

Appendix A

Examples of Air Emission Calculations

(For Information Only)

Appendix A.1 Calculation of Annual Emissions Using Continuous Emission Monitoring System (CEMS) Data

Company A has a Continuous Emission Monitoring System (CEMS) to measure emissions for an oil fired boiler.

Example of a CEMS Output For a Boiler Burning No.6 Fuel Oil									
Period	O ₂ (%V)	Fuel Rate, Q _t (10 ³ kg/hr)	Stack Gas Flow Rate, Q (dRm ³ /min)	Measured Concentration C _x , (ppmvd)			Calculated Emission Rate, Er _x (see equations below)		
				SO ₂	NO _x	CO	SO ₂ (kg/hr)	NO _x (kg/hr)	CO (kg/hr)
12:00	2.1	20.9	4,467	1,004	216.2	31.5	704	109	10
12:15	2	21.1	4,491	1,100	200.6	25.5	776	102	8
12:30	2.1	20.9	4,467	1,050	216.7	25.1	737	109	8
12:45	1.9	21	4,438	1,070	220.5	20.8	746	110	6
13:00	1.9	21.2	4,496	1,070	213.8	19.4	756	109	6
13:15	1.8	21	4,425	1,050	214.0	19.4	730	107	6
13:30	2	21	4,472	1,100	209.1	21.5	773	106	7
13:45	2	21.1	4,491	1,078	210.8	50.3	760	107	16

The following equation is used to calculate the emissions from the measured concentrations:

$$Er_x = \frac{(C_x * MW_x * Q * 60)}{(V * 10^6)}$$

- Where
- Er_x = Emission rate of contaminant x, kg/hr
 - C_x = Concentration of contaminant x, ppmvd
 - MW_x = Molecular weight of the contaminant x, g/g-mole
MW_{SO₂} = 64, MW_{NO_x} = 46 (as MW_{NO₂}), MW_{CO} = 28
 - Q = Dry stack gas volumetric flow rate at reference conditions, dRm³/min (reference conditions: 101.325 kPa and 25°C)
 - V = Volume occupied by 1 mole of ideal gas at reference conditions (= 24.45 litres/g-mole)

$$\begin{aligned} \text{Total SO}_2 \text{ emissions for the 1}^{\text{st}} \text{ hour} &= (704+776+737+746) / 4 \text{ kg} \\ &= 741 \text{ kg SO}_2 \end{aligned}$$

$$\begin{aligned} \text{Total SO}_2 \text{ emissions for the 2}^{\text{nd}} \text{ hour} &= (756+730+773+760) / 4 \text{ kg} \\ &= 755 \text{ kg SO}_2 \end{aligned}$$

To calculate the SO₂ emissions for the reporting period, sum all hourly emission values for that reporting period.

To calculate the annual emissions, sum all hourly emission values for the year or sum the four quarterly emission values for the year.

Appendix A.2 Calculation of Annual Emissions Using Predictive Emission Monitoring (PEM)

The following is an example of Predictive Emission Monitoring (PEM) analysis for particulate matter (PM) emissions from a boiler unit burning a specific blend of coal at an average equipment loading condition.

Example of a PEM Analysis of Input Coal Flow and Contaminant Emission										
Sub-bituminous Coal Flowrate, tonnes/hour	61	62	63	64	65	66	67	68	69	70
Particulate Matter Emission, kg/hr	15	16	16	16	16	17	17	17	17	18

PEM Monitoring Results		Predicted Particulate Matter (PM) Emission Rate Er, (kg/hour)
Time (hour)	Coal Flowrate (tonnes/hour)	
1	64	16
2	64	16
3	66	17
4	65	16
5	66	17
6	67	17
7	68	17
8	69	17
9	70	18
10	70	18
Total for a period of 10 hours		
	669 tonnes	169 kg

The average PM emission rate = 169 kg/10 hour = 16.9 kg PM/hr

If the boiler operated under the same conditions for 5,000 hours in a year, then the calculated annual PM emissions (E_x) will be:

$$E_x = D * Er_x$$

Where

- E_x = Emission of contaminant x, kg/year
- D = Discharge unit annual operating hours, hours
- Er_x = Average emission rate of contaminant x, kg/hr

E_{PM} = 5,000 * 16.9 = 84,500 kg PM /year

Reporting Threshold Consideration

Contaminant	CAS	Calculated Emission (kg/yr)	Threshold (kg/yr)	Equal to or Greater than Threshold	Reported Value (kg)
PM	N/A - M08	84,500	20,000 *	✓	84,500

* MOE release based threshold (Table 2A)

The owner and operator of a facility must report the emissions of PM since its facility emissions of PM exceed the reporting threshold for that contaminant.

Appendix A.3 Calculation of Annual Emissions Using Source Testing Results

Company C has conducted source tests during normal operating conditions. The summary of the test results are as follows:

Summary of Source Testing Results				
Source Testing Results	#1	#2	#3	Average
Stack gas flow rate, Q (dm ³ /min)	2,000	2,100	1,900	2,000
SO ₂ , kg/hr	100	120	80	100
NO _x (expressed as NO ₂), kg/hr	60	65	40	55

The estimated emission at test conditions is:

$$E_x = Er_x * T$$

Where

E_x	=	Emission of contaminant x, kg/year
Er_x	=	Average emission rate of contaminant x, kg/hr
T	=	Time, total operating hours in a given year

If the process operated 7,000 hours under normal (i.e., testing) conditions in the reporting year, then the calculated annual emission of SO₂ is:

$$E_{SO_2} = 100 \text{ kg/hr} * 7,000 \text{ hr} = 700,000 \text{ kg/yr}$$

For NO_x emissions, the reporting requirement is that NO_x has to be expressed as NO (not NO₂). Thus, conversion to NO is required:

$$\begin{aligned} \text{NO}_x \text{ (expressed as NO)} &= 0.6522 * \text{NO}_x \text{ (expressed as NO}_2\text{)} \\ &= 0.6522 * 55 = 35.9 \text{ kg/hr} \end{aligned}$$

$$E_{NO_x} = 35.9 \text{ kg/hr} * 7,000 \text{ hr} = 251,300 \text{ kg/year (note: expressed as NO)}$$

Reporting Threshold Consideration

Contaminant	CAS	Calculated Emission (kg/yr)	Threshold (kg/yr)	Equal to or Greater than Threshold	Reported Value (kg)
Sulphur Dioxide, SO ₂	7446-09-5	700,000	20,000 *	✓	700,000
Oxides of Nitrogen (as NO)	10102-43-9	251,300	14,000 *	✓	251,300

* MOE release based threshold (Table 2A)

Company C must report its emissions of the above contaminants since its facility emissions for each contaminant exceed the respective reporting thresholds.

