Estimation of Emissions

*Recommended Methods for Completion of the
Construction Permit Application Form EC*

Disclaimer

This construction permit manual cannot be used to bind the Iowa DNR, and it is not a substitute for applicable state and federal statutes and regulations.

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Acronyms and Key Terms

ACFM	Actual Cubic Feet per Minute
ASTM	American Society for Testing and Materials
CEMS	Continuous Emissions Monitoring System
CO	Carbon Monoxide
DNR	Iowa Department of Natural Resources
DSCFM	Dry Standard Cubic Feet per Minute
EPA	United States Environmental Protection Agency
HAP	Hazardous Air Pollutant
IAC	Iowa Administrative Code
LBS	Pounds
LPG	Liquefied Petroleum Gas
mmbtu	Million British Thermal Units
mmcf	Million Cubic Feet
mmscf	Million Standard Cubic Feet
NO_X	Nitrogen Oxides
Pb	Lead
PSD	Prevention of Significant Deterioration
PM	Particulate Matter
PM_{10}	Particulate Matter less than or equal to 10 microns in diameter
$PM_{2.5}$	Particulate Matter less than or equal to 2.5 microns in diameter
SCF	Standard Cubic Feet
SO_2	Sulfur Dioxide
THAP	Total Hazardous Air Pollutants
VOC	Volatile Organic Compound

On-line Resources and Tools

DNR Air Quality Bureau
http://www.iowacleanair.gov

EPA Emission Factors
To access AP-42 and WebFIRE emission factors go to:
http://www.epa.gov/ttn/chief/

SIC Codes
www.osha.gov/pls/imis/sicsearch.html

NAICS Codes
http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012
http://www.naicscode.com/

SCC Codes
http://www.iowadnr.gov/InsideDNR/RegulatoryAir/EmissionsInventory/EmissionsEstimateTools.aspx
Scroll down to "Classification Lists." Click on "Source Classification Code (SCC) List." Ethanol and Biodiesel plants should click on "Ethanol and Biodiesel Source Classification Code (SCC) List."

Calculation Spreadsheet and Tools
To access calculation spreadsheets for painting operations, haul roads, and asphalt, concrete and limestone processes go to:
http://www.iowadnr.gov/InsideDNR/RegulatoryAir/EmissionsInventory/EmissionsEstimateTools.aspx
Scroll down to "Emissions Inventory Worksheets" then click on the spreadsheet of interest.

Iowa Administrative Code (IAC)
http://www.legis.iowa.gov/IowaLaw/AdminCode/agencyDocs.aspx
https://www.legis.iowa.gov/law/administrativeRules/agencies
See section 567, Chapters 20-32

Construction Permit Application Forms. Instructions and Guidance Documents
http://www.iowadnr.gov/InsideDNR/RegulatoryAir/ConstructionPermits/ConstructionPermittingMaterials.aspx

Chapter 1: Introduction

This document provides guidance for estimating emissions for use on the construction permit application Form EC. It is intended to reflect the most recent information on data sources, emission factors, and methods that are consistent with DNR and EPA guidance. The applicant is required to calculate emissions for each emission point for all regulated air pollutants including the seven criteria pollutants and other regulated non criteria pollutants. The pollutants asked to be reported on the Form EC are:

- Particulate Matter (PM)
- Particulate matter with an aerodynamic diameter ≤ to 10 microns (PM_{10})
- Particulate matter with an aerodynamic diameter ≤ to 2.5 microns ($PM_{2.5}$)
- Sulfur Dioxide (SO_2)
- Nitrogen Oxides (NO_x)
- Volatile Organic Compounds (VOC)
- Carbon Monoxide (CO)
- Lead (Pb)
- Single Hazardous Air Pollutant (SHAP) – meaning the highest individual HAP emitted
- Total Hazardous Air Pollutants (THAP) – meaning the combined emissions from all HAP emitted

The definition of volatile organic compounds (VOC) can be found in Appendix A and a listing of all 187 regulated HAPs can be found in Appendix B.

This document does not mandate the use of specific estimation methods, but recommends emission factors and estimation methods. It is intended to be a living document which the DNR plans to periodically update to incorporate new or updated emission factors and methods as they become available.

To stay informed of important updates, please visit the Air Quality Bureau's webpage. Additionally, you may wish to subscribe to the "IAirTech" list serve, which delivers regulatory news, program updates, and technical guidance directly to your email. To subscribe, send a blank E-mail to: join-iairtech@lists.ia.gov. The subject line should remain blank.

Chapter 2: Emissions Estimation Methods

This chapter provides a general overview of available methods for estimating emissions. There is not a prescribed estimation method for construction permit applications, rather a range of options that can be used based on the data available to the applicant. Estimation methods for specific source types are included later in this document. Also additional resources for estimation methods are listed at the end of this chapter.

When selecting the method used to calculate emissions, it is important to understand the difference between potential and actual emissions. In general, **potential emissions** reflect the emissions that will occur if an emission unit is operated at its maximum design rate. Federal enforceable limits may be used to reduce the calculated potential emissions. Examples of federally enforceable limits found in permits include restrictions on the amount of fuel burned, hours operated, or raw material processed. **Actual emissions** are the actual rate of pollutant emissions from an emission unit calculated using the emission unit's actual operating hours, production rates, and quantities of materials processed, stored, or combusted. Please refer to the definitions of both potential-to-emit (PTE) and actual emissions from 567 IAC 22.100 located in the glossary of this document. Examples of both potential and actual emission calculations can be found on page 17 of this document.

General Hierarchy
Emissions must be based on the best possible method and may vary between source categories. In general, DNR recommends that emissions be calculated using the hierarchy of estimation methods detailed below. The methods listed are in order of decreasing accuracy. Supporting documentation that allows DNR to recreate your calculations should be included for any calculations that cannot be easily verified. Please note that CEM data and stack tests are measures of actual emissions during a specific time period.

1. ***Continuous Emissions Monitoring System (CEMS)*** directly measure pollutant concentrations in the exhaust stack 24 hours a day. When combined with a flowmeter it can also convert the concentration into an accurate mass measurement. This is the most accurate method for determining continuous actual emissions.

    Most likely used for: NO_X, SO_2 or CO emissions from utilities, portland cement plants, large combustion units or other units with CEMs.

2. A ***Stack Test*** measures the concentration of pollutants in the exhaust stack during the test period and converts the concentration to a mass measurement using the flow measured during the test period. Stack test data can provide an accurate source-specific emission rate for many different processes and pollutants under the testing conditions measured.

    Most likely used for: PM, PM_{10}, $PM_{2.5}$, SO_2, NO_x, CO, Pb, VOC or HAP from a source where a test has been completed or for estimating emissions for sources that are identical or similar to sources where a test has been completed.

3. ***Material Balance or Mass Balance*** can only be used on specific types of emission units. Information must first be gathered on process rates, material used, and material properties (usually from ***safety data sheets*** (SDS) sometimes also referred to as MSDS). By combining this information with the knowledge of the process, an emission estimation can be made.

    Most likely used for: VOC and HAP emissions from surface coating operations and estimated SO_2 emissions from combustion using the sulfur content of the fuel.

4. ***EPA or State-Approved Emissions Factors*** are the basis for many calculations. Emission factors generally represent industry averages and show the relationship between quantity of emissions and the production rate. Sources of emission factors are contained in Chapter 6 of this guide.

    Most likely used for: PM, PM$_{10}$, PM$_{2.5}$, SO$_2$, NO$_X$, CO, Pb, VOC or HAP from any source where a source categories has been evaluated by the EPA or state.

5. ***Vendor Supplied Emissions Factors or Emissions Data*** may be used if stack test information or EPA-approved emissions factors are not available. This data should only be used to calculate emissions if the manufacturer's data is based on approved EPA reference method stack testing and no significant changes have been made to the emission unit. Many times vendor estimates of emissions do not correlate to the pollutants required to be documented on the construction permit application because vendors use alternative methods to test emissions. Supporting documentation must be submitted to show how the estimation was made.

6. ***Engineering Estimation*** is allowed if a more preferred method is not available. Some processes may have no published guidance regarding the estimation of emissions. In these cases, the estimation must be the best possible assessment given the amount of data available. Supporting documentation must be submitted to show how the estimation was made.

Avoid these Commons Mistakes Made by Applicants

✓ *Overestimated control efficiencies*
There are cases where an applicant will calculate emissions based on an unrealistic control efficiency for the type of control. Assuming high control efficiency may result in the DNR requiring a compliance demonstration such as a stack test or additional monitoring and recordkeeping on the control device in a final permit. If the applicant is proposing to use higher control efficiency than is claimed by the guidance document in Appendix C, supporting documentation should be included with the application to substantiate the claims.

✓ *Back-calculated emissions from allowable emission rates*
Instead of using emission factors or test data, sometimes an applicant will simply use an allowable rate such as 0.1 gr/dscf and back-calculate to a proposed lb/hr emission rate. This is not acceptable and does not show the potential emissions from the process. It also does not demonstrate the ability of the process to meet the emission standards.

✓ *Using a control efficiency even though emission factor is a controlled emission factor*
Some applicants may not realize that certain emission factors already account for control equipment and they inadvertently add their control efficiency on top of the controlled emission factor.

✓ *Use of outdated emission factors*
Outdated emissions factors may not account for newer equipment that can be inherently less polluting, or better test data showing a particular pollutant is emitted at a higher rate than previously thought. This is another example of why it is important to understand where an emission factor is from and its limitations.

✓ *Not using actual test data when available*
Some applicants have used an emission factor instead of their own test data because the emission factor predicts a lower emission rate. This is why it is important to evaluate whether test data is available for the same or similar source.

✓ *Forgetting that some pollutants are both a VOC and HAP*
Many HAPs are also VOCs. List such pollutants as both a HAP and a VOC.

