Emissions Calculations

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Air Quality Workshop

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Introduction

Q: What is an Air Emissions Inventory?

A: It is a report describing a facility. It lists activities/equipment that release emissions through various processes and quantifies emissions released.

Two fundamental questions to ask before completing emission calculations:

- **What is this emission?**
- **Where did this emission come from?**

Presentation Structure

Topics and Example Calculations Include:

- **Overview of General Emission Calculation Equation**
- **Notes and Example Calculations**
  - **AP-42 Emission Factors**
  - **WebFIRE Emission Factors**
  - **Particulate Matter**
  - **Control Scenarios**
  - **Volatile Organic Compounds (VOCs)**
- **Guidance for Reporting Chromium Emissions**
- **Final Important Items to Remember**

Overview of General Equation

$$A \times EF = E$$

A **is Activity Rate**

EF **is Emission Factor (determined by method)**

E **is calculated Emission**

Overview of General Equation

$A \times EF = E$

A **is Activity Rate**

Identify an Activity or Process By Reviewing:

- **Permit Information**
- **Previous Emissions Inventory**
- **Permit Application**
- **Comprehensive Process Flow Diagrams**
- **Manufacturer or Supplier Details**
- **Site Maps**
- **Plot Plans**

Overview of General Equation

$A \times EF = E$

A **is Activity Rate**

Collect Information On:

- **Source Classification Code**
- **Process Material**
- **Process Rate**
- **Hours Process Occurred**
- **Design Capacity**
- **Fuel Data**
- **Reportable Pollutants**
- **Control Scenario**
- **Permit or Rule Limit**
- **Excess Emissions**

Overview of General Equation

$A \times EF = E$ ***EF*** **is Emission Factor (determined by method)**

Q: What is an Emission Factor?

A: 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.

Overview of General Equation

$A \times EF = E$ *EF* is Emission Factor (determined by method)

Relative Accuracy

Calculation Methods

- Continuous Emission Monitoring System (CEMS)
- EPA RM Stack Test
- Similar Unit EPA RM Stack Test
- Manufacture Test Data
- Process Simulation Software
- Mass Balance
- WebFIRE Data Factors (EPA)
- AP-42 or other EPA Documents

Overview of General Equation

All Values Have Physical Dimensions

$$A \times EF = E$$

Two fundamental questions to ask before completing emission calculations:

- **What is this emission?**
- **Where did this emission come from?**

Overview of General Equation

$A \times EF = E$ ***EF*** **is Emission Factor (determined by method)**

http://www.epa.gov/ttn/chief/index.html

WebFIRE and AP-42

Industrial Boiler

CO calculation using AP-42

Activity Information:

- **Source Classification Code:** **10200602**
- **Process Material:** **Natural Gas**
- **Process Rate:** **673 MMscf/1 year**
- **Hours Process Occurred:** **8,025**
- **Design Capacity (if applicable):** **84 MMbtu/1 hour**
- **Fuel Data (if applicable):** **1,001 MMbtu/1 MMscf**
- **Reportable Pollutants:** **example**
- **Control Scenario (if applicable):** **none**

Industrial Boiler

CO calculation using AP-42

Table 1.4-1. EMISSION FACTORS FOR NITROGEN OXIDES (NO_x) AND CARBON MONOXIDE (CO) FROM NATURAL GAS COMBUSTION[a]

Combustor Type (MMBtu/hr Heat Input) [SCC]	NO_x[b]		CO	
	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
Large Wall-Fired Boilers (>100) [1-01-006-01, 1-02-006-01, 1-03-006-01]				
Uncontrolled (Pre-NSPS)[c]	280	A	84	B
Uncontrolled (Post-NSPS)[c]	190	A	84	B
Controlled - Low NO_x burners	140	A	84	B
Controlled - Flue gas recirculation	100	D	84	B
Small Boilers (<100) [1-01-006-02, 1-02-006-02, 1-03-006-02, 1-03-006-03]				
Uncontrolled	100	B	84	B
Controlled - Low NO_x burners	50	D	84	B
Controlled - Low NO_x burners/Flue gas recirculation	32	C	84	B

http://www.epa.gov/ttn/chief/index.html

Industrial Boiler

CO calculation using AP-42

$$A \times EF = E$$

$$\frac{673\ MMscf\ NG}{1\ year} \times \frac{84\ lbs\ CO}{1\ MMscf\ NG} = \frac{56,532\ lbs\ CO}{1\ year}$$

