estimates for several types of storage tanks, including: vertical and horizontal fixed roof tanks, internal and external floating roof tanks, dome external floating roof tanks, and underground storage tanks. To use the program, enter specific information about storage tank construction and the stored liquid. The *TANKS* program then estimates the annual or seasonal emissions of VOC and produces a report. The emissions can be separated into breathing and working losses. A batch mode of operation is available to generate a single report for multiple tanks.

The *TANKS* program employs a chemical database of over 100 organic liquids, and a meteorological database of over 240 cities in the United States. The program allows the addition of more chemicals and cities, if desired. *TANKS* is capable of calculating individual component emissions from known mixtures and estimating emissions from crude oils and selected refined petroleum products using liquid concentration HAP profiles supplied with the program.

Landfill Gas Air Emissions Model (version 2.01)

www.epa.gov/ttn/chief/software

The *Landfill Gas Emissions Model* was developed by the Clean Air Technology Center (CATC). This model can be used to estimate emission rates for methane, carbon dioxide, nonmethane organic compounds, and individual HAPs from landfills. The program can also be used by landfill owners and operators to determine if a landfill is subject to the control requirements of the federal New Source Performance Standard (NSPS) for new municipal solid waste landfills (40 CFR 60 Subpart WWW) or the emission guidelines for existing municipal solid waste landfills (40 CFR 60 Subpart Cc).

PM Calculator

www.epa.gov/ttn/chief/software/pmcalc/index.html

PM Calculator is applicable to point sources only and requires the user to input uncontrolled emissions (either total filterable particulate or filterable PM-10) for each source, the source category classification (SCC) and the control device, if any. The program will then calculate controlled emissions for filterable PM-2.5 and filterable PM-10 for each point source.

Speciate 3.2

www.epa.gov/ttn/chief/software/speciate/index.html

The *SPECIATE* database contains organic compound and particulate matter speciated profiles for more than 300 source types. The profiles attempt to break the total volatile organic compound (VOC) or particulate matter (PM) emissions from a particular source into the individual compounds (in the case of VOC) or elements (for PM).

WATER9

www.epa.gov/ttn/chief/software/water/

WATER9 is a Windows based computer program consisting of analytical expressions for estimating air emissions of individual waste constituents in wastewater collection, storage, treatment, and disposal facilities; a database listing many of the organic compounds; and procedures for obtaining reports of constituent files, including air emissions and treatment effectiveness. Contact the WATER9 and CHEMDAT8 hotline at (919)541-5610 for more information.

MDI Emissions Estimator Software

www.polyurethane.org/regulatory/emissions.asp/index.html

MDI Emissions Estimator Software is a tool that provides a fast and convenient method to estimate MDI emissions from typical process applications and activities. The software program is based upon the methodology outlined in the [MDI/Polymeric MDI Emissions Reporting Guidelines for the Polyurethane Industry](#). The program has built-in calculation modules to estimate emissions for the following activities:

- Working and breathing losses from storage tanks
- Enclosed processes based upon cavity size
- Fugitive Emissions from process areas
- Enclosed processes based upon foam density
- Open continuous processes
- Filling/Blending operations
- Open processes involving adhesive/coating operations
- Spills

Included in the software are 18 illustrated examples based upon real-life applications. Illustrated examples include:

Adhesives	Boats	Particleboard
Air Filter	Doors	Rebond
Appliance- Refrigerator	Filling/Blending	Recreation
Appliance -Truck	Laminator Boardstock	Spills
Automotive	Mobile Homes	Spray Foam
Boardstock	Packaging	Water heater

CATC Software

www.epa.gov/ttn/catc/products.html#software

CATA Software contains a variety of ZIP files, WordPerfect files, Acrobat files, and ASCII text files that can be downloaded to your PC. The programs are compressed files that can be used to estimate emissions for a variety of control devices such as electrostatic precipitators, scrubbers and incinerators. The site also contains a number of reports from studies conducted on a variety of devices.

MOBILE6

www.epa.gov/otaq/m6.htm

The EPA's Vehicle Emission Modeling Software, *MOBILE6*, is an emission factor model for predicting gram per mile emissions of HC, CO, NO_x, CO₂, PM, and toxics from cars, trucks, and motorcycles under various conditions. It is used by EPA in evaluating control strategies for highway mobile sources, by States, and other local and regional planning agencies in the development of emission inventories and control strategies for State Implementation Plans (SIPs) under the Clean Air Act, and in the development of environmental impact statements (EISs).

Air CHIEF

www.epa.gov/ttn/chief/software/airchief/index.html

As a part of its commitment to protecting global air quality, the U. S. Environmental Protection Agency is working to provide current emissions data in convenient, easy-to-access formats to federal, state, and local regulatory agencies, businesses, and the general public. An important tool in this effort is the Air ClearingHouse For Inventories And Emission Factors (*Air CHIEF*) in CD-ROM format.