✓ *Not matching the units of measure when calculating emissions*
Use the correct units of measure for emission factors. Units of measure need to correspond between emission factors and the maximum rated capacity.

✓ *Not using the worst case assumptions to calculate potential emissions*
Calculation of potential emissions must be done assuming the worst case values for each pollutant. In addition, potential hours for calculating the ton per year emission rate should be divided by 8760 hours per year unless you are requesting a permit limit on the number of hours you can operate each year.

Chapter 3: Using CEMS to Estimate Emissions

A continuous emission monitoring system (CEMS) measures in real-time the continuous concentration of emissions in the stack. It determines emissions by taking periodic pollutant analyzer measurements (e.g. every several seconds to every several minutes) and using a conversion equation, graph, or computer program to calculate an emission rate. CEMS are required under some of the EPA regulations for either continual compliance determinations or determination of exceedances of the standards.

A CEMS provides the most accurate estimate of actual emissions from a specific emissions unit or group of emissions units, because it is a continuous measurement of emissions. Data from a CEMS would only be available for units that are already operating. Historically, because of the cost, CEMS have only been installed on very large sources of air contaminants.

Using CEMS to Estimate Actual Emissions

To calculate short-term actual emissions from a CEMS, a facility may use a statistical analysis, such as the 95% confidence interval. The large number of data points allows for much more accuracy in predicting the true mean for the emissions from an emission point. In calculating long-term actual emissions, the facility should sum all data from the calendar year, including appropriate data substitution to represent CEMS downtime.

Using CEMS to Estimate Potential Emissions

The use of the 95% confidence interval is not the proper methodology for representing the short-term or long-term potential emissions because the value represents the *average* emission rate and the emission point would likely be emitting at higher rates about 50% of the time.

One statistical method the DNR would recommend for estimating potential emission is to use the average emission rate from the CEMS plus two (2) standard deviations. As can be seen in Figure 1, for a normal distribution curve the mean plus or minus one (1) standard deviation contains approximately 68.27% of the data. If one uses plus or minus two (2) standard deviations it is 95.45% and finally the use of plus or minus three (3) standard deviations results in 99.73% of the data.
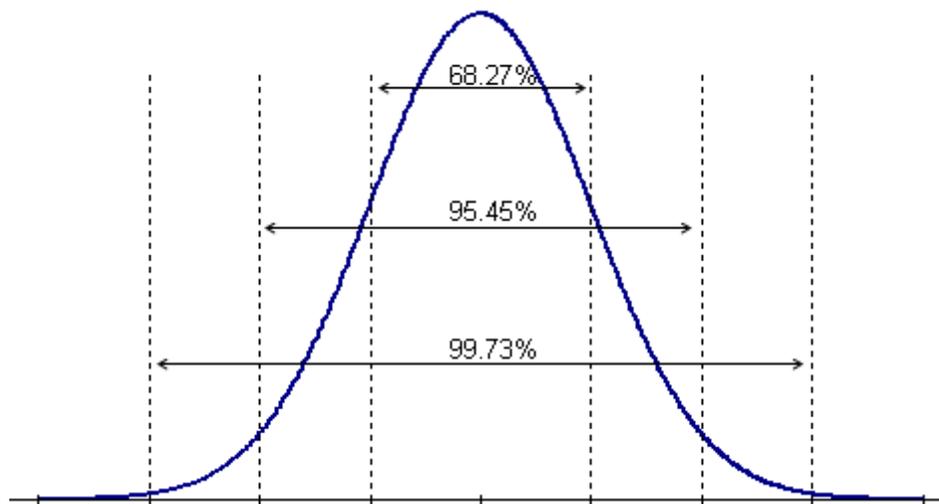
Figure 1: Normal Distribution Curve with Representation of 1, 2 and 3 Standard Deviations

The DNR feels that the average plus two standard deviations represents a reasonable degree of certainty (95.45%) for estimating the short-term potential emissions from the source. This finding is based on a

review of the methodology recommended and used by a substantial sampling of prestigious research and academic institutions.

Other statistical methods may be acceptable in estimating emissions using the actual data generated from a CEMS. However, any proposed method should be based on an approved statistical analysis technique and could be subject to additional testing to verify the estimated emissions.

Chapter 4: Using a Stack Test to Estimate Emissions

One of the most common and reliable methods of estimating emissions can be the use of test data. A stack test measures in real-time an instantaneous concentration of emissions in the stack. It determines emissions by taking many measurements across the diameter of a stack and using the actual stack flow data, temperature and moisture to calculate an emission rate.

Since stack tests sample the actual amount of pollution generated from an emission unit, the data is very reliable. Though since stack tests are based on a single instance in time, it's important to be aware that the emissions can fluctuate outside of the ranges observed during the test. Typically stack tests consist of three (3) individual runs. However, there will be variability in the tested emissions amongst the three runs.

Using a Stack Test to Estimate Actual Emissions

To calculate short-term actual emissions from a stack test, a facility may use the average emission rate determined from the three test runs. However, since there are only three runs there may be limited accuracy using this methodology. In calculating long-term actual emissions, the facility may use the average emission rate and the number of hours a source operates during the calendar year.

Using a Stack Test to Estimate Potential Emissions

In estimating potential emissions it is necessary to account for the variation of those emissions measured during the test and those emissions during the times that emissions were not measured. A reasonable statistical approach must be used to allow for the probability that emissions emitted at times other than during those measured during the three (3) test runs may result in a higher average emission rate than the previous stack test. The stack test does not define the maximum emission rate as it is only a sample of emission rates at the production rate(s) during the test. Using the average could result in an estimate this in not accurate 50% of the time, since an average rate is only a numerical treatment of the three (3) data points, but cannot predict the likelihood of a specific emission rate over the normal distribution of emissions. In order to account for this variability the use of a confidence interval is appropriate.

Confidence limits for a mean are an interval estimate for the mean. Interval estimates are desirable because the estimate of the mean varies from stack test to stack test. Instead of a single estimate for the mean, a confidence interval generates a lower and upper limit for the mean. The interval estimate gives an indication of how much uncertainty there is in the estimate of the true mean. Typically the DNR requires only one (1) stack test of three (3) individual runs. So instead of incurring additional cost by repeated testing the confidence interval is used to predict the actual spread of the emission data points. Additional testing would result in a greater number of data points which would result in greater certainty in the estimate of the true mean.

There are two (2) decisions that need to be made when using a confidence interval (CI). The first is the degree of certainty to be used. The DNR uses the 95% CI which means there is a 95% confidence the limit will be met. In other words the emission unit is not expected to exceed its emissions estimate more than 5% of the time.

The second decision is on the correct formula to be used. As stated above a stack test is only a sample of emission rates. Both the mean (μ) and the standard deviation (σ) are unknown for the emission data from an emission point. The standard deviation is replaced by the estimated standard deviation (S) which is also known as the standard error. The standard error is an estimate for the true value of the standard deviation.

Since the standard error is an estimate for the true value of the standard deviation, the distribution of the sample mean (x) is no longer normal with the mean (μ) and the standard deviation (σ). Instead, the sample mean follows the *t distribution*. The *t distribution* is also described by its degrees of freedom. For a sample size (n), the *t distribution* will have n-1 degrees of freedom. When the *t distribution* is used it is called the student T-test.

The use of the student T-test and the 95% confidence interval on stack test data to determine potential emissions is the standard statistical approach used by the DNR as well as by EPA (40 CFR Part 60, Appendix C). This statistical approach is used to predict the range of emissions based on sampled emission rates. The formula used for the upper bound 95% confidence interval is:

$$95\% \text{ CI} = \text{avg} + t\frac{S}{\sqrt{n}}$$

95% CI = the 95% confidence interval emission rate that is determined by the analysis of the stack test data

avg = the average of the stack test runs

t = the percentage point of the *t* distribution with n-1 degrees of freedom

S = the standard deviation of the test runs

n = the number of test runs being used to calculate the 95% CI.

Appendix F includes a table of t–values and also includes an example calculation of potential emissions using stack test data from a diesel fired generator.

Chapter 5: Using a Material or Mass Balance to Estimate Emissions

The use of material balances involves the examination of the process to determine whether emissions can be estimated solely on knowledge of operating parameters, material compositions, and total material usage.

One common area to apply material balances is in estimating emissions from solvent evaporation sources (e.g. surface coating operations). The simplest material balance assumes that all solvent used in a process will evaporate to become air emissions. For example, for many surface coating operations, it can be assumed that all of the organic solvent in the coating evaporates to the atmosphere during the application and drying processes. In such cases, uncontrolled emissions equal the amount of solvent contained in the surface coating plus any added thinners. The applicant will need to supply copies of Safety Data Sheets (SDS) or Product Specification Sheets which provide VOC and HAP content.

Material balances are very accurate in cases where all the consumed solvent is emitted to the atmosphere without being captured and vented to air pollution control equipment. However, if the emissions unit is equipped with air pollution control equipment, both the capture and control efficiency of the control equipment will have to be used to estimate actual emissions. Please refer to Appendix C for estimated control equipment control efficiencies. For large, controlled coating lines, it may be necessary to determine the capture efficiency by using Method 204 from Part 51, Subpart M.

In other situations, emissions will not equal solvent consumption if waste solvent is removed or collected. Moreover, for certain type of materials, (e.g., reactive coatings, some printing inks), some fraction of the solvent is believed to be retained either in final coating or the substrate rather than evaporated after application. In this case, a method of accounting for the non-emitted solvent is required to avoid an overestimation of emissions.

Another type of material balance can be used to estimate sulfur dioxide (SO_2) and hydrochloric acid (HCl) emissions from combustion sources by using stoichiometric calculations. All sulfur or chlorine in a fuel is combusted and assumed to form sulfur dioxide or hydrogen chloride. However, it is important to note that this assumption is **not** valid in the case of coal-fired units since sulfur is emitted as sulfite (SO_3) or sulfuric acid mist (H_2SO_4). In addition, some of the sulfur stays in the ash and boiler slag. In the case of HCl, some of the chlorine stays in the ash as it reacts with other components such as mercury.