Convert to Tons

$$\frac{56,532\ lbs\ CO}{1\ year} \times \frac{1\ ton}{2,000\ lbs} = \frac{28.266\ tons\ CO}{1\ year}$$

Company > Facility > Emission Unit > Process >

Help with this page | Delete Process

EU ID 9100 Emission Unit Name: Urea Boiler #1

Is Process Data Confidential? N

Process ID: 44498

SCC: 10200602

Process Description: External Combustion Boilers,Industrial,Natural Gas,10-100 Million Btu/hr

Process Material

Natural Gas

Material I/O: Used (Input)

Process Rates:

Maximum Hourly:	Typical Daily:	**Actual Annual:**
0.0840	1.85	673

Million standard cubic feet

Combustion Processes

Design Capacity: 84 Units: MMBTU/HR

Fuel Data for Combustion Processes

Fuel Heat Content: 1001 Units: MMBTU/MMSCF

% Sulfur: 0 % Ash: 0

Hours/Day: 24 Days/Week: 7 Weeks/Year: 52

Actual Hours/Year: 8025

Seasonal fractions: Spring: 0.25 Summer: 0.25 Fall: 0.25 Winter: 0.25

Add New Pollutant | Save Changes to Process Data

Delete Pollutant

Updated? NO

Company > Facility > Emission Unit > Emission >

Pollutant ID: 22887

Pollutant Description: * Carbon Monoxide

CAS: 630080

Actual Emissions: 28.266 Tons

[Includes All Excess Emissions]

Calculation Method: AP-42 Factors

Reference: Table 1.4-1

Emission Factor: 84

Factor Numerator Units: Pounds

Factor Denominator Units: Million standard cubic feet

(< .001 TPY)

Method/Factor includes Control Efficiency?

Control 1: * Uncontrolled

Control 2: * Uncontrolled

Control 1 Efficiency (%): 0

Control 2 Efficiency (%): 0

Capture Efficiency (%): 0

Excess Emissions: 0 Tons

Permit/Rule Limit: 45.40 Tons/yr

Save Changes to Pollutant Data

Updated? NO

Reciprocating Emergency Generator

NO_x calculation using WebFIRE

Activity Information:

- **Source Classification Code:** **20200102**
- **Process Material:** **Diesel Fuel**
- **Process Rate:** **10 gal Diesel/1 hour**
- **Hours Process Occurred:** **50**
- **Design Capacity (if applicable):** **400 hp**
- **Fuel Data (if applicable):** **137 MMbtu/1,000 gal**
- **Reportable Pollutants:** **example**
- **Control Scenario (if applicable):** **none**

Reciprocating Emergency Generator

NO_x calculation using WebFIRE

☑ **SCC** 20200102 Details

Internal Combustion Engines > Industrial > Distillate Oil (Diesel) > Reciprocating

POLLUTANT Nitrogen oxides (NOx) NEI NOX CAS

Primary Control / Secondary Control : UNCONTROLLED ,

Emission Factor -- 6.040E2 Lb per 1000 Gallons

Distillate Oil (Diesel) Burned;