Appendix A.4 Estimation of Annual Emissions Using Mass Balance Method

Company D applied 15,000 litres of 'ECOAT' (a surface coating compound) in a given year. What should the company report?

In general, coatings consist of resins (binders), pigments, additives, solvents, diluents, and thinners. Resins, pigments, and additives are the solid (non-evaporative or non-volatile) portion of the coating. Conversely, the volatile portion of the coating can consist of water, solvents, diluents, and thinners. These compounds evaporate during the mixing, application, and curing of the coating. Most solvents, diluents, and thinners contain VOCs.

The mass balance method is used here to calculate the VOC emissions and determine MPO quantities of individual contaminants.

Mass Balance Equation

$$M_e = M_i - M_p - M_a - M_c$$

Where	M_e	=	Mass of compound A emitted, kg
	M_i	=	Mass of compound A in the input stream, kg
	M_p	=	Mass of compound A in the finishing product, kg
	M_a	=	Mass of compound A accumulated in the system, kg
	M_c	=	Mass of compound A captured for recovery or disposal, kg

For this coating process operation, there is no loss of coating compound to the coating equipment and no loss to the system's liquid/solid waste streams. All the volatiles, including VOCs that are in a particular coating, are emitted into the atmosphere.

In order to apply the mass balance approach, the VOC content in the coating compound needs to be established or obtained from Material Data Safety Sheet (MSDS) for that compound. The annual consumption of the compound could be obtained from the facility's operation log or sales slips.

MATERIAL SAFETY DATA SHEET		
SECTION 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION		
PRODUCT NAME: ECOAT		
SUPPLIER: ABCDE CORP		
SECTION 2 - COMPOSITION / INFORMATION ON INGREDIENTS		
Chemical Name	CAS #	Percent by weight
Methyl Ethyl Ketone	78-93-3	25%
Xylene	1330-20-7	25%
Ethyl Benzene	100-41-4	15%
N-Butyl Alcohol	123-86-4	10%
Carbon Black	133-86-4	<2%
Other		balance
SECTION 3 - PHYSICAL AND CHEMICAL PROPERTIES		
Specific Gravity : 1.35 Percent volatiles:75% by weight		

Note : In some cases, the % of volatiles value reported in the MSDS contains water and other non-VOC components. The quantities of these components, if they can be identified, should be excluded from the % volatiles during VOC emission calculations.

Determination of Reporting Applicability for Table 2A Contaminants

As *Company D* used more than 3,000 kg/yr of coating material, it meets one of the reporting criteria listed in Section 2.2 of the Guideline. *Company D* then has to assess the Table 2A contaminants emitted and compare the emissions against the corresponding thresholds.

The following steps show how the **mass balance approach** is used to calculate VOC (from Table 2A contaminant list) emissions.

The following equations are used by this company:

1. Calculate uncontrolled VOC emissions from the coating material using the above MSDS

$$E_{VOC} = Q * p * d / 100$$

Where E_{VOC} = Total uncontrolled VOC emission, kg
 Q = Total annual consumption of coating material, litres
 p = Density of coating material, kg/L
 d = VOC content by weight in coating material, %

Density of coating material = 1.35 * 1 kg/litre = 1.35 kg/litre (from MSDS)
 d = 75 % (from MSDS)

Uncontrolled VOC emission = 15,000 * 1.35 * 75 / 100
 = 15,188 kg / year

Reporting Threshold Consideration

Contaminant	CAS	Calculated Emission (kg/yr)	Threshold (kg/yr)	Equal to or Greater than Threshold	Reported Value (kg)
VOC	N/A - M16	15,188	10,000 *	✓	15,188

* MOE release based threshold (Table 2A)

Company D must report its emissions of VOCs since its facility emissions of VOCs exceeds the reporting threshold for that contaminant.

Determination of Reporting Applicability for Table 2C Contaminants

Company D also has to assess the contaminants manufactured, processed or otherwise used (MPO) within the facility. The following steps show how the **mass balance approach** is used to calculate the MPO quantities of contaminants.

2. Calculate MPO quantities of an individual compound

$$M_y = Q * p * w_y / 100$$

Where M_y = Quantity of compound y in the coating material, kg
 Q = Total annual consumption of coating material, litres
 p = Density of coating material, kg/L
 w_y = Percent by weight of compound y in the coating material, %

Methyl Ethyl Ketone

$$M_{\text{Methyl Ethyl Ketone}} = 15,000 \text{ litres} * 1.35 \text{ kg/litres} * 25/100 = 5,063 \text{ kg}$$

Xylene

$$M_{\text{xylene}} = 15,000 \text{ litres} * 1.35 \text{ kg/litres} * 25/100 = 5,063 \text{ kg}$$

Ethyl Benzene

$$M_{\text{Ethyl Benzene}} = 15,000 \text{ litres} * 1.35 \text{ kg/litres} * 15/100 = 3,085 \text{ kg}$$

N-Butyl Alcohol

$$M_{\text{N-Butyl Alcohol}} = 15,000 \text{ litres} * 1.35 \text{ kg/litres} * 10/100 = 2,025 \text{ kg}$$

MPO Threshold Consideration

Contaminant	CAS	Calculated MPO Quantity (kg/yr)	Threshold (kg/yr)
N-Butyl Alcohol	71-36-3	2,025	10,000 ***
Ethylbenzene	100-41-4	3,085	10,000 ***
Methyl Ethyl Ketone	78-93-3	5,063	10,000 ***
Xylene (mixed)	1330-20-7	5,063	10,000 ***

*** NPRI MPO threshold (Table 2C)

Company D is not required to proceed to calculate and report the emissions of the above contaminants to air since the respective MPO thresholds were not exceeded.