Material balances, in general, are difficult to use to estimate particulate matter emissions because only a small portion of the material used in a process is emitted to the atmosphere. Facilities will need to provide good documentation to support claims of material lost during a process. Weighing the material collected in air pollution control equipment over a discrete period may be useful if no other method of estimating emissions is readily available.

Material Balance Estimation Method

To calculate potential emissions using a material balance, a facility can use their proposed material usage limit (lbs per year, gallons per year), in conjunction with their proposed material pollution concentration limit (% by weight, or lbs per gallon), subtracting the quantity consumed and quantity recovered, as appropriate, as shown in the equation below. In most cases, it is appropriate to assume that no material is consumed or recovered.

Calculating Potential Emissions using Material Balance Equation

$$\text{Emissions (TPY)} = \frac{[\text{Quantity Used} - \text{Quantity Consumed} - \text{Quantity Recovered}] * \text{Pollutant Concentration}}{2000 \text{ lb/ton}}$$

$$\text{Emissions (lb/hr)} = \frac{[\text{Emissions (tons/yr) x 2000 lb/ton}]}{\text{Potential Hours of Operation}}$$

Emissions = the amount of potential emissions of regulated pollutant from the emission point in pounds or tons per year.

Quantity Used = the amount of material the facility is requesting to use in either pounds or gallons per year.

Quantity Consumed = the amount of material that is consumed by the process being used in either pounds or tons. In most cases, it is appropriate to assume that no material is consumed.

Quantity Recovered = the amount of material that is recovered by the process being used in either pounds or tons. In most cases, it is appropriate to assume that no material is recovered. Please note that if a limit is based on an amount of material recovered the final permit will have recordkeeping requirements for the facility to track the quantity recovered.

Pollutant Concentration = the amount of regulated pollutant contained in the material the facility is requesting to use. When using a material balance approach to calculate potential emissions, it is important to use the "worst-case" values for each pollutant or material. For example, if a facility uses multiple solvents, you would base the estimate on the solvent with the highest pollutant concentration to calculate potential emissions.

Potential Hours of Operation = the number of hours the equipment will potentially operate per year. The applicant should use 8,760 hr/yr unless requesting to limit the number of hours the emission unit can operate in the construction permit.

Appendix F includes an example calculation of potential emissions using mass balance for a paint booth.

Chapter 6: Using an Emissions Factor to Estimate Emissions

The level of air emissions from a facility depends on many factors. For many industrial processes, technical information is available to assist in determining the quantity and types of air pollutants that a process would create and thus be emitted without any control. The information on the quantity of air pollutants generated during a particular process is referred to as an emissions factor.

The Environmental Protection Agency and state air pollution control agencies sometimes will develop and publish emission factors for specific source categories. This is often done when a large number of similar industrial operations are available. These factors represent industry-wide averages and show the relationship between emissions and a measure of production, such as pounds of pollution per ton of material processed. It is important when using emissions factors, you must always use the most recent approved version as industry standards and equipment changes over time.

The DNR is aware of five distinct sources of emission factors, most of which are maintained by the EPA:

- **AP-42 Compilation of Air Pollution Emission Factors** is the recommended source of air pollutant emission factors, with descriptions of activities emitting criteria and hazardous air pollutants. AP-42 can be accessed from the CHIEF Internet site http://www.epa.gov/ttn/chief/ap42/. AP-42 has been published since 1972 and is the primary accumulation of EPA's emission factor information. It contains emission factors and process information for more than 200 air pollution source categories. A source category is a specific industry sector or group of similar emitting sources. The emission factors have been developed and compiled from source test data, material balance studies, and engineering estimates. AP-42 emission factors are often the only method available for estimating emissions.

- **WebFIRE** is the internet version of EPA's Factor Information Retrieval (FIRE) Data System and it has replaced the software application, FIRE version 6.25, and the Microsoft Access version of the database. An internet version called WebFIRE allows more frequent updates and is easier to access. WebFire is available at http://cfpub.epa.gov/oarweb/index.cfm?action=fire.main. WebFire allows the user to search for emission factor information in cases where you have limited knowledge of the emissions process of interest (e.g. a wood-fired boiler). You can retrieve emission factor records by entering one or more simple terms such as source category name (e.g., dry cleaning, wood combustion, boilers), process description (e.g., spreader stoker, catalytic cracking), EPA's Source Classification Code (SCC), or any other viable search term likely to be found in an emissions factor record.

- **TANKS** is a software program that estimates VOCs and hazardous air pollutants from vertical and horizontal fixed-roof tanks, internal and external floating-roof tanks, domed external floating roof tanks and underground storage tanks. It is based on the emissions estimation procedures presented in Section 7.1 of AP-42, 5th Edition. TANKS can be downloaded from the CHIEF web site http://www.epa.gov/ttn/chief/software/tanks/. There are some reports that this program will not operate on new computers with the most recent version of the Windows operating system.

- **LandGEM** is a software program estimates the emission rates for total landfill gas, methane, CO_2 and non-methane organic compounds from landfills.

- **MDI Emissions Estimator Software** is a tool that provides a fast and convenient method to estimate MDI (methylene diisocyanate) emissions from typical process applications and activities. The tool is available in a lockable spreadsheet allowing users to easily import data and print reports. The software is available at http://polyurethane.americanchemistry.com/Health-Safety-and-Product-Stewardship/Emissions

Specific data from different states can be obtained by an internet search of their websites or by calling them and asking for specific information. No state currently maintains a published emission factor clearinghouse like the EPA.

Published emission factors are generally given a rating. This rating is an indication of reliability (or robustness) of the factor. The rating is based on the estimated reliability of the data used to develop the factor and on both the amount and the representative characteristics of the data. Factors based on many observations, or on more widely accepted test procedures are assigned higher rankings. Conversely, a factor based on a single observation of questionable quality, or one extrapolated from another factor for a similar process would likely be rated lower.

The AP-42 and FIRE emission factor rating is an overall assessment of how good a factor is based on both the quality of the data and how well the factor represents the emission source. Higher ratings are for factors based on many unbiased observations or on widely accepted test procedures.

- **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 – Unrated**. Factors generally come from the EPA locating and estimating documents. The data are not necessarily poor (i.e. "E" rated), but there is not enough information to rate the factors according to the rating protocol.

When an applicant uses a lower-rated emission factor it is important to add a safety margin into the emission factor; otherwise the applicant could be underestimating their emissions from the process.

Calculating Potential Emissions using Emissions Factor Equation

$$ER \text{ (lb/hr)} = MRC \times EF \times (1 - CE)$$

$$ER \text{ (Tons/yr)} = \frac{ER \text{ (lb/hr)} \times Hours}{2000}$$

Emission Rate (ER) = amount of potential emissions of regulated pollutant from the emission point in pounds per hour or tons per year.

Maximum Hourly Rated Capacity (MRC) = the maximum design rate of the equipment such as tons/hr, gal/hr, or MMcf/hr.

Emissions Factor (EF) = value based on the amount of pollution produced and the raw material processed such as lb/ton, lb/gal, or lb/MMcf.

Control Efficiency (CE) = control equipment pollutant removal efficiency represented as a decimal (e.g. if the control device is rated at 95% use 0.95 in the equation). More information of control efficiencies is contained in Chapter 7.

Potential Hours of Operation (Hours) = the number of hours the equipment will potentially operate per year. The applicant should use 8,760 hr/yr unless requesting to limit the number of hours the emission unit can operate in the construction permit.

Potential-to-emit is calculated assuming equipment is running at maximum capacity while operating at the maximum hours of operation under its physical and operational design. Usually, the maximum hours of operation are 8,760 hours per year unless enforceable limitations on hours of operation have been incorporated within the construction permit or an enforcement order for that equipment. **Only federally enforceable limitations on raw materials, fuels, capacity or hours of operation can be used to limit potential emissions.** "Bottlenecks" do not count unless federally enforceable. The calculation of potential emissions must be done with "worst-case" values for each pollutant.

Appendix F includes example calculations of potential emissions using emission factors for a diesel fired engine, a natural gas boiler, and a grain receiving pit.

Chapter 7: Estimating Control Equipment Efficiency

Facilities can reduce the amount of pollutants emitted to the atmosphere from these processes by installing air pollution control equipment. The level of control depends on various factors including: the type of equipment used; the design of the equipment; the process involved; temperature; air flow rates; raw materials; how well the equipment is operated and maintained; combustion products; as well as the pollutant(s) targeted for control. Control efficiency is contaminant specific. The basic types of emissions control devices are cyclones, wet scrubbers, baghouses, electrostatic precipitators, combustion systems, condensers, absorbers and adsorbers.

Generally it is best to use the information provided by the control equipment manufacturer as a guideline to estimate efficiency as they have taken into account all of the above aspects when designing a system. If information is not available from the manufacturer, DNR staff has prepared a general guidance document identifying typical control efficiencies achieved by different generic types of control equipment.

If multiple pieces of control equipment are used in series or if a capture hood is involved it is necessary to estimate the combined control efficiency.

A capture hood or capture system precedes the control equipment

This scenario arises when the process equipment is not directly ducted to the control equipment but rather uses capture hoods or fans to direct the emissions to the control equipment. In this case an estimate must be made of how well the fans direct emissions to the control equipment.

If there is a capture device the **combined control efficiency** is calculated by the following formula:

Combined Control Efficiency = Capture Efficiency x Control Efficiency

Combined Control Efficiency = the estimate of the combined efficiency of the collection system and the pollution control device in percent reduction.

Capture Efficiency = the percent of emissions expected to be captured by the collection system.

Control Efficiency = the percent of emissions expected to be controlled by the control equipment.