Quality -- D Emissions Factors Applicability

http://www.epa.gov/ttn/chief/index.html

Reciprocating Emergency Generator

NO_x calculation using WebFIRE

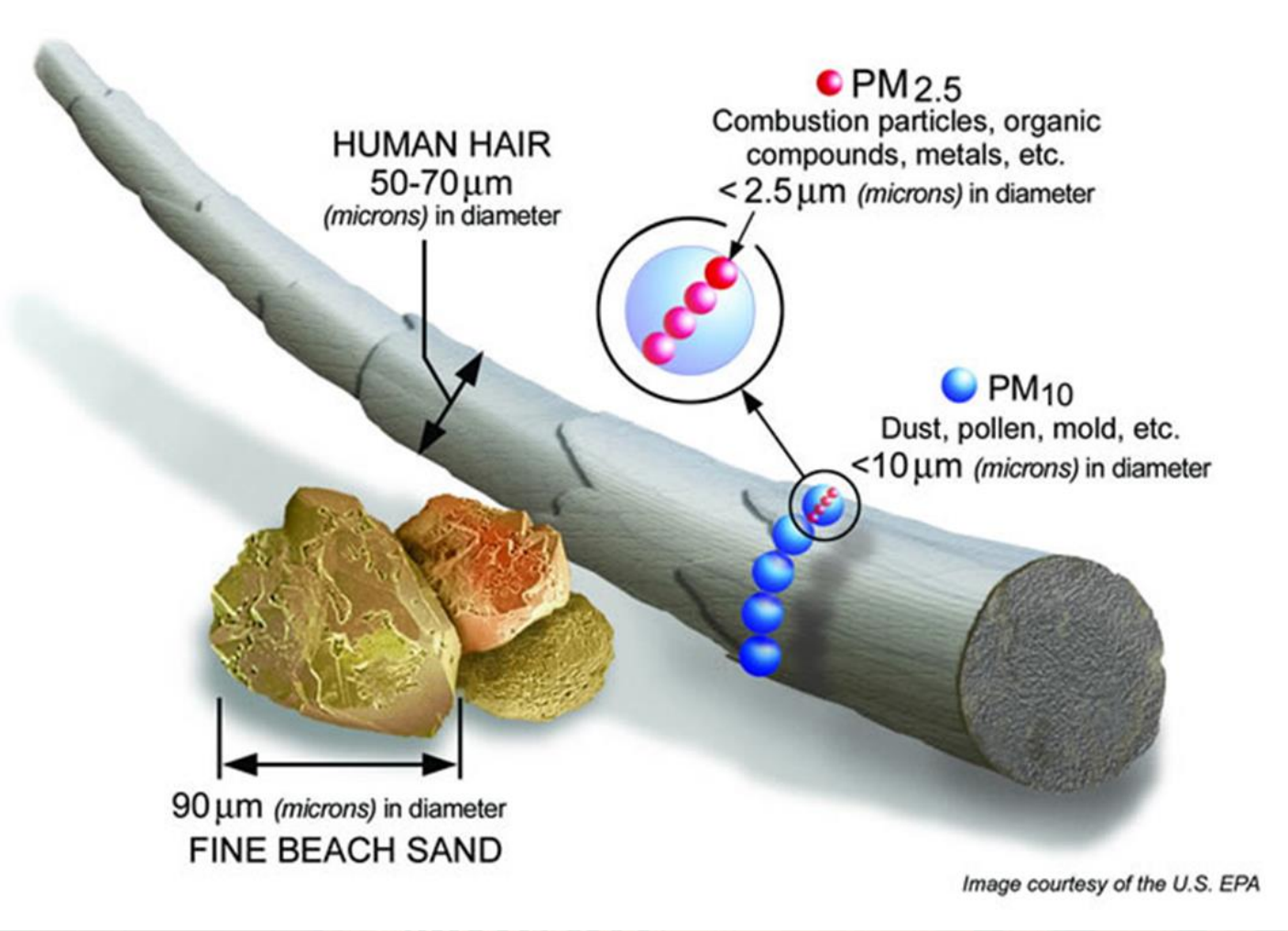
$$A \times EF = E$$

$$\frac{500\ gal\ diesel}{1\ year} \times \frac{604\ lbs\ NO_x}{1{,}000\ gal\ diesel} = \frac{302\ lbs\ NO_x}{1\ year}$$

Convert to Tons

$$\frac{302\ lbs\ NO_x}{1\ year} \times \frac{1\ ton}{2{,}000\ lbs} = \frac{0.151\ tons\ NO_x}{1\ year}$$

Particulate Matter (PM)



Particulate Matter (PM)

Two classes of Particulate Matter (PM) are reported in OK DEQ Air Emission Inventories:

- **PM-10, which is <u>all</u> particulate matter where**

$$aerodynamic\ diameter \leq 10\ \mu m$$

[This value should always be ≥ PM-2.5 in OK DEQ AEIs]

- **PM-2.5, which is <u>all</u> particulate matter where**

$$aerodynamic\ diameter \leq 2.5\ \mu m$$

[PM (Condensable) is part of PM-2.5]

Stone Quarry Tertiary Crushing

PM-10 calculation using AP-42

Activity Information:

- **Source Classification Code:** **30502003**
- **Process Material:** **Stone**
- **Process Rate:** **1,361,120 tons/1 year**
- **Hours Process Occurred:** **3,640**
- **Design Capacity (if applicable):** **-**
- **Fuel Data (if applicable):** **-**
- **Reportable Pollutants:** **example**
- **Control Scenario (if applicable):** **none**

Stone Quarry Tertiary Crushing

PM-10 calculation using AP-42

Table 11.19.2-2 (English Units). EMISSION FACTORS FOR CRUSHED STONE PROCESSING OPERATIONS (lb/Ton)[a]

Source [b]	Total Particulate Matter [r,s]	EMISSION FACTOR RATING	Total PM-10	EMISSION FACTOR RATING	Total PM-2.5	EMISSION FACTOR RATING
Primary Crushing (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Primary Crushing (controlled) (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Secondary Crushing (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Secondary Crushing (controlled) (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Tertiary Crushing (SCC 3-050030-03)	0.0054[d]	E	0.0024[o]	C	ND[n]	
Tertiary Crushing (controlled) (SCC 3-05-020-03)	0.0012[d]	E	0.00054[p]	C	0.00010[q]	E

http://www.epa.gov/ttn/chief/index.html

Stone Quarry Tertiary Crushing

PM-10 calculation using AP-42

$$A \times EF = E$$

$$\frac{1,361,120\ tons\ stone}{1\ year} \times \frac{0.0024\ lbs\ PM_{10}}{1\ ton\ stone} = \frac{3,267\ lbs\ PM_{10}}{1\ year}$$

Convert to Tons

$$\frac{3,267\ lbs\ PM_{10}}{1\ year} \times \frac{1\ ton}{2,000\ lbs} = \frac{1.633\ tons\ PM_{10}}{1\ year}$$

Control Scenarios

Q: What is a Control Scenario?

A: It is a control system, abatement equipment, or an approach applied to reduce emissions of a pollutant.

Control Scenarios

Q: What is Capture Efficiency?

A: When a control scenario is operating as designed, it is the percentage of air emissions that are directed to the control equipment or an estimate of that portion of an affected emissions stream that is collected and routed to the control measure.

Control Scenarios

Q: What is Control Efficiency?

A: It is the percentage of actual air emissions prevented from being emitted by the control scenario.

- **The efficiency should reflect device degradation.**
- **Any emissions during control scenario downtime should be accounted for in the total actual emissions.**

Control Scenarios

$A \times EF = E$

E is Emission

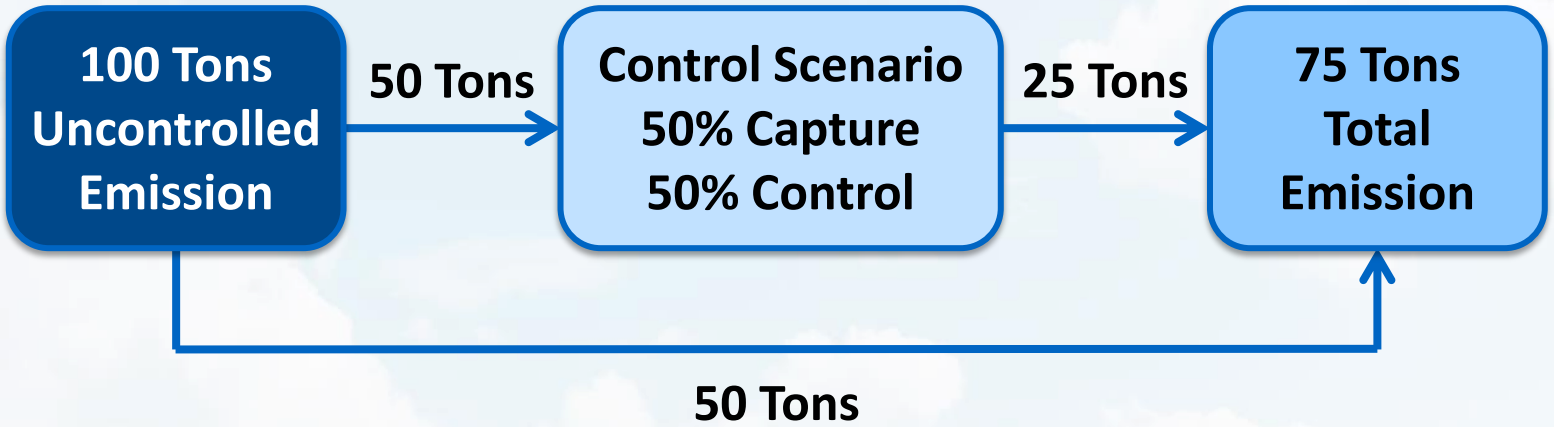
To Include a Control Scenario:

- **Calculate the Emission**
- **Apply the Capture Efficiency**
- **Apply the Control Efficiency to the Captured Emission**
- **Sum the Uncaptured Emission and the Emission Remaining After Applying the Control Efficiency**

Control Scenarios

$$A \times EF = E$$

E **is Emission**



$$A \times EF\left(1 - \frac{ER}{100}\right) = E$$

Not all Capture Efficiencies are 100%.
Use appropriately.

Stone Quarry Tertiary Crushing

PM-10 calculation using AP-42 and a Control

Activity Information:

- **Source Classification Code:** **30502003**
- **Process Material:** **Stone**
- **Process Rate:** **1,361,120 tons/1 year**
- **Hours Process Occurred:** **3,640**
- **Reportable Pollutants:** **example**
- **Control Scenario (if applicable):** **Dust Suppression**

Capture = 100%
Control = 77.7%

Stone Quarry Tertiary Crushing

PM-10 calculation using AP-42 and a Control

$$A \times EF\left(1 - \frac{ER}{100}\right) = E$$

$$\frac{1.633\ tons\ PM_{10}}{1\ year}\left(1 - \frac{77.7}{100}\right) = \frac{0.364\ tons\ PM_{10}}{1\ year}$$

Many Capture Efficiencies are 100%

Volatile Organic Compounds (VOC)

VOC Reporting Guidance:

- **Calculate and report Total VOC emissions.**
- **Calculate and report all HAP VOCs as appropriate.**
- **Total VOC emissions must be ≥ the sum of individually reported HAP VOC emissions.**
  - **Do <u>not</u> subtract individually reported HAP VOCs from Total VOC.**
  - **Every process having an individual HAP VOC pollutant emission reported must have a Total VOC emission reported.**

Volatile Organic Compounds (VOC)

Guidance on Using Manufacturer VOC Data:

- **Verify whether the manufacturer's emission factor refers to Total VOC.**
- **Verify whether the manufacturer's VOC emission factor accounts for formaldehyde and other aldehyde compounds.**
  - **This is especially relevant for JJJJ engines.**
- **Use caution when mixing emission factors from different sources, e.g., manufacturer and AP-42 emission factors.**
- **Review the EPA's definition of VOC for clarification.**

4-Stroke, Lean Burn Engine

Total VOC calculation using vendor data

Activity Information:

- **Source Classification Code:** **20200254**
- **Process Material:** **Natural Gas**
- **Process Rate:** **138,000 bhp-hr**
- **Hours Process Occurred:** **100**
- **Design Capacity (if applicable):** **1,380 bhp**
- **Fuel Data (if applicable):** **1,020 MMbtu/1 MMscf**
- **Reportable Pollutants:** **example**
- **Control Scenario (if applicable):** **none**

4-Stroke, Lean Burn Engine

Total VOC calculation using vendor data

Emissions*		
NOx	g/bkW-hr (g/bhp-hr)	0.67 (0.50)
CO	g/bkW-hr (g/bhp-hr)	3.26 (2.43)
CO_2	g/bkW-hr (g/bhp-hr)	635 (474)
VOC**	g/bkW-hr (g/bhp-hr)	0.64 (0.48)

*at 100% load and speed, all values are listed as not to exceed
**Volatile organic compounds as defined in U.S. EPA 40 CFR 60, subpart JJJJ
***ISO 3046/1

How does JJJJ define VOC?