Appendix A.5 Estimation of Annual Emissions Using Fuel Analysis

Fuel analysis can be used to predict emissions based on the application of conservation laws. The presence of certain elements in fuels may be used to predict their presence in emission streams. This includes toxic elements such as metals found in coal as well as other elements such as sulphur that may be converted to other compounds during the combustion process.

The basic equation used in fuel analysis emission estimation is:

$$Er_{Xe} = Q_f * C_x * \frac{(MW_{Xe})}{(MW_x)} * \frac{(100 - CE_{Xe})}{100}$$

Where	Er_{Xe}	=	Emission rate of contaminant xe, kg/hr
	Q_f	=	Fuel flow rate, kg/hr
	C_x	=	Concentration of contaminant x in fuel, g/g-fuel
	MW_{Xe}	=	Molecular weight of contaminant xe emitted, g/g-mole
	MW_x	=	Molecular weight of contaminant x in fuel, g/g-mole
	CE_{Xe}	=	Overall emission control efficiency of contaminant xe, %

SO₂ emissions from coal combustion can be calculated based on the concentration of sulphur in the coal. This approach assumes complete conversion of sulphur to SO₂. Therefore, for every kg of sulphur (MW = 32g) burned, 2 kg of SO₂ (MW = 64 g) are emitted. The application of this emission estimation technique is shown as follows:

Q_f	=	20,000 kg/hr
C_s	=	1.5%
MW_{SO_2}	=	Molecular weight of SO ₂ emitted (= 64)
MW_s	=	Molecular weight of sulphur in fuel (= 32)
CE_{SO_2}	=	90%

Hourly emission of SO₂ = 20,000 * 1.5/100 * (64/32) * (100 - 90)/100 = 60 kg/hr

If the boiler is operated 8,000 hours per year, then

Annual emission of SO₂ = hourly emission rate * number of operating hours/year
 = 60 kg/hr * 8,000 hr = 480,000 kg

Reporting Threshold Consideration

Contaminant	CAS	Calculated Emission (kg/yr)	Threshold (kg/yr)	Equal to or Greater than Threshold	Reported Value (kg)
Sulphur Dioxide, SO ₂	7446-09-5	480,000	20,000 *	✓	480,000

* MOE release based threshold (Table 2A)

The owner and operator of a facility must report the emissions of sulphur dioxide since its facility emissions of sulphur dioxide exceed the reporting threshold for that contaminant.

Appendix A.6 Estimation of Annual Emissions Using Emission Factors

The following example shows the general approach in using the emission factors method to calculate emissions from an electric induction furnace process. It should be noted that emissions of all the contaminants in the emission profile are calculated and shown here for completeness. Facilities should be aware that emission calculations of any of the Table 2B and 2C contaminants are required only if they meet their respective MPO requirement.

Foundry F produced 5,000 tonnes of grey iron in a given year. The scrap metal was melted in an electric induction furnace and made into iron castings. Foundry F has to (i) calculate the emissions of applicable contaminants listed in Table 2A and compare against the respective contaminant reporting thresholds; and (ii) evaluate the MPO quantities of applicable contaminants listed in Tables 2B and 2C, and calculate the emissions of the contaminants that meet their respective MPO requirements.

Emission factors are commonly used when site-specific stack monitoring data are unavailable. These established emission factors are available from many sources^{1,2,3,5,6}.

The basic equation used in emission factor emissions calculation is:

$$E_x = BQ * EF_x * \frac{100 - CE_x}{100}$$

Where E_x = Emission of contaminant x, kg
 BQ = Activity rate or base quantity (BQ), BQ unit
 EF_x = Uncontrolled emission factor of contaminant x, kg/BQ unit
 CE_x = Overall emission control efficiency of contaminant x, %
 or

$$E_x = BQ * CEF_x$$

Where E_x = Emission of contaminant x, kg
 BQ = Activity rate or base quantity (BQ), BQ unit
 CEF_x = Controlled emission factor of contaminant x, kg/BQ unit
 x

The following steps shows how to obtain the emission factors for this particular process:

- I. FIRE database²
 The following emission factors are available.

SCC: 3-04-003-03	
Description: Grey Iron Foundries/Electric Induction Furnace	
Contaminant	Factors (kg/tonne of iron produced)
Lead	0.02725 which is the average of the range (0.0045 to 0.05) given in FIRE
Manganese	0.01125
PM	0.45
PM ₁₀	0.43

II. Particulate Matter Calculator⁶

The following particle size distribution can be obtained from PM Calculator and is used to derive the emission factor for PM_{2.5}.

SCC: 3-04-003-03	
Particle	Particle Size Distribution (PSD)
PM ₁₀	0.96
PM _{2.5}	0.94

Derived PM_{2.5} emission factor would be:

$$EF_{PM_{2.5}} = 0.45 * 0.94 = 0.42 \text{ kg/tonne}$$

III. SPECIATE database⁵

Since there are no VOC emissions in this process, VOC speciation is not necessary. The PM speciation profile for this process is **28201** (Cast Iron Induction Furnace) and the following contaminants' speciation percentages are obtained and used to derive their respective emission factors.

SCC: 3-04-003-03		
PM Factor: 0.45 kg/tonne (from FIRE)		
PM Profile: 28201		
Profile Name: Cast Iron Induction Furnace		
Contaminant	% of PM	Derived Emission Factor (kg/tonne)
Aluminum	1.3	$0.45 * 1.3 / 100 = 0.00585$
Arsenic	0.012	$0.45 * 0.012 / 100 = 0.000054$
Bromine	0.021	$0.45 * 0.021 / 100 = 0.000095$
Cadmium	0.012	$0.45 * 0.012 / 100 = 0.000054$
Chlorine	2.5	$0.45 * 2.5 / 100 = 0.01125$
Chromium	0.024	$0.45 * 0.024 / 100 = 0.000108$
Cobalt	0.002	$0.45 * 0.002 / 100 = 0.000009$
Copper	0.12	$0.45 * 0.12 / 100 = 0.00054$
Iron	5.7	$0.45 * 5.7 / 100 = 0.02565$
Nickel	0.098	$0.45 * 0.098 / 100 = 0.000441$
Titanium	0.48	$0.45 * 0.48 / 100 = 0.00216$
Vanadium	0.006	$0.45 * 0.006 / 100 = 0.000027$
Zinc	2.9	$0.45 * 2.9 / 100 = 0.01305$

After gathering the emission factors, the emissions can be estimated by multiplying these factors with the process activity.