Example
A company submits an application for a baghouse used to control particulate matter for a grain unloading dump pit. The dump pit fan is estimated to capture 80% of the emissions that are released. The baghouse is estimated to have a control efficiency of 95%. The combined control efficiency is:

$$CE = \frac{80 \ x \ 95}{100} = 76\%$$

The combined control efficiency for particulate matter from this combination is 76%.

A system has more than one piece of control equipment installed on the same process

In the situation where a process will have multiple pieces of control equipment in series, determining the control efficiency is not as simple as adding together the control efficiencies. The control efficiency of a secondary piece of control equipment is dependent upon many factors. Therefore, caution should be used in assigning the control efficiency to the second control device because it could be considerably less efficient as a secondary control device than it would be as the primary emissions control device.

The **combined control efficiency** is calculated using the following formula:

$$\text{Control Efficiency} = (CE_1 + CE_2) - \frac{(CE_1 \text{ x } CE_2)}{100}$$

Combined Control Efficiency = the estimate of the combined efficiency of the two pollution control devices in series in percent reduction.

CE_1 = control efficiency for first device.

CE_2 = control efficiency for second device.

This formula only works for combining two control efficiencies. For combining more than two control efficiencies use the result of the combined control efficiency and the next control efficiency to calculate multiple efficiencies.

Example
A company submits an application for an emission unit that has two (2) control devices in series for particulate matter. The first control device is a cyclone with a control efficiency of 50%. The second control device is a wet scrubber with an efficiency of 80%. The combined control efficiency is:

$$CE = (50 + 80) - \frac{(50 \text{ x } 80)}{100} = 90\%$$

The combined control efficiency for particulate matter from this combination is 90%.

References

Air & Waste Management Association, Air Pollution Engineering Manual, 1992

United States Environmental Protection Agency, AP-42 Compilation of Air Pollutant Emission Factors, Volume 1, Fifth Edition, 1995. <http://www.epa.gov/ttn/chief/ap42/index.html>.

United States Environmental Protection Agency, Landfill Gas Emissions Model (LandGEM), version 3.02, 2005. <http://www.epa.gov/ttn/catc/products.html#software>.

United States Environmental Protection Agency, WebFIRE - Factor Information Retrieval (FIRE) Data System, 2005. <http://cfpub.epa.gov/webfire/>.

Glossary

Actual emissions means the actual rate of emissions of a pollutant from an emissions unit, as determined in accordance with the following:

1. In general, actual emissions as of a particular date shall equal the average rate, in tons per year, at which the unit actually emitted the pollutant during a two-year period immediately preceding that date and is representative of normal source operations. The director may allow the use of a different time period upon a demonstration that it is more representative of normal source operations. Actual emissions shall be calculated using the unit's actual operating hours, production rates, and types of materials processed, stored or combusted during the selected time period. Actual emissions for acid-rain-affected sources are calculated using a one-year period.
2. Lacking specific information to the contrary, the director may presume that source-specific allowable emissions for the unit are equivalent to the actual emissions of the unit.
3. For any emissions unit that has not begun normal operations on a particular date, actual emissions shall equal the potential to emit of the unit on that date.
4. For purposes of calculating early reductions of hazardous air pollutants, actual emissions shall not include excess emissions resulting from a malfunction or from startups and shutdowns associated with a malfunction.

Actual emissions for purposes of determining fees shall be the actual emissions calculated over a period of one year.

Continuous Emission Monitor (CEM) – Equipment that measures the concentration or emission rate of a gas or particulate matter using analyzer measurements and a conversion equation, graph, or computer program. Installation and operation of a CEM may be required by EPA or DNR to determine compliance with specific standards. Operation of a CEM must meet performance specifications, certification procedures, and recordkeeping and reporting requirements as specified in applicable regulations.

Emission Factor – The relationship between the amount of pollution produced and the amount of raw material processed. For example – pounds of CO_2 emitted per ton of coal combusted.

Material or Mass Balance - A process of estimating emissions using knowledge of the process, process rate, material used, and material properties.

Potential to emit means the maximum capacity of a stationary source to emit any air pollutant under its physical and operational design. Any physical or operational limitation on the capacity of a source to emit an air pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitation is enforceable by the administrator. This term does not alter or affect the use of this term for any other purposed under the Act, or the term "capacity factors" as used in Title IV of the Act or regulations relating to acid rain.

For the purposes of determining potential to emit for country grain elevators, the provisions set forth in 567 – subrule 22.10(2) shall apply.

For purposes of calculating potential to emit for emergency generators, "maximum capacity" means one of the following:

1. 500 hours of operation annually, if the generator has actually been operated less than 500 hours per year for the past five years;
2. 8,760 hours of operating annually, if the generator has actually been operated more than 500 hours in one of the past five years; or
3. The number of hours specified in a state or federally enforceable limit.

Stack Test – A test that measures the concentration of pollutants in the exhaust stack. Measurements are performed following procedures specified and developed by the US EPA and/or Iowa DNR. Such testing is required by DNR to be conducted by various stationary sources to determine compliance with applicable air emission limits.

Appendix A – Definition of Volatile Organic Compounds (VOC)[1]

Volatile organic compounds (VOC) means any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions. This includes any such organic compound other than the following, which have been determined to have negligible photochemical reactivity:

methane
ethane
methylene chloride (dichloromethane)
propylene carbonate
dimethyl carbonate
1,1,1-trichloroethane (methyl chloroform)
1,1,2-trichloro-1,2,2- trifluoroethane (CFC-113)
trichlorofluoromethane (CFC-11)
dichlorodifluoromethane (CFC-12)
chlorodifluoromethane (HCFC-22)
trifluoromethane (HFC-23)
1,2-dichloro 1,1,2,2-tetrafluoroethane (CFC- 114)
chloropentafluoroethane (CFC-115)
1,1,1-trifluoro 2,2- dichloroethane (HCFC-123)
1,1,1,2-tetrafluoroethane (HFC-134a)
1,1- dichloro 1-fluoroethane (HCFC-141b)
1-chloro 1,1-difluoroethane (HCFC- 142b)
2-chloro-1,1,1,2-tetrafluoroethane (HCFC-124)
pentafluoroethane (HFC-125)
1,1,2,2-tetrafluoroethane (HFC-134)
1,1,1-trifluoroethane (HFC-143a)
1,1-difluoroethane (HFC-152a)
parachlorobenzotrifluoride (PCBTF)
cyclic, branched, or linear completely methylated siloxanes
acetone
perchloroethylene (tetrachloroethylene)\
3,3-dichloro-1,1,1,2,2- pentafluoropropane (HCFC-225ca)
1,3-dichloro-1,1,2,2,3- pentafluoropropane (HCFC-225cb)
1,1,1,2,3,4,4,5,5,5-decafluoropentane (HFC 43-10mee)
difluoromethane (HFC-32)
ethylfluoride (HFC-161)
1,1,1,3,3,3-hexafluoropropane (HFC-236fa)
1,1,2,2,3-pentafluoropropane (HFC-245ca)
1,1,2,3,3-pentafluoropropane (HFC-245ea)
1,1,1,2,3- pentafluoropropane (HFC-245eb)
1,1,1,3,3-pentafluoropropane (HFC- 245fa)
1,1,1,2,3,3-hexafluoropropane (HFC-236ea)
1,1,1,3,3- pentafluorobutane (HFC-365mfc)
chlorofluoromethane (HCFC-31)
1 chloro- 1-fluoroethane (HCFC-151a)
1,2-dichloro-1,1,2-trifluoroethane (HCFC- 123a)
1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane (C4F9OCH3)
2-(difluoromethoxymethyl)- 1,1,1,2,3,3,3-heptafluoropropane ((CF3)2CFCF2OCH3)
1-ethoxy- 1,1,2,2,3,3,4,4,4-nonafluorobutane (C4F9OC2H5)
2- (ethoxydifluoromethyl)-1,1,1,2,3,3,3-heptafluoropropane ((CF3)2CFCF2OC2H5)

1,1,1,2,2,3,3-heptafluoro-3-methoxy-propane

3-ethoxy-1,1,1,2,3,4,4,5,5,6,6,6-dodecafluoro-2-(trifluoromethyl) hexane

1,1,1,2,3,3,3-heptafluoropropane

methyl formate

trans–1,3,3,3–tetrafluoropropene

2-amino-2-methyl-1-propanol (AMP)

hydrofluoropolyethers (HFPEs) as follows:

1. HCF2OCF2H (also known as HFE–134)
2. HCF2OCF2OCF2H (also known as HFE– 236cal2)
3. HCF2OCF2CF2OCF2H (also known as HFE–338pcc13)
4. HCF2OCF2OCF2CF2OCF2H (also known as H-Galden 1040X or H-Galden ZT 130 or 150 or 180)

methyl acetate and perfluorocarbon compounds which fall into these classes:

(i) Cyclic, branched, or linear, completely fluorinated alkanes

(ii) Cyclic, branched, or linear, completely fluorinated ethers with no unsaturations

(iii) Cyclic, branched, or linear, completely fluorinated tertiary amines with no unsaturations

(iv) Sulfur containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluorine.