4-Stroke, Lean Burn Engine

Total VOC calculation using vendor data

NOx (as NO2)	g/bhp-hr	0.50	(11)(12)
CO	g/bhp-hr	2.43	(11)(13)
THC (mol. wt. of 15.84)	g/bhp-hr	4.77	(11)(13)
NMHC (mol. wt. of 15.84)	g/bhp-hr	0.72	(11)(13)
NMNEHC (VOCs) (mol. wt. of 15.84)	g/bhp-hr	0.48	(11)(13)(14)
HCHO (Formaldehyde)	g/bhp-hr	0.44	(11)(13)
CO2	g/bhp-hr	474	(11)(13)
EXHAUST OXYGEN	% DRY	9.0	(11)(15)
LAMBDA		1.68	(11)(15)

13. … THC, NMHC, and NMNEHC do not include aldehydes.
14. VOCs – Volatile organic compounds as defined in … JJJJ.

4-Stroke, Lean Burn Engine

Total VOC calculation using vendor data

$$A \times EF = E$$

$$\frac{138,000\ bhp - hr}{1\ year} \times \frac{0.92\ g\ Total\ VOC}{1\ bhp - hr} = \frac{126,960\ g\ Total\ VOC}{1\ year}$$

Convert to Tons

$$126,960\ g\ Total\ VOC = 0.140\ tons\ Total\ VOC$$

Volatile Organic Compounds (VOC)

Guidance on Using Manufacturer VOC Data:

- **Use caution when mixing emission factors from different sources, e.g., manufacturer and AP-42 emission factors.**
  - **Using a manufacturer Total VOC emission factor implies individual VOC emission factors require review.**
  - **TCEQ Emission Inventory Guidance *Appendix A***
    - **VOC Emissions → Vendor Data → Speciation**
- **Revisit 2014 emission inventory submissions if errors or oversights are identified.**

Chromium Compounds

Chromium and Chromium Compounds
CAS#: n/a MW: ??

Chromium (Cr)
CAS#: 7440473 MW: 51.996

Chromium (VI) (Cr)
CAS#: 18540299 MW: 51.996

Chromium (III) (Cr)
CAS#: 16065831 MW: 51.996

Chromium Compounds

Chromium reporting guidance:

- **Do <u>not</u> report Chromium if you are reporting either Chromium (VI) or Chromium (III) at that process.**
- **Do <u>not</u> use emission factors to derive a new factor.**

Chromium (Cr)
CAS#: 7440473 MW: 51.996

Chromium (VI) (Cr)
CAS#: 18540299 MW: 51.996

Chromium (III) (Cr)
CAS#: 16065831 MW: 51.996

Chromium Compounds

Chromium reporting guidance:

- **Do <u>not</u> report Chromium if you are reporting either Chromium (VI) or Chromium (III) at that process.**
- **Do <u>not</u> use emission factors to derive a new factor.**
- **Does all Chromium come from a single chemical?**
  - **Chromium (VI) and Chromium (III) speciation info exists for numerous chemicals.**
  - **Contact Joshua.Kalfas@deq.ok.gov.**
- **Revisit 2014 emission inventory submissions if errors or oversights are identified.**

Important Items To Remember

- **A Facility's Potential To Emit (PTE) Does <u>Not</u> Equal a Facility's Actual Emissions.**
- **Remember to Apply Most Current Guidance.**
- **"The best available data at the time the emission inventory is or should have been prepared shall be used to determine emissions."**
- **Report Gap-Filled CEMS Data.**
- **Calculation Parameters Are Needed For Redbud!**
- **Do Reported Parameters Enable Emissions Verification?**
- **Supporting Documentation Must Be Maintained.**

Differences Between EI and TRI?

Pollutant (air emissions)	EI Facility Sum	TRI Facility Sum	TRI Range
Ammonia	0.855	4.800	
Benzene	1.637	2.075	Yes
Biphenyl	0.009	0.128	Yes
Carbon disulfide	0.598	0.725	Yes
Cumene	0.171	0.250	Yes
Ethylbenzene	1.573	2.950	
Hexane	4.802	7.800	
Hydrogen sulfide	0.010	1.325	Yes
Naphthalene	0.782	0.925	Yes
Nickel and Nickel compounds	0.020	0.125	Yes
Xylenes (mixed isomers)	8.510	15.000	

OK DEQ Emission Inventory Section

If you would like to see an example calculation for another industry, activity, or control scenario not presented today:

E-mail aei@deq.ok.gov with your request.

Questions?

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http://www.deq.state.ok.us/aqdnew/emissions/index.htm