Summary of the calculated emission profile

SCC: 3-04-003-03				
Description: Grey Iron Foundries/Electric Induction Furnace				
Activity, BQ : 5,000 tonnes				
Control: No Control, all CE_x = 0				
Contaminant	CAS	Emission Factors EF_x (kg/tonne) ^{note}		Emissions E_x (kg)
Aluminum	7429-90-5	0.00585	S	29
Arsenic	NA - 02	0.00005	S	0.27
Bromine	7726-95-6	0.0001	S	0.47
Cadmium	NA - 03	0.00005	S	0.27
Chlorine	7782-50-5	0.01125	S	56
Chromium	NA - 04	0.000108	S	0.54
Cobalt	NA - 05	0.000009	S	0.05
Copper	NA - 06	0.00054	S	2.7
Iron	7439-89-6	0.02565	S	128
Lead	NA - 08	0.02725	F	136
Manganese	NA - 09	0.01125	F	56
Nickel	NA - 11	0.000441	S	2.2
PM	N/A - M08	0.45	F	2,250
PM ₁₀	N/A - M09	0.43	F	2,150
PM _{2.5}	N/A - M10	0.42	P	2,100
Titanium	7440-32-6	0.00216	S	11
Vanadium	7440-62-2	0.00003	S	0.14
Zinc	NA - 14	0.01305	S	65

Notes F = Factors from FIRE
 S = Factors from speciation profile
 P = Factors from PM Calculator

Reporting Threshold Consideration

Contaminant	CAS	Calculated Emission (kg/yr)	Threshold (kg/yr)	Equal to or Greater than Threshold	Reported Value (kg)
PM	N/A - M08	2,250	20,000 *	No	— BTH
PM ₁₀	N/A - M09	2,150	500 *	✓	2,150
PM _{2.5}	N/A - M10	2,100	300 *	✓	2,100

* MOE release based threshold (Table 2A)
 — BTH means below reporting threshold.

Foundry F must report its emissions of PM₁₀ and PM_{2.5} since its facility emissions of each of these contaminants exceed the reporting thresholds for these contaminants. For a contaminant whose emissions do not exceed its reporting threshold, the contaminant name has to be reported and identified with assigned codes indicating that the emission is below the reporting threshold or that there is no emission reportable.

Appendix A.7 Calculation of Annual Emissions Using an Emission Estimation Model

Plant G is a ready mix concrete batching facility with 500 metres (0.5 kilometre) of unpaved roadway and an average daily traffic volume of 50 trucks (each truck weighs 20 tonnes and has 6 wheels). *Plant G* operated only 240 days in a given year.

To calculate the fugitive emissions from the unpaved road, an emission estimation algorithm can be used. USEPA has an empirical equation used in calculating the quantity in kilograms (kg) of size specific particulate emissions from an unpaved road per vehicle kilometre travelled (VKMT) (refer to AP-42³, chapter 13, Section 2.2 for details). The EPA empirical equation for the unpaved road is adopted and converted to SI units (International System of Units) as follows:

$$EF = \frac{k(s / 12)^a (W / 3)^b}{(M / 0.2)^c}$$

Where EF = Size-specific emission factor, kg/VKMT
 s = Surface material silt content, %
 W = Mean vehicle weight, tonnes
 M = Surface material moisture content, %

and

Constant	PM _{2.5}	PM ₁₀	PM
k (kg/VKMT)	0.111	0.76	2.96
a	0.8	0.8	0.8
b	0.4	0.4	0.5
c	0.3	0.3	0.4

Range of Source Conditions Required to Apply the Above Equation						
Surface Silt Content, %	Mean Vehicle Weight		Mean Vehicle Speed		Mean No. of Wheels	Surface Moisture Content, %
	Mg	ton	km/hr	mph		
1.2 - 35	1.4 - 260	1.5 - 290	8 - 88	5 - 55	4 - 7	0.03 - 20

To apply the above equation for *Plant G*, the following parameters must be determined first.

Vehicle kilometres travelled on the unpaved road within the facility (VKMT) in a given year:

VKMT = no. of trucks/day * length of unpaved road * # operating days/year * 2 ← in/out traffic
 = 50 * 0.5 * 240 * 2 = 12,000 VKMT

Mean vehicle weight (W) = 20 tonnes

Plant G's unpaved roadway has the following characteristics:

Silt content (s) = 5 %
 Moisture content (M) = 10 % (assume moderate season with normal precipitation)

The calculated emission rates are :

$$EF_{PM} = \frac{2.96(5/12)^{0.8}(20/3)^{0.5}}{(10/0.2)^{0.4}} = 0.7933 \text{ kg PM / vkmt}$$

$$EF_{PM_{10}} = \frac{0.762(5/12)^{0.8}(20/3)^{0.4}}{(10/0.2)^{0.3}} = 0.2498 \text{ kg PM}_{10} / \text{vkmt}$$

$$EF_{PM_{2.5}} = \frac{0.111(5/12)^{0.8}(20/3)^{0.4}}{(10/0.2)^{0.3}} = 0.0364 \text{ kg PM}_{2.5} / \text{vkmt}$$

The corresponding annual emission estimates are :

$$E_x = VKMT * EF_x$$

Where E_x = Emission of contaminant x, kg/year
 $VKMT$ = Annual vehicle kilometres travelled, km
 EF_x = Emission factor of contaminant x, kg/VKMT

PM emission = 12,000 * 0.7933 = 9,519 kg/yr

PM₁₀ emission = 12,000 * 0.2498 = 2,998 kg/yr

PM_{2.5} emission = 12,000 * 0.0364 = 437 kg/yr

Reporting Threshold Consideration

Contaminant	CAS	Calculated Emission (kg/yr)	Threshold (kg/yr)	Equal to or Greater than Threshold	Reported Value (kg)
PM	N/A - M08	9,519	20,000 *	No	— BTH
PM ₁₀	N/A - M09	2,998	500 *	✓	2,998
PM _{2.5}	N/A - M10	437	300 *	✓	437

* MOE release based threshold (Table 2A)

— BTH means below reporting threshold.