Appendix B – List of Hazardous Air Pollutants (HAP)

CAS Number Chemical Name

A

75-07-0 Acetaldehyde
60-35-5 Acetamide
75-05-8 Acetonitrile
98-86-2 Acetophenone
53-96-3 2-Acetylaminofluorene
107-02-8 Acrolein
79-06-1 Acrylamide
79-10-7 Acrylic acid
107-13-1 Acrylonitrile
107-05-1 Allyl chloride
92-67-1 4-Aminobiphenyl
62-53-3 Aniline
90-04-0 o-Anisidine
0 Antimony Compounds
0 Arsenic Compounds
1332-21-4 Asbestos (friable)

B

71-43-2 Benzene
92-87-5 Benzidine
98-07-7 Benzoic trichloride
100-44-7 Benzyl chloride
0 Beryllium Compounds
92-52-4 Biphenyl
111-44-4 Bis(2-chloroethyl) ether
542-88-1 Bis(chloromethyl) ether
75-25-2 Bromoform
74-83-9 Bromomethane (Methyl Bromide)
106-99-0 1,3-Butadiene
106-88-7 1,2-Butylene oxide (1,2-Epoxybutane)

C

0 Cadmium Compounds
156-62-7 Calcium cyanamide
133-06-2 Captan
63-25-2 Carbaryl
75-15-0 Carbon disulfide
56-23-5 Carbon tetrachloride
463-58-1 Carbonyl sulfide
120-80-9 Catechol
133-90-4 Chloramben
57-74-9 Chlordane
7782-50-5 Chlorine
79-11-8 Chloroacetic acid
532-27-4 2-Chloroacetophenone
108-90-7 Chlorobenzene
510-15-6 Chlorobenzilate
75-00-3 Chloroethane (Ethyl chloride)
67-66-3 Chloroform

74-87-3 Chloromethane (Methyl chloride)
107-30-2 Chloromethyl methyl ether
126-99-8 Chloroprene
0 Chromium Compounds
0 Cobalt Compounds
0 Coke Oven Emissions
1319-77-3 Cresol/Cresylic acid (isomers/mixtures)
108-39-4 m-Cresol
95-48-7 o-Cresol
106-44-5 p-Cresol
98-82-8 Cumene
0 Cyanide Compounds

D

94-75-7 2,4-D, salts and esters
3547-04-4 DDE
117-81-7 Di(2-ethylhexyl) phthalate (DEHP)
334-88-3 Diazomethane
132-64-9 Dibenzofuran
96-12-8 1,2-Dibromo-3-chloropropane
106-93-4 1,2-Dibromoethane (Ethylene dibromide)
84-74-2 Dibutyl phthalate
106-46-7 1,4-Dichlorobenzene(p)
91-94-1 3,3'-Dichlorobenzidine
75-34-3 1,1-Dichloroethane (Ethylidene dichloride)
107-06-2 1,2-Dichloroethane (Ethylene dichloride)
75-09-2 Dichloromethane (Methylene chloride)
78-87-5 1,2-Dichloropropane (Propylene dichloride)
542-75-6 1,3-Dichloropropylene
62-73-7 Dichlorvos
111-42-2 Diethanolamine
121-69-7 N,N-Dimethylaniline
64-67-5 Diethyl sulfate
119-90-4 3,3'-Dimethoxybenzidine
60-11-7 4-Dimethylaminoazobenzene
119-93-7 3,3'-Dimethylbenzidine
68-12-2 Dimethyl formamide
57-14-7 1,1-Dimethyl hydrazine
131-11-3 Dimethyl phthalate
77-78-1 Dimethyl sulfate
79-44-7 Dimethylcarbamyl chloride
534-52-1 4,6-Dinitro-o-cresol
51-28-5 2,4-Dinitrophenol
121-14-2 2,4-Dinitrotoluene
123-91-1 1,4-Dioxane
122-66-7 1,2-Diphenylhydrazine

E

106-89-8 Epichlorohydrin
140-88-5 Ethyl acrylate
100-41-4 Ethylbenzene
107-21-1 Ethylene glycol
75-21-8 Ethylene oxide
96-45-7 Ethylene thiourea

151-56-4 Ethyleneimine

F
0 Fine Mineral Fibers
50-00-0 Formaldehyde

G
0 Glycol Ethers (a listing can be found on line at **http://www.epa.gov/ttn/atw/glycol2000.pdf**)

H
76-44-8 Heptachlor
87-68-3 Hexachloro-1,3-butadiene
118-74-1 Hexachlorobenzene
77-47-4 Hexachlorocyclopentadiene
67-72-1 Hexachloroethane
822-06-0 Hexamethylene-1,6-diisocyanate
680-31-9 Hexamethylphosphoramide
110-54-3 Hexane
302-01-2 Hydrazine
7647-01-0 Hydrochloric acid
7664-39-3 Hydrogen fluoride
123-31-9 Hydroquinone

I
78-59-1 Isophorone

L
0 Lead Compounds
58-89-9 Lindane

M
108-31-6 Maleic anhydride
0 Manganese Compounds
0 Mercury Compounds
67-56-1 Methanol
72-43-5 Methoxychlor
60-34-4 Methyl hydrazine
74-88-4 Methyl iodide
108-10-1 Methyl isobutyl ketone
624-83-9 Methyl isocyanate
80-62-6 Methyl methacrylate
1634-04-4 Methyl tert-butyl ether
101-14-4 4,4'-Methylenebis(2-chloroaniline)
101-68-8 Methylenebis(phenylisocyanate)
101-77-9 4,4'-Methylenedianiline

N
91-20-3 Naphthalene
0 Nickel Compounds
98-95-3 Nitrobenzene
92-93-3 4-Nitrobiphenyl
100-02-7 4-Nitrophenol

79-46-9 2-Nitropropane
62-75-9 N-Nitrosodimethylamine
59-89-2 N-Nitrosomorpholine
684-93-5 N-Nitroso-N-methylurea

P

56-38-2 Parathion
87-86-5 Pentachlorophenol
108-95-2 Phenol
106-50-3 p-Phenylenediamine
75-44-5 Phosgene
7803-51-2 Phosphine
7723-14-0 Phosphorus (yellow or white)
85-44-9 Phthalic anhydride
1336-36-3 Polychlorinated biphenyls
0 Polycyclic Organic Matter
1120-71-4 Propane sultone
123-38-6 Propionaldehyde
57-57-8 beta-Propiolactone
114-26-1 Propoxur
75-56-9 Propylene oxide
75-55-8 Propyleneimine

Q

91-22-5 Quinoline
106-51-4 Quinone
82-68-8 Quintozene

R

0 Radionuclides (including Radon)

S

0 Selenium Compounds
100-42-5 Styrene
96-09-3 Styrene oxide

T

1746-01-6 2,3,7,8-Tetrachlorodibenzo-p-dioxin
(TCDD)
79-34-5 1,1,2,2-Tetrachloroethane
127-18-4 Tetrachloroethylene
7550-45-0 Titanium tetrachloride
108-88-3 Toluene
95-80-7 2,4-Toluene diamine (2,4-Diaminotoluene)
584-84-9 2,4-Toluene diisocyanate
95-53-4 o-Toluidine
800-135-2 Toxaphene
120-82-1 1,2,4-Trichlorobenzene
71-55-6 1,1,1-Trichloroethane
79-00-5 1,1,2-Trichloroethane
79-01-6 Trichloroethylene
95-95-4 2,4,5-Trichlorophenol
88-06-2 2,4,6-Trichlorophenol

121-44-8 Triethylamine
1582-09-8 Trifluralin
540-84-1 2,2,4-Trimethylpentane

U
51-79-6 Urethane

V
108-05-4 Vinyl acetate
593-60-2 Vinyl bromide
75-01-4 Vinyl chloride
75-35-4 Vinylidene chloride

X
1330-20-7 Xylene (mixed isomers)
108-38-3 m-Xylene
95-47-6 o-Xylene
106-42-3 p-Xylene

Appendix C – Control Efficiency Guidance
Control Efficiency Table

Control Device or Practice	Control Efficiency (%)						
	TSP	PM$_{10}$	SOx	NOx	VOC	CO	Pb
Wet Scrubber - high efficiency	note 1		note 2				
Wet Scrubber - med efficiency	note 1		note 2				
Wet Scrubber - low efficiency	note 1		note 2				
Gravity Collector	3[a]	--	--	--	--	--	2[a]
Centrifugal Collector (cyclone)-high efficiency*	95[c]	80[a]	--	--	--	--	65[a]
Centrifugal Collector (cyclone)-med efficiency*	75[c]	50[a]	--	--	--	--	40[a]
Centrifugal Collector (cyclone)-low efficiency*	35[c]	10[a]	--	--	--	--	8[a]
Electrostatic Precipitator-high efficiency**	95[a]	95[a]	--	--	--	--	75[a]
Electrostatic Precipitator-medium efficiency**	80[a]	80[a]	--	--	--	--	65[a]
Electrostatic Precipitator-low efficiency**	70[a]	70[a]	--	--	--	--	55[a]
Fabric Filter	99[a]	95[c]	--	--	--	--	80[a]
Catalytic Afterburner	--	--	--	--	95[c]	--	--
Direct Flame Afterburner	--	--	--	--	95[c]	--	--
Flaring	--	--	--	--	90[a]	--	--
Low NOx Burners	--	--	--	note 3	--	--	--
Staged Combustion	--	--	--	40[a]	--	--	--
Flue Gas Recirculation	--	--	--	50[a]	--	--	--
Reduced Combustion Air Preheat	--	--	--	note 4	--	--	--
Steam or Water Injection	--	--	--	65[a]	--	--	--
Low Excess Air Firing	--	--	--	30[a]	--	--	--
Fuel with low Nitrogen Content	--	--	--	50[a]	--	--	--
Sulfuric Acid Plant-Single Contact Process	--	--	50[a]	--	--	--	--
Sulfuric Acid Plant-Double Contact Process	--	--	95[a]	--	--	--	--
Vapor Recovery System (Condensers)	--	--	--	--	note 5	--	--
Activated Carbon Adsorption	--	--	note 6				--
Gas Absorption Column-packed	90[a]	90[a]	note 2				--
Gas Absorption Column-tray type	25[a]	25[a]	note 2				--
Spray Tower	20[a]	20[a]	note 2				--
Venturi Scrubber	90[a]	90[a]	note 2				--
Impingement Plate Scrubber	note 7		--	--	--	--	--
Mat or Panel Filter	90[c]	90[c]	--	--	--	--	--
Dust Suppression by Water Spray	40[a]	40[a]	--	--	--	--	--
Dust Suppression by Chemical or Wetting Agents	40[a]	40[a]	--	--	--	--	--
Catalytic Reduction	--	--	--	note 8	--	--	--