The *Air CHIEF* CD-ROM gives the public and private sector users access to air emission data specific to estimating the types and quantities of pollutants that may be emitted from a wide variety of sources. Updated annually, *Air CHIEF* offers on one disc literally thousands of pages contained in some of EPA's most widely used and requested documents. Included are the US EPA Emission Factor and Inventory Group's most popular emission estimation tools. *Air CHIEF* is published annually.

Air CHIEF version 9.0 has been developed in Adobe Acrobat® format and is **now available** for distribution by the Government Printing Office. This version of *Air CHIEF* contains many features, such as linking between related documents, web links directly to the CHIEF web site for easy access to the most recent updates, and enhanced full-CD searching. Included on *Air CHIEF* version 9.0 are:

- Compilation of Air Pollutant Emission Factors (AP-42), Fifth Edition, Volume 1: Stationary Point and Area Sources (including Supplements A, B, C, D, E, F and Update 2001)
- Compilation of Air Pollutant Emission Factors (AP-42), Fifth Edition, Volume 2: Mobile Sources, selected tables
- EIIP Preferred and Alternative for Estimating Air Emissions from (source)
- AP-42 Background Files
- Factor Information Retrieval (*FIRE*) Version 6.23 Data
- Source Classification Codes (codes)/Area and Mobile Source (AMS) Codes, October 2000

-
- 1997 North American Industrial Classification System (NAICS) matched to 1987 U.S. Standard Industrial Classification Codes (SIC)
 - 1999 National Toxics Inventory Documentation for Area and Mobile Sources
 - Emission Inventory Guidance for the Implementation of Ozone and PM NAAQS and Regional Haze Regulations
 - Emission Inventory Training Material
 - Handbook for Criteria Pollutants Emission Inventory Development
 - National Air Pollutant Emission Trends Report 1900-1998
 - National Air Pollutant Emission Trends Procedures 1985-1999

Also included on *Air CHIEF* are the installable copies of these software programs:

- *BEIS*
- *CHEM9*
- *FIRE*
- *Landfill Model*
- *PMCALC*
- *SPECIATE*
- *WATER9*

Version 9.0 System Requirements

The minimum requirements to run *Air CHIEF* are an IBM-compatible PC with a 486 processor running at 33 megahertz or better (a 486 or Pentium processor is recommended), with at least 4 MB RAM, 5 MB hard disk space, plus 7 MB additional temporary disk space available during installation. *Air CHIEF* requires a CD-ROM drive and must be used with Windows 95, Windows 98 or Windows NT to utilize all features. For viewing PDF files inside of a Web browser, Netscape Navigator versions 3.0 or later or Microsoft Internet Explorer or later are recommended (*Data on the CD-ROM can be retrieved using other operating systems with the appropriate Acrobat Reader.*)

How to Order Air CHIEF

The *Air CHIEF* CD-ROM Version 9.0 is available by calling the Info Chief Help Desk at (919) 541-1000 or send e-mail to info.chief@epa.gov.

Where To Go For Help On CHIEFS

For information or assistance regarding the availability or use of any of the CHIEF tools and services, contact the Info CHIEF help desk:

By e-mail: info.chief@epa.gov

By phone: (919) 541-1000

By fax: (919) 541-5680

By mail: Info CHIEF
Emission Factor And Inventory Group (MD-14)
Office of Air Quality Planning and Standards
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

SOURCE-SPECIFIC EMISSION FACTORS

Source-specific emission factor data are similar to and are used in the same manner as generic emission factor data, except that they are applicable to a specific source/device/process. Source-specific emission factors can be developed from fuel analyses, source tests, and laboratory analysis. These data are often available as a part of the information developed for permitting and enforcement purposes; sometimes the facility operator will have the required data as a result of monitoring and analysis performed by the facility operator for purposes of quality control and process optimization. Inquiries of the facility operator are necessary to determine the existence and extent of the data available for use in developing emission factors for a specific source/device/process.

Source-specific emission factors may also be available in the form of emissions per hour that a process creates at a device. These data are often developed as a result of permit processing and may be used as an allowable emission rate for the device/process. Emission rate data can be used if it is representative of the actual operating conditions and is not simply an upper limit that is seldom achieved.

INDUSTRY-SPECIFIC GUIDANCE

The Air Quality Division of the Michigan Department of Environmental Quality is continually working closely with trade associations to develop some industry specific guidance on estimating annual air pollution emissions from facilities. The guidance includes the SCC codes that should be reported, along with emission factors, emission models, and other factors that sources should consider when submitting their report. Currently, guidance has been developed for the following nine industries:

- Coating
- Electroplating
- Foundries
- Hot Mix Asphalt Plants
- Landfills
- Mineral Product Processes
- Oil And Gas Industry
- Petroleum Bulk Plants and Terminals
- Plastic Manufacturing