Plant G must report its emissions of PM₁₀ and PM_{2.5} since its facility emissions of each of these contaminants exceed the reporting thresholds for these contaminants. For a contaminant whose emissions do not exceed its reporting threshold, the contaminant name has to be reported and identified with assigned codes indicating that the emission is below the reporting threshold or that there is no emission reportable.

Appendix A.8 Reporting Polycyclic Aromatic Hydrocarbons (PAH) Emissions

Company H has two combustion sources that are emitting Polycyclic Aromatic Hydrocarbons (PAHs). Emissions from each combustion source are exhausted directly to the atmosphere through separate stacks. Emission measurements were performed at the stacks each year.

Approach (using source testing method)

Step 1. Obtain Test Results

Stack 1 test result

Contaminant	CAS	Emission Rate, Er (microgram/sec)
PAH - Acenaphthene	83-32-9	100
PAH - Anthracene	120-12-7	200
PAH - Benzo(a)pyrene	50-32-8	2
PAH - Benzo(g,h,i)perylene	191-24-2	15
PAH - Fluoranthene	206-44-0	400
PAH - Phenanthrene	85-1-8	1,000

Note : Measurements are at normal loading capacity.

Stack 2 test result

Contaminant	CAS	Emission Rate, Er (microgram/sec)
PAH - Acenaphthylene	208-96-8	200
PAH - Anthracene	120-12-7	150
PAH - Benzo(a)phenanthrene (Chrysene)	218-1-9	40
PAH - Benzo(a)pyrene	50-32-8	10
PAH - Benzo(g,h,i)perylene	191-24-2	20
PAH - Fluoranthene	206-44-0	500
PAH - Indeno(1,2,3-c,d)pyrene	193-39-5	3
PAH - Perylene	198-55-0	0.3
PAH - Phenanthrene	85-1-8	2,000

Step 2. Calculate Emissions

If the two combustion sources operated for 24 hours each day and 360 days within the reporting year.

$$Annual\ Emission\ (kg/yr) = Er\ (\mu g/s) * \frac{360 * 24 * 3,600}{10^9}$$

Summary of the calculated emission profile

Contaminant	CAS	Calculated Emission (kg/yr)		
		Stack 1	Stack 2	Combined
PAH - Acenaphthene	83-32-9	3.11		3.11
PAH - Acenaphthylene	208-96-8		6.22	6.22
PAH - Anthracene	120-12-7	6.22	4.67	10.89
PAH - Benzo(a)phenanthrene (Chrysene)	218-1-9		1.24	1.24
PAH - Benzo(a)pyrene	50-32-8	0.06	0.31	0.37
PAH - Benzo(g,h,i)perylene	191-24-2	0.47	0.62	1.09
PAH - Fluoranthene	206-44-0	12.44	15.55	27.99
PAH - Indeno(1,2,3-c,d)pyrene	193-39-5		0.09	0.09
PAH - Perylene	198-55-0		0.009	0.009
PAH - Phenantrene	85-1-8	31.1	62.21	93.31

Reporting Threshold Consideration 1

Contaminant	CAS	Calculated MPO Quantity (kg/yr)			Equal to or Greater than MOE MPO Threshold of 5 kg/yr **	Reported Value (kg)
		Stack 1	Stack 2	Combined		
PAH - Acenaphthene	83-32-9	3.11		3.11	No	— BTH
PAH - Acenaphthylene	208-96-8		6.22	6.22	✓	6.22

** MOE MPO based threshold (Table 2B)
— BTH means below reporting threshold.

Company H is not required to proceed to calculate and report the emissions of Acenaphthene to air since its MPO threshold was not exceeded. However, *Company H* is required to proceed to calculate and report the emissions of Acenaphthylene to air since its MPO threshold was exceeded.

Reporting Threshold Consideration 2

Contaminant	CAS	Calculated Emission (kg/yr)			Exceed NPRI Alternate Threshold of total 50 kg/yr ****	Reported Value (kg)
		Stack 1	Stack 2	Combined		
PAH - Benzo(a)phenanthrene (Chrysene)	218-1-9		1.24	1.24		1.24
PAH - Benzo(a)pyrene	50-32-8	0.06	0.31	0.37		0.37
PAH - Benzo(g,h,i)perylene	191-24-2	0.47	0.62	1.09		1.09
PAH - Fluoranthene	206-44-0	12.44	15.55	27.99		27.99
PAH - Indeno(1,2,3-c,d)pyrene	193-39-5		0.09	0.09		0.09
PAH - Perylene	198-55-0		0.009	0.009		0.009
PAH - Phenantrene	85-1-8	31.1	62.21	93.31		93.31
TOTAL				124	✓	report all

**** NPRI alternate threshold (Table 2C)

Since these PAHs are subjected to NPRI's alternate threshold requirement, NPRI's reporting guideline should be consulted. The 50 kg/yr threshold applies to total quantity of contaminants released and transferred.

Reporting Threshold Consideration 3

Company H determined that the amount of Anthracene MPO (including by-products) is less than the 10 tonnes MPO threshold and is not required to proceed to calculate and report the contaminant emissions. (Anthracene is a Table 2C contaminant).

Appendix A.9 Estimation of Annual Emissions for Portable Facilities

The following example shows the general approach in using the emission factors method to calculate emissions from Company I. It should be noted that emissions of all the contaminants in the emission profile are calculated and shown here for completeness. The facility should be aware that emission calculations of any of the Table 2B and 2C contaminants are required only if they meet their respective MPO requirement.