Control Efficiency Table (continued)

Control Device or Practice	Control Efficiency (%)						
	TSP	PM$_{10}$	SOx	NOx	VOC	CO	Pb
Wet Lime Slurry Scrubbing	--	--	85 [c]	--	--	--	--
Multiple Cyclone w/o Fly Ash Reinjection	80 [a]	80 [a]	--	--	--	--	65 [a]
Multiple Cyclone with Fly Ash Reinjection	50 [a]	50 [a]	--	--	--	--	40 [a]
Water Curtain	50 [c]	10 [a]	--	--	--	--	--

[a] – Control efficiency was taken from a literature review and developmental work by the Minnesota Pollution Control Agency

[b] – Control efficiency was taken from AP-42

[c] – Control efficiency was developed from the combination of a literature review and developmental work by the Minnesota Pollution Control Agency, AP-42, and staff judgment

* Low, medium, and high efficiency cyclones will be defined based on pressure drop. The ranges of pressure drops are as follows:

Low-efficiency cyclones	2-4 inches water
Medium-efficiency cyclones	4-7 inches water
High-efficiency cyclones	7-10 inches water

** Low, medium, and high efficiency electrostatic precipitators (ESP) will be defined based on the specific collection area (SCA). The SCA is the total collector plate area divided by the gas volume flow rate. It is usually expressed in terms of square feet per 1000 acfm of gas flow. For example, the SCA of an ESP with a gas flow rate of 250,000 acfm and collection plate area of 100,000 square feet is:

$$100,000 \text{ ft}^2 / 250,000 \text{ acfm} \times 0.001 = 400 \text{ ft}^2/\text{thousand acfm}$$

The ranges of SCA for low, medium, and high efficiency ESPs are as follows:

Low-efficiency ESP	< 400
Medium-efficiency ESP	400 - 700
High-efficiency ESP	> 700

Typical control efficiencies were not assigned to all control devices because some efficiencies strongly depend on source specific parameters. In these instances the table will refer to one of the notes listed below for additional information.

Note 1. Particulate control equipment represented by these classifications should be included in the other, more specific categories (i.e., venturi scrubbers or packed bed absorption columns).

Note 2. The achievable gaseous pollutant control efficiencies for these types of control equipment will depend on the pollutant solubility, the solvent used, the vapor-liquid contact time, and the contact area. These devices are normally designed to achieve a promulgated control efficiency rather than the maximum achievable reduction. Control efficiencies for these devices should be evaluated on a case-by-case basis.

Note 3. Low NOx burners (LNB) have been developed by many boiler and burner manufacturers for both new and retrofit applications. Low NOx burners limit NOx formation by controlling both the stoichiometric and temperature profiles of the combustion process. This control is achieved with design features that regulate the aerodynamic distribution and mixing of the fuel and air, yielding one or more of the following conditions:
1. Reduced O_2 in the primary combustion zone, which limits fuel NOx formation;
2. Reduced flame temperature, which limits thermal NOx formation; and
3. Reduced residence time at peak temperature, which limits thermal NOx formation.

The amount of NOx reduction achievable is dependent upon the combustion system and burner design, actual operating practices, and fuel characteristics. The amount of reduction should be based on the manufacturer's demonstration.

Note 4. The amount of NOx reduction achievable from reducing preheating of combustion air will vary according to the temperatures before and after the modification. Therefore, efficiencies for this process should be evaluated on a case-by-case basis.

Note 5. Control efficiencies for a particular condenser will vary for different VOC compounds and depends on both the partial pressure of the pollutant and the operating parameters of the condenser. Efficiencies should be evaluated on a case-by-case basis.

Note 6. Since the overall control efficiency will depend on source specific parameters such as the physical characteristics of the absorbent bed and gaseous stream, the temperature, and the choice of regeneration technique, efficiencies should be evaluated on a case-by-case basis.

Note 7. Depending on the application control efficiencies may range from 25-99%. Efficiencies should be evaluated on a case-by-case basis.

Note 8. Generic classification; recommend specific technologies be addressed on an individual basis. Two widely used NOx control technologies include Selective Catalytic Reduction (SCR) and Selective Noncatalytic Reduction (SNCR). SCR can obtain reductions of 60-90%. Urea based SNCR can achieve reductions of 30-80% and ammonia based 55-85%.

Appendix D – Units of Measure Conversions[2]

To convert from	To	Multiply by
Kilograms (kg)	Pounds (lbs)	2.20462
Pounds (lbs)	Kilograms (kg)	0.45359
Pounds (lbs)	Tons	0.0005
Cubic meters (m^3)	Cubic feet (ft^3)	35.31467
Cubic feet (ft^3)	Cubic meters (m^3)	0.028317
Gallons (liquid, US)	Liters (l)	3.78541
Liters (l)	Gallons (liquid, US)	0.26417
Barrels of Liquid Fuel (bbl)	Cubic meters (m^3)	0.15891
Cubic meters (m^3)	Barrels of Liquid Fuel (bbl)	6.289
Barrels of Liquid Fuel (bbl)	Gallons (liquid, US)	42
Gallons (liquid, US)	Barrels of Liquid Fuel (bbl)	0.023810
Gallons (liquid, US)	Cubic meters (m^3)	0.0037854
Liters (l)	Cubic meters (m^3)	0.001
Feet (ft)	Meters (m)	0.3048
Meters (m)	Feet (ft)	3.28084
Miles (mi)	Kilometers (km)	1.60934
Kilometers (km)	Miles (mi)	0.62137
Square feet (ft^2)	Acres	2.29568×10^{-5}
Square meters (m^2)	Acres	2.47105×10^{-4}
Square miles (mi^2)	Square kilometers (km^2)	2.58999
Degrees Celsius (°C)	Degrees Fahrenheit (°F)	°C = (5/9) x (°F - 32)
Degrees Fahrenheit (°F)	Degrees Celsius (°C)	°F = (9/5) x °C +32
Degrees Celsius (°C)	Kelvin (K)	K = °C + 273.15
Btu	Hp-hours	3.9275×10^{-4}
Horsepower-hours	Btu (mean)	2.5425×10^{3}
Horsepower (mechanical)	Kilowatts	0.74558
Kilowatts	Horsepower (mechanical)	1.341
Grains	Pounds (avdp.)	1.4286×10^{-4}
Pounds (avdp.)	Grains	7000
Kelvin (K)	Degrees Rankine (°R)	1.8
Joules	Btu	9.47817×10^{-4}
Btu	MMBtu	1×10^{-6}
Pascals (Pa)	Inches of Mercury (inHg)	2.95334×10^{-4}
Ounces (avdp.)	Pounds (avdp.)	0.0625
Grams/Liter	Pounds/gallon (liquid, US)	0.008345

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[2] From EPA AP-42, Appendix A. Additional factors may be found here.

Appendix E – Select Conversion Factors

Table 1: Common Fuel Parameters[3]

Type of Fuel	Heating Value		Sulfur	Ash
	Kcal	Btu	% (by weight)	% (by weight)
Liquid Fuels				
Residual Oil	$9.98 \times 10^6/m^3$	150,000/gal	0.5-4.0	0.05-0.1
Distillate Oil / Diesel	$9.30 \times 10^6/m^3$	140,000/gal	0.0015-0.5	N
Gasoline	$8.62 \times 10^6/m^3$	130,000/gal	0.03-0.04	N
Kerosene	$8.32 \times 10^6/m^3$	135,000/gal	0.02-0.05	N
Liquid Petroleum Gas	$6.25 \times 10^6/m^3$	94,000/gal	N	N
Gaseous Fuels				
Natural Gas	$9,341/m^3$	1,050/SCF	N	N
Propane	23,054Kcal/gal	91,500/gal	N	N
Digester/ Biogas Gas		400-900/scf	0-10,000ppm	N

N = negligible.
Ash content may be considerably higher when sand, dirt, etc., are present.

Table 2: Conversion of Standard Cubic Feet to Actual Cubic Feet

To convert scfm to acfm at standard pressure:

$$acfm = \frac{[(actual\ temperature\ (°F) + 460)\ x\ scfm]}{[standard\ temperature\ (°F) + 460]}$$

Where, standard temperature = 70 °F

Table 3: Table Percentage of Paint Transfer Efficiency[4]

Method Of Application	Description of Surface Coated		
	Flat Surface	Table Leg Surface	Bird Cage Surface
Air Atomized	50	15	10
Airless	75-80	10	10
Electrostatic			
Disk	95	90-65	90-95
Airless	80	70	70
Air Atomized	75	65	65

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[3] Adapted from EPA AP-42, Appendix A. Additional factors may be found here.
[4] Adapted from Air Pollution Engineering Manual (1992), Table 2, page 362.

Appendix F – Sample Emission Calculations

Diesel Fired Engine Example using Emission Factors:

Facility requesting a permit for a diesel powered generator. The diesel internal combustion engine is rated at 4,550 kW with a maximum fuel consumption rate of 337 gallons of diesel per hour. The diesel contains a 0.5% maximum sulfur content by weight.

The emission factors for a stationary diesel engine can be found in the May 19th 1999 IDNR Memo entitled "Emission factors for Stationary Diesel and all Stationary Dual-Fuel Engines". The factors for NOx, CO, SO2, PM/PM10, and VOC are provided below. Additional factors for benzene, toluene and other compounds are also available at the AP-42 website: http://www.epa.gov/ttn/chief/ap42/ch03/index.html

$$ER = MRC \times EF \times (1 - CE)$$

Given,

MRC = 337 gallons of diesel per hour

CE = 0, as there is no control equipment in this project

EF = emission factors are pollutant and process dependent

Pollutant	Emission Factors, lb/MMBtu
NOx	3.2
CO	0.85
SO_2	1.01 x S1
PM/PM$_{10}$/PM$_{2.5}$*	0.14
VOC	0.09

Where, S1 is % (by weight) sulfur content in diesel fuel

* Assumes all particulate to be less than 1 micrometer in size. If necessary, AP-42 chapter 3.4 provides additional information about particulate matter size.