Company I is a **portable Hot Mix Asphalt facility** producing 75,000 tonnes of asphalt in a given reporting year. The portable facility operated 8 months in the Sarnia area and the remaining 4 months in Walford. The company has identified the following three emission contributing sources:

1. A #2 Oil fired drum type dryer, 5 million BTU/hr capacity
(equipped with a baghouse for controlling particulate emissions)
2. Storage Piles
3. Haul Road (unpaved road)

Since Company I operates a dryer which uses #2 Oil as the fuel input and has a rated energy input capacity of 5 million BTU/hr, it meets one of the reporting criteria [refer to Section 2.2(2) of the Guideline] and must calculate and report emissions of Table 2A contaminants. Company I has to (i) calculate the emissions of applicable contaminants listed in Table 2A and compare against the respective contaminant reporting thresholds; and (ii) evaluate the MPO quantities of applicable contaminants listed in Tables 2B and 2C, and calculate the emissions for the contaminants that meet their respective MPO requirements.

The operating conditions of Company I for the two locations are as follows:

<i>Company : K</i>		
Operation Location	Sarnia	Walford
Period of Operation	January to August	September to December
Tonnes of Asphalt produced	50,000 tonnes	25,000 tonnes
Storage piles	20,000 tonnes	10,000 tonnes
Cold Aggregate Handling	46,000 tonnes	23,000 tonnes
Length of Unpaved Road within Facilities	0.4 km	0.33 km
Total Traffic per Operating Period	3,500	1,500
Total VKMT Travelled on Unpaved Road (per operating period)	2,750	1,000
Silt Content	5	5
Moisture %	10	10

The Emission Factors method (refer to example A.6) was used by this company to calculate emissions. Emission factor information was obtained from FIRE database², AP-42³, and the particle size distribution (PSD) from PM Calculator⁶. The corresponding emission calculation approach is as follows:

Summary of the calculated emission profile

SCC		3-05-002-58				
DESCRIPTION		Minerals/Asphalt Concrete Rotary Drum Dryer/Mixer, Oil-fired				
Location		Sarnia	Walford	TOTAL		
Production, tonnes		50,000	25,000	75,000		
Contaminant	CAS	Emission Factor (kg/tonnes) (and reference)		Calculated Emission (kg)		
Arsenic	7440-38-2	0.00000055	AP-42	0.0275	0.01375	0.04125
Acetaldehyde	75-07-0	0.00065	AP-42	32.5	16.25	48.75
Acetone	67-64-1	0.00042	AP-42	21	10.5	31.5
Acrolein	107-02-8	0.000013	AP-42	0.65	0.325	0.975
Benzene	71-43-2	0.0002	AP-42	10	5	15
Cadmium	7440-43-9	0.00000022	AP-42	0.011	0.0055	0.0165
Carbon Dioxide	124-38-9	19	AP-42	950,000	475,000	1,425,000
Carbon Monoxide	630-8-0	0.018	AP-42	900	450	1350
Chromium	7440-47-3	0.000006	AP-42	0.3	0.15	0.45
Copper	7440-50-8	0.0000031	AP-42	0.155	0.0775	0.2325
Ethylbenzene	100-41-4	0.00019	AP-42	9.5	4.75	14.25
Formaldehyde	50-00-0	0.0012	AP-42	60	30	90
Lead	7439-92-1	0.0000017	AP-42	0.085	0.0425	0.1275
Manganese	7439-96-5	0.0000055	AP-42	0.275	0.1375	0.4125
Mercury	7439-97-6	0.0000000037	AP-42	0.000185	0.000093	0.000278
Methane	74-82-8	0.0096	AP-42	480	240	720
Methyl Ethyl Ketone	78-93-3	0.00001	AP-42	0.5	0.25	0.75
Nickel	7440-2-0	0.0000075	AP-42	0.375	0.1875	0.5625
Oxides of Nitrogen (as NO ₂)	10102-44-0	0.0375	AP-42	1,875	938	2,813
PAH - Acenaphthylene	208-96-8	0.000011	AP-42	0.55	0.275	0.825
PAH - Anthracene	120-12-7	0.0000018	AP-42	0.09	0.045	0.135
PAH - Fluorene	86-73-7	0.0000085	AP-42	0.425	0.2125	0.6375
PAH - Phenanthrene	85-01-8	0.000028	AP-42	1.4	0.7	2.1
PAH - Pyrene	129-00-0	0.0000015	AP-42	0.075	0.0375	0.1125
PM	N/A - M08	0.02	AP-42	1,000	500	1,500
PM ₁₀	N/A - M09	0.015	AP-42	750	375	1,125
PM _{2.5}	N/A - M10	0.0052	AP-42+PSD	260	130	390
Propionaldehyde	123-38-6	0.000065	AP-42	3.25	1.625	4.875
Quinone	106-51-4	0.00008	AP-42	4	2	6
Silver	7440-22-4	0.0000007	AP-42	0.035	0.0175	0.0525
Sulphur Dioxide	7446-09-5	0.028	AP-42	1,400	700	2,100
Toluene	108-88-3	0.00037	AP-42	18.5	9.25	27.75
VOC	N/A - M16	0.0345	AP-42	1,725	863	2,588
Xylene	1330-20-7	0.000082	AP-42	4.1	2.05	6.15
Zinc	7440-66-6	0.000021	AP-42	1.05	0.525	1.575

Summary of the calculated emission profile

SCC		3-05-002-03				
DESCRIPTION		Minerals/Asphalt Concrete Storage Piles				
Location		Sarnia	Walford	TOTAL		
Quantity, tonnes		20,000	10,000	30,000		
Contaminant	CAS	Emission Factor (kg/tonnes) (and reference)		Calculated Emission (kg)		
PM	N/A - M08	0.17	FIRE + PSD	3,400	1,700	5,100
PM ₁₀	N/A - M09	0.06	FIRE	1,200	600	1,800
PM _{2.5}	N/A - M10	0.019	FIRE + PSD	380	190	570

Summary of the calculated emission profile

SCC		3-05-002-90				
DESCRIPTION		Minerals/Asphalt Concrete Haul Roads-General (Road Dust)				
Location		Sarnia	Walford	TOTAL		
Vehicle Kilometre Travelled (VKMT)		2,750	1,000	3,750		
Contaminant	CAS	Emission Factor (kg/VKMT) (and reference)		Calculated Emission (kg)		
PM	N/A - M08	2.39	AP-42	6,573	2,390	8,963
PM ₁₀	N/A - M09	0.51	AP-42	1,403	510	1,913
PM _{2.5}	N/A - M10	0.074	AP-42	203.5	74	277.5

Calculation of the unpaved road emission is based on the USEPA unpaved road emission estimation equation. Please see example A.7 for reference.

Summary of the calculated emission profile

(Total of emissions from above three processes: 3-05-002-58, 3-05-002-03, 3-05-002-90)

Total Emission for Portable Facility (Two Locations)				
Contaminant	CAS	Calculated Emission (kg)		
		Sarnia	Walford	Total
Acetaldehyde	75-07-0	32.5	16.25	48.75
Acetone	67-64-1	21	10.5	31.5
Acrolein	107-02-8	0.65	0.325	0.975
Arsenic	NA - 02	0.0275	0.01375	0.04125
Benzene	71-43-2	10	5	15
Cadmium	NA - 03	0.011	0.0055	0.0165
Carbon Dioxide	124-38-9	950,000	475,000	1,425,000
Carbon Monoxide	630-8-0	900	450	1350
Chromium	NA - 04	0.3	0.15	0.45
Copper	NA - 06	0.155	0.0775	0.2325
Ethylbenzene	100-41-4	9.5	4.75	14.25
Formaldehyde	50-00-0	60	30	90
Lead	NA - 08	0.085	0.0425	0.1275
Manganese	NA - 09	0.275	0.1375	0.4125
Mercury	NA - 10	0.000185	0.000093	0.000278
Methane	74-82-8	480	240	720
Methyl Ethyl Ketone	78-93-3	0.5	0.25	0.75
Nickel	NA - 11	0.375	0.1875	0.5625
Oxides of Nitrogen (as NO) ^{note}	10102-43-9	1225	612.5	1,837.5
PAH - Acenaphthylene	208-96-8	0.55	0.275	0.825
PAH - Anthracene	120-12-7	0.09	0.045	0.135
PAH - Fluorene	86-73-7	0.425	0.2125	0.6375
PAH - Phenanthrene	85-01-8	1.4	0.7	2.1
PAH - Pyrene	129-00-0	0.075	0.0375	0.1125
PM	N/A - M08	10,973	4,590	15,563
PM ₁₀	N/A - M09	3,353	1,485	4,838
PM _{2.5}	N/A - M10	843	394	1,237
Propionaldehyde	123-38-6	3.25	1.625	4.875
Quinone	106-51-4	4	2	6
Silver	NA - 13	0.035	0.0175	0.0525
Sulphur Dioxide	7446-09-5	1,400	700	2,100
Toluene	108-88-3	18.5	9.25	27.75
VOC	N/A - M16	1,725	863	2,588
Xylene	1330-20-7	4.1	2.05	6.15
Zinc	NA - 14	1.05	0.525	1.575

Note The calculated oxides of nitrogen emission from AP-42 factors is expressed as NO₂. This value is multiplied by 0.6522 to obtain the reported oxides of nitrogen emissions as NO.

Reporting Threshold Consideration

Total Emission for Portable Facility (Two Locations)					
Contaminant	CAS	Calculated Emission (kg/yr)	Threshold (kg/yr)	Equal to or Greater than Threshold	Reported Value (kg)
Carbon Dioxide	124-38-9	1,425,000	100,000,000 *	No	— BTH
Carbon Monoxide	630-8-0	1350	20,000 *	No	— BTH
Oxides of Nitrogen (as NO) ^{note}	10102-43-9	1,837.5	14,000 *	No	— BTH
PM	N/A - M08	15,563	20,000 *	No	— BTH
PM ₁₀	N/A - M09	4,838	500 *	✓	4,838
PM _{2.5}	N/A - M10	1,237	300 *	✓	1,237
Sulphur Dioxide	7446-09-5	2,100	20,000 *	No	— BTH
VOC	N/A - M16	2,588	10,000 *	No	— BTH

Note The calculated oxides of nitrogen emissions from AP-42 factors are expressed as NO₂. This value is multiplied by 0.6522 to obtain the reported oxides of nitrogen emission expressed as NO.

* MOE release based threshold (Table 2A)
— BTH means below reporting threshold.

Company I must report its emissions of PM₁₀ and PM_{2.5} since its facility emissions of each of these contaminants exceed the reporting thresholds for these contaminants. For a contaminant whose emissions do not exceed its reporting threshold, the contaminant name has to be reported and identified with assigned codes indicating that the emission is below the reporting threshold or that there is no emission reportable.

Reporting Threshold Consideration 1 of PAH

Contaminant	CAS	Calculated MPO Quantity (kg/yr)	Equal to or Greater than MOE MPO Threshold of 5 kg/yr **	Reported Value (kg)
PAH - Acenaphthylene	208-96-8	0.825	No	— BTH
PAH - Fluorene	86-73-7	0.638	No	— BTH

** MOE MPO based threshold (Table 2B)
— BTH means below reporting threshold.

Company I is not required to proceed to calculate and report the emissions of Acenaphthylene or Fluorene to air since their respective MPO thresholds were not exceeded.

Reporting Threshold Consideration 2 of PAH

Total Emission for Portable Facility (Two Locations)				
Contaminant	CAS	Calculated Emission (kg/yr)	Exceed NPRI Alternate Threshold of total 50 kg/yr ****	Reported Value (kg)
PAH - Phenanthrene	85-01-8	2.1		
PAH - Pyrene	129-00-0	0.1125		
TOTAL		2.2	No	---

**** NPRI alternate threshold (Table 2C)

Since these PAHs are subjected to NPRI's alternate threshold requirement, NPRI's reporting guideline should be consulted. The 50 kg/yr threshold applies to total quantity of contaminants released and transferred.