The Estimated Emissions for this generator are calculated as follow:

$$ER_{NOx} = \frac{337 \; gallons \; of \; diesel}{hour} \times \frac{137,000 \; Btu}{gallon \; of \; diesel} \times \frac{3.2 \; lb \; of \; NOx}{MMBtu} \times \frac{1 \; MMBtu}{10^6 \; Btu} = \mathbf{148} \; \frac{\mathbf{lb \; of \; NOx}}{\mathbf{hr}}$$

$$ER_{CO} = \frac{337 \; gallons \; of \; diesel}{hour} \times \frac{137,000 \; Btu}{gallon \; of \; diesel} \times \frac{0.85 \; lb \; of \; CO}{MMBtu} \times \frac{1 \; MMBtu}{10^6 \; Btu} = \mathbf{39} \; \frac{\mathbf{lb \; of \; CO}}{\mathbf{hr}}$$

$$ER_{SO_2} = \frac{337 \; gal \; of \; diesel}{hour} \times \frac{137,000 \; Btu}{gal \; of \; diesel} \times \frac{(1.01 \times 0.5) \; lb \; of \; SO_2}{MMBtu} \times \frac{1 \; MMBtu}{10^6 \; Btu} = \mathbf{0.51} \; \frac{\mathbf{lb \; of \; SO_2}}{\mathbf{hr}}$$

$$ER_{PM/PM_{10}/PM_{2.5}} = \frac{337 \; gallons \; of \; diesel}{hour} \times \frac{137,000 \; Btu}{gallon \; of \; diesel} \times \frac{0.14 \; lb \; of \; PM/PM_{10}/PM_{2.5}}{MMBtu} \times \frac{1 \; MMBtu}{10^6 \; Btu}$$
$$= \mathbf{6.5} \; \frac{\mathbf{lb \; of \; PM/PM_{10}/PM_{2.5}}}{\mathbf{hr}}$$

$$ER_{VOC} = \frac{337 \; gallons \; of \; diesel}{hour} \times \frac{137,000 \; Btu}{gallon \; of \; diesel} \times \frac{0.09 \; lb \; of \; VOC}{MMBtu} \times \frac{1 \; MMBtu}{10^6 \; Btu} = \mathbf{4.2} \; \frac{\mathbf{lb \; of \; VOC}}{\mathbf{hr}}$$

Calculate the annual emission rates using:

$$\text{ER (Tons/yr)} = \frac{\text{ER (lb/hr) x Hours of operation}}{\frac{2,000 \; lb}{ton}}$$

$$ER_{NOx} = 148 \; \frac{lb \; of \; NOx}{hr} \; \text{x} \; \frac{8,760 \; hr}{year} \; \text{x} \; \frac{1 \; ton}{2,000 \; lb} = \mathbf{648} \; \frac{\textbf{tons of NOx}}{\textbf{year}}$$

$$ER_{CO} = 39 \; \frac{lb \; of \; CO}{hr} \text{x} \; \frac{8,760 \; hr}{year} \; \text{x} \; \frac{1 \; ton}{2,000 \; lb} = \mathbf{171} \; \frac{\textbf{tons of CO}}{\textbf{year}}$$

$$ER_{SO_2} = 0.51 \; \frac{lb \; of \; SO_2}{hr} \text{x} \; \frac{8,760 \; hr}{year} \; \text{x} \; \frac{1 \; ton}{2,000 \; lb} = \mathbf{4.4} \; \frac{\textbf{tons of } SO_2}{\textbf{year}}$$

$$ER_{\text{PM/PM}_{10}/\text{PM}_{2.5}} = 6.5 \; \frac{lb \; of \; \text{PM/PM}_{10}/\text{PM}_{2.5}}{hr} \text{x} \; \frac{8,760 \; hr}{year} \; \text{x} \; \frac{1 \; ton}{2,000 \; lb} = \mathbf{28.5} \; \frac{\textbf{tons of PM/PM}_{10}/\textbf{PM}_{2.5}}{\textbf{year}}$$

$$ER_{VOC} = 4.2 \; \frac{lb \; of \; VOC}{hr} \text{x} \; \frac{8,760 \; hr}{year} \; \text{x} \; \frac{1 \; ton}{2,000 \; lb} = \mathbf{18.4} \; \frac{\textbf{tons of VOC}}{\textbf{year}}$$

Diesel Fired Engine Example using Stack Test Data:

The facility used in the last example conducts a stack test on the generator emissions for PM and has requested to use the test data to establish an emission limit for PM. The example below provides detail regarding the statistical analysis of the test data using the 95% confidence interval (CI). The test was conducted using 3 runs, below are the stack test results:

Stack Test Results	Run 1	Run 2	Run 3
Emission rate, lb/hr	2.56	2.84	3.23

First calculate the average (or arithmetic mean):

$$\text{Mean} = x = \frac{2.56 \frac{lbs\ PM}{hr} + 2.84 \frac{lbs\ PM}{hr} + 3.23 \frac{lbs\ PM}{hr}}{3} = \boldsymbol{2.88 \frac{lbs\ PM}{hr}}$$

Next calculate the sample standard deviation (not the population standard deviation):

$$standard\ deviation = \sigma = \frac{\sqrt{\sum(x - \bar{x})^2}}{(n-1)}$$

Where,

$\bar{x}$ = each test run emission rate

n = number of test runs

$$\sigma = \frac{\sqrt{(2.88 - 2.56)^2 + (2.88 - 2.84)^2 + (2.88 - 3.23)^2}}{(3-1)} = \boldsymbol{0.34 \frac{lbs\ PM}{hr}}$$

Now calculate the 95% confidence interval (CI) for the stack test results using the student t-test method:

$$95\%\ CI = x + t\frac{\sigma}{\sqrt{n}}$$

Where,

t = the student t-test percentage point of the *t* distribution with n-1 degrees of freedom, see table following the example calculations for a table of t values.

$$95\%\ CI = 2.88 \frac{lbs\ PM}{hr} + 2.92 \text{ x } \frac{0.34 \frac{lbs\ PM}{hr}}{\sqrt{3}} = \boldsymbol{3.44 \frac{lbs\ PM}{hr}}$$

t distribution table

df	90%	95%	97.5%	99%	99.5%	99.95%
			SIGNIFICANCE LEVEL FOR ONE-DIRECTION TEST			
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.598
3	1.638	2.353	3.182	4.541	5.841	12.941
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.859
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.405
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
16	1.337	1.746	2.120	2.583	2.921	4.015
17	1.333	1.740	2.110	2.567	2.898	3.965
18	1.330	1.734	2.101	2.552	2.878	3.922
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.850
21	1.323	1.721	2.080	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.500	2.807	3.767
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.060	2.485	2.787	3.725
26	1.315	1.706	2.056	2.479	2.779	3.707
27	1.314	1.703	2.052	2.473	2.771	3.690
28	1.313	1.701	2.048	2.467	2.763	3.674
29	1.311	1.699	2.045	2.462	2.756	3.659
30	1.310	1.697	2.042	2.457	2.750	3.646
40	1.303	1.684	2.021	2.423	2.704	3.551
60	1.296	1.671	2.000	2.390	2.660	3.460
120	1.289	1.658	1.980	2.358	2.617	3.373
?	1.282	1.645	1.960	2.326	2.576	3.291

Paint Booth Example using Mass Balance:

A facility requests a permit to install a paint booth where they intend to paint large tractor parts. The facility will use 2 high efficiency air assisted-airless spray guns. The information needed to calculate emissions is the annual volume of spray material, VOC content, HAP content, solids content, transfer efficiency, and control efficiency of the paint filters. The calculations for this example will use mass balance to determine emissions.

Given,

Spray material, VOC content	3.5 lb/gal
Spray material, HAP content	1.8 lb/gal
Spray material, solids content ($PM/PM_{10}/PM_{2.5}$*)	9.8 lb/gal
Transfer efficiency (TE)	75%
Control efficiency (CE)	90%
Spray gun capacity	7.5 gal/hr
Annual volume of spray paint	75,000 gal

* Assume all solids in the paint material are particulate less than 1 micrometer in size.

The $PM/PM_{10}/PM_{2.5}$ emissions are estimated using a mass balance that accounts for paint sprayed that coats the surface and is controlled by the dry filters:

$$ER = MRC \times (1\text{-}TE) \times (1 - CE)$$

$$ER_{PM/PM_{10}/PM_{2.5}} = \frac{7.5\ gal\ of\ paint}{hour \times gun} \times 2\ guns \times \frac{9.8\ lb\ of\ solids}{gal\ of\ paint} \times (1 - 0.75) \times (1 - 0.9) = \textbf{3.7}\ \frac{\textbf{lb of } \textbf{PM/PM}_{10}/\textbf{PM}_{2.5}}{\textbf{hr}}$$

With the annual emissions calculated as follows:

$$ER\ (tons/yr) = \frac{ER\ (lb/hr) \times Hours}{\dfrac{2,000\ lb}{ton}}$$

$$ER_{PM/PM_{10}/PM_{2.5}} = 3.7\ \frac{lb\ of\ PM/PM_{10}/PM_{2.5}}{hr} \times \frac{8,760\ hr}{year} \times \frac{1\ ton}{2,000\ lb} = \textbf{16.1}\ \frac{\textbf{tons of } \textbf{PM/PM}_{10}/\textbf{PM}_{2.5}}{\textbf{year}}$$

VOC and HAP emissions are estimated using a mass balance. A mass balance assume that the entire VOC and HAP content within the product is lost to the atmosphere on an annual basis.

$$ER_{VOC} = \frac{75,000\ gal\ of\ paint}{year} \times \frac{3.5\ lb\ of\ VOC}{gal\ of\ paint} \times \frac{1\ ton}{2,000\ lb} = \textbf{131}\ \frac{\textbf{tons of VOC}}{\textbf{hr}}$$

$$ER_{HAP} = \frac{75,000\ gal\ of\ paint}{year} \times \frac{1.8\ lb\ of\ HAP}{gal\ of\ paint} \times \frac{1\ ton}{2,000\ lb} = \textbf{68}\ \frac{\textbf{tons of HAP}}{\textbf{hr}}$$

Natural Gas Boiler Example using Emission Factors:

A facility is requesting a permit to install a 50 MMBtu/hr natural gas boiler with no control measures to reduce NOx.