Reporting Threshold Consideration 3 of PAH

Company I determined that the amount of Anthracene MPO (including by-products) is less than the 10 tonnes MPO threshold and is not required to proceed to calculate and report the contaminant emissions. (Anthracene is a Table 2C contaminant).

Appendix A.10 Calculation of Annual Emissions from an Office Building

Commercial buildings are required to report SO₂, NO_x, CFCs, HFCs and HCFCs emissions only.

Office Building J uses two natural gas boilers for providing space heating for the building in cold winter months and hot water throughout the year. The following example shows the general approach in using the emission factors method to calculate emissions from *Office Building J*. It should be noted that emissions of all the contaminants in the emission profile are calculated and shown here for completeness.

Boiler #1: 100 million BTU/hr
 Boiler #2: 100 million BTU/hr
 Annual fuel consumption 20,000,000 m³ natural gas (from gas bills)

Apportionment of fuel consumption to the two boilers (estimation)
 Boiler #1: 12,000,000 m³
 Boiler #2: 8,000,000 m³

The emission factors for a natural gas-fired boiler are available from AP-42³ (Chapter 1 Section 4) and are tabulated below:

Emissions Calculation using AP-42³ Factors

Summary of the calculated emission profile

SCC		1-03-006-02		
DESCRIPTION		External Combustion Boilers/Commercial/Institutional Natural Gas, 10 - 100 million BTU/hr		
Annual Natural Gas Consumption, m ³ converted to million cu.ft.		20,000,000 706.3		
Contaminant	CAS	Emission Factor (lb/million cu.ft.) (and reference)		Calculated Emission (kg)
Arsenic	7440-38-2	0.0002	AP-42	0.064
Benzene	71-43-2	0.0021	AP-42	0.672
Beryllium	7440-41-7	< 0.000012	AP-42	< 0.00384
Cadmium	7440-43-9	0.0011	AP-42	0.352
Carbon Dioxide	124-38-9	120,000	AP-42	38,400,000
Carbon Monoxide	630-8-0	84	AP-42	26,900
Chromium	7440-47-3	0.0014	AP-42	0.448
Cobalt	7440-48-4	0.000084	AP-42	0.02688
Copper	7440-50-8	0.00085	AP-42	0.272
Formaldehyde	50-00-0	0.075	AP-42	24
Hexane	110-54-3	1.8	AP-42	577
Lead	7439-92-1	0.0005	AP-42	0.16
Manganese	7439-96-5	0.00038	AP-42	0.1216
Mercury	7439-97-6	0.00026	AP-42	0.0832
Methane	74-82-8	2.3	AP-42	737
Nickel	7440-02-0	0.0021	AP-42	0.672
Naphthalene	91-20-3	0.00061	AP-42	0.1952
Nitrous Oxide	10024-97-2	2.2	AP-42	705

Contaminant	CAS	Emission Factor (lb/million cu.ft.) (and reference)		Calculated Emission (kg)
Oxides of Nitrogen (as NO ₂)	10102-44-0	100	AP-42	32,000
PAH - Acenaphthene	83-32-9	< 0.0000018	AP-42	< 0.000576
PAH - Acenaphthylene	208-96-8	< 0.0000018	AP-42	< 0.000576
PAH - Anthracene	120-12-7	< 0.0000024	AP-42	< 0.000768
PAH - Benz(a)anthracene	56-55-3	< 0.0000018	AP-42	< 0.000576
PAH - Benzo(a)phenanthrene (Chrysene)	218-01-9	< 0.0000018	AP-42	< 0.000576
PAH - Benzo(a)pyrene	50-32-8	< 0.0000012	AP-42	< 0.000384
PAH - Benzo(b)fluoranthene	205-99-2	< 0.0000018	AP-42	< 0.000576
PAH - Benzo(g,h,i)perylene	191-24-2	< 0.0000012	AP-42	< 0.000384
PAH - Benzo(k)fluoranthene	207-08-9	< 0.0000018	AP-42	< 0.000576
PAH - Dibenzo(a,h)anthracene	53-70-3	< 0.0000012	AP-42	< 0.000384
PAH - Fluoranthene	206-44-0	0.000003	AP-42	0.00096
PAH - Fluorene	86-73-7	0.000003	AP-42	0.00096
PAH - Indeno(1,2,3-cd)pyrene	193-39-5	< 0.0000018	AP-42	< 0.000576
PAH - Phenanthrene	85-01-8	0.000017	AP-42	0.00544
PAH - Pyrene	129-00-0	0.000005	AP-42	0.0016
PM	N/A - M08	7.6	AP-42	2,435
PM ₁₀	N/A - M09	7.6	AP-42	2,435
PM _{2.5}	N/A - M10	7.6	AP-42	2,435
Selenium	7782-49-2	< 0.000024	AP-42	< 0.00768
Sulphur Dioxide	7446-09-5	0.6	AP-42	192
Toluene	108-88-3	0.0034	AP-42	1.088
Vanadium	7440-62-2	0.0023	AP-42	0.736
VOC	N/A - M16	5.5	AP-42	1,761
Zinc	7440-66-6	0.029	AP-42	9.28

Reporting Threshold Consideration

Contaminant	CAS	Calculated Emission, (kg/yr)	Reporting Threshold (kg/yr)	Equal to or Greater than Threshold	Reported Value (kg)
Oxides of Nitrogen (as NO) ^{note}	10102-43-9	20,870	14,000 *	✓	20,870
Sulphur Dioxide	7446-09-5	192	20,000 *	No	— BTH

Note The calculated oxides of nitrogen emission from AP-42 factors is expressed as NO₂. This value is multiplied by 0.6522 to obtain the reported oxides of nitrogen emission expressed as NO.

* MOE release based threshold (Table 2A)
— BTH means below reporting threshold.

Office Building J must report its oxides of nitrogen (as NO) emissions since its facility emissions of oxides of nitrogen (as NO) exceed the reporting threshold for this contaminant. For a contaminant whose emissions do not exceed its reporting threshold, the contaminant name has to be reported and identified with assigned codes indicating that the emission is below the reporting threshold or that there is no emission reportable.