The emission factors used are from webfire (http://cfpub.epa.gov/webfire/#compliance-functions) and are for a boiler less than 100 MMBtu/hr. The factors for NOx, CO, SO2, PM/PM$_{10}$/PM$_{2.5}$, and VOC are provided below. Additional factors for other compounds, such as HAP, are also available in the webfire database.

$$ER = MRC \times EF \times (1 - CE)$$

Given,

MRC = 50 MMBtu/hr

CE = 0, project does not use control equipment

EF = emission factors are pollutant and process dependent

Pollutant	Emission Factors, lb/10^{6}Cubic ft
NOx	100
CO	84
SO$_2$	0.6
PM/PM$_{10}$/PM$_{2.5}$*	7.6
VOC	5.5

* Assumes all particulate to be less than 1 micrometer in size.

The Estimated Emissions for this project are calculated as follow:

$$ER_{NOx} = \frac{50\ MMBtu}{hour} \times \frac{100\ lb\ of\ NOx}{10^6\ cubic\ feet\ NG} \times \frac{1\ cubic\ foot\ NG}{1,020\ Btu} \times \frac{10^6\ Btu}{1\ MMBtu} = \mathbf{4.9}\ \frac{lb\ of\ NOx}{hr}$$

$$ER_{CO} = \frac{50\ MMBtu}{hour} \times \frac{84\ lb\ of\ CO}{10^6\ cubic\ feet\ NG} \times \frac{1\ cubic\ foot\ NG}{1,020\ Btu} \times \frac{10^6\ Btu}{1\ MMBtu} = \mathbf{4.1}\ \frac{lb\ of\ CO}{hr}$$

$$ER_{SO_2} = \frac{50\ MMBtu}{hour} \times \frac{0.6\ lb\ of\ SO_2}{10^6\ cubic\ feet\ NG} \times \frac{1\ cubic\ foot\ NG}{1,020\ Btu} \times \frac{10^6\ Btu}{1\ MMBtu} = \mathbf{0.029}\ \frac{lb\ of\ SO_2}{hr}$$

$$ER_{PM/PM_{10}/PM_{2.5}} = \frac{50\ MMBtu}{hour} \times \frac{7.6\ lb\ of\ PM/PM_{10}/PM_{2.5}}{10^6\ cubic\ feet\ NG} \times \frac{1\ cubic\ foot\ NG}{1,020\ Btu} \times \frac{10^6\ Btu}{1\ MMBtu}$$
$$= \mathbf{0.37}\ \frac{lb\ of\ PM/PM_{10}/PM_{2.5}}{hr}$$

$$ER_{VOC} = \frac{50\ MMBtu}{hour} \times \frac{5.5\ lb\ of\ VOC}{10^6\ cubic\ feet\ NG} \times \frac{1\ cubic\ foot\ NG}{1,020\ Btu} \times \frac{10^6\ Btu}{1\ MMBtu} = \mathbf{0.27}\ \frac{lb\ of\ VOC}{hr}$$

Calculate the annual emission rates using:

$$ER \text{ (tons/yr)} = \frac{ER \text{ (lb/hr) x Hours of operation}}{\frac{2{,}000 \; lb}{ton}}$$

$$ER_{NOx} = 4.9 \; \frac{lb \; of \; NOx}{hr} \; \times \; \frac{8{,}760 \; hr}{year} \; \times \; \frac{1 \; ton}{2{,}000 \; lb} = \mathbf{21.5} \; \frac{\textit{tons of NOx}}{\textit{year}}$$

$$ER_{CO} = 4.1 \; \frac{lb \; of \; CO}{hr} \times \frac{8{,}760 \; hr}{year} \; \times \; \frac{1 \; ton}{2{,}000 \; lb} = \mathbf{18.0} \; \frac{\textit{tons of CO}}{\textit{year}}$$

$$ER_{SO_2} = 0.029 \; \frac{lb \; of \; SO_2}{hr} \times \frac{8{,}760 \; hr}{year} \; \times \; \frac{1 \; ton}{2{,}000 \; lb} = \mathbf{0.13} \; \frac{\textit{tons of } SO_2}{\textit{year}}$$

$$ER_{\mathbf{PM/PM_{10}/PM_{2.5}}} = 0.37 \; \frac{lb \; of \; \mathrm{PM/PM_{10}/PM_{2.5}}}{hr} \times \frac{8{,}760 \; hr}{year} \; \times \; \frac{1 \; ton}{2{,}000 \; lb} = \mathbf{1.62} \; \frac{\textit{tons of } \mathbf{PM/PM_{10}/PM_{2.5}}}{\textit{year}}$$

$$ER_{VOC} = 0.27 \; \frac{lb \; of \; VOC}{hr} \times \frac{8{,}760 \; hr}{year} \; \times \; \frac{1 \; ton}{2{,}000 \; lb} = \mathbf{1.18} \; \frac{\textit{tons of VOC}}{\textit{year}}$$

Grain Receiving Example using Emission Factors:

A facility requests a permit to receive tractor trailers hauling corn to its grain elevator/feed mill operation. The proposed emission units are being by a baghouse (control efficiency of 80%) that captures all particulate matter coming from grain receiving unloading area. The emission factors were sourced from the section on grain processing in AP-42, the AP-42 website is: http://www.epa.gov/ttn/chief/ap42/ch09/index.html. In this case the grain is handled/processed under the control of one collection system (baghouse) with one emission point. The facility anticipates receiving 100 tons of grain per hour by truck with 75% being hopper bottom trucks and 25% straight trucks, which have different emission factors.

The weighted average emission factors for grain receiving are:

$$Weighted\ Average\ EF_{PM} = (0.75 \times 0.035\frac{lb\ of\ PM}{tons\ of\ corn}) + (0.25 \times 0.18\frac{lb\ of\ PM}{tons\ of\ corn}) = \mathbf{0.071}\ \frac{\boldsymbol{lb\ of\ PM}}{\boldsymbol{ton\ of\ corn}}$$

$$Weighted\ Average\ EF_{PM10} = (0.75 \times 0.0078\frac{lb\ of\ PM}{tons\ of\ corn}) + (0.25 \times 0.059\frac{lb\ of\ PM}{tons\ of\ corn}) = \mathbf{0.021}\ \frac{\boldsymbol{lb\ of\ PM_{10}}}{\boldsymbol{ton\ of\ corn}}$$

$$Weighted\ Average\ EF_{PM2.5} = (0.75 \times 0.0013\frac{lb\ of\ PM}{tons\ of\ corn}) + (0.25 \times 0.010\frac{lb\ of\ PM}{tons\ of\ corn}) = \mathbf{0.0035}\ \frac{\boldsymbol{lb\ of\ PM_{2.5}}}{\boldsymbol{ton\ of\ corn}}$$

Calculated controlled PM emissions for this project are calculated using:

ER = MRC x EF x (1 - CE)

$$ER_{PM} = \frac{100\ tons\ of\ corn}{hr}\ \text{x}\ \frac{0.071\ lb\ of\ PM}{ton\ of\ corn}\ \text{x}\ (1-0.8) = \mathbf{1.42}\ \frac{\boldsymbol{lb\ of\ PM}}{\boldsymbol{hr}}$$

$$ER_{PM} = \frac{1.42\ lb\ of\ PM}{hr}\ \text{x}\ \frac{8760\ hr}{yr}\ \text{x}\ \frac{1\ ton\ of\ PM}{2,000\ lb\ of\ PM} = \mathbf{6.2}\ \frac{\boldsymbol{tons\ of\ PM}}{\boldsymbol{year}}$$

$$ER_{PM10} = \frac{100\ tons\ of\ corn}{hr}\ \text{x}\ \frac{0.021\ lb\ of\ PM_{10}}{ton\ of\ corn}\ \text{x}\ (1-0.8) = \mathbf{0.42}\ \frac{\boldsymbol{lb\ of\ PM_{10}}}{\boldsymbol{hr}}$$

$$ER_{PM10} = \frac{0.42\ lb\ of\ PM_{10}}{hr}\ \text{x}\ \frac{8760\ hr}{yr}\ \text{x}\ \frac{1\ ton\ of\ PM_{10}}{2,000\ lb\ of\ PM_{10}} = \mathbf{1.8}\ \frac{\boldsymbol{tons\ of\ PM_{10}}}{\boldsymbol{year}}$$

$$ER_{PM2.5} = \frac{100\ tons\ of\ corn}{hr}\ \text{x}\ \frac{0.0035\ lb\ of\ PM_{2.5}}{ton\ of\ corn}\ \text{x}\ (1-0.8) = \mathbf{0.07}\ \frac{\boldsymbol{lb\ of\ PM_{2.5}}}{\boldsymbol{hr}}$$

$$ER_{PM2.5} = \frac{0.07\ lb\ of\ PM_{2.5}}{hr}\ \text{x}\ \frac{8760\ hr}{yr}\ \text{x}\ \frac{1\ ton\ of\ PM_{2.5}}{2,000\ lb\ of\ PM_{2.5}} = \mathbf{0.31}\ \frac{\boldsymbol{tons\ of\ PM_{2.5}}}{\boldsymbol{year}}$$