

# Application of Air Pollution Emissions Equations to Surface Mining

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## Overview

- ◆ what is an emission inventory?
- ◆ sources and types of emissions
- ◆ government reporting requirements
- ◆ science of emissions equations
- ◆ control of emissions
  - typical approaches
  - unique approaches for surface mining

## What is an emissions inventory?

- ◆ it is an accounting of each gram of contaminant emitted to the atmosphere from each source within the facility

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## Sources and Types of Emissions

- ◆ emissions from vehicles and equipment
  - engine emissions (PM, SO<sub>2</sub>, NO<sub>x</sub>, VOCs)
- ◆ process specific emissions
  - blasting (PM – TSP, PM<sub>10</sub>, PM<sub>2.5</sub>)
  - drop points (PM)
- ◆ fugitive emissions
  - vehicle travel (PM)
  - wind erosion from stockpiles and open areas (PM)

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## Reporting Requirements ... 1

- ◆ two basic reporting requirements
  - NPRI
  - O.Reg.127
- ◆ they require:
  - an annual report of any quantities of emissions above certain thresholds
  - preparation and maintenance of records of these emission quantities for 3-7 years
  - making records publicly available by posting on the Web or during regular business hours
  - if emissions of smog related pollutants are above a threshold then Smog Season (May 1 to September 1) reporting is also required

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## Reporting Requirements ... 2

- reporting to NPRI and O.Reg.127 does NOT relieve industry from having a Certificate of Approval (Air) to emit pollutants to the atmosphere
- a C of A is based on the equipment based maximum possible emissions over 30 minutes whereas O.Reg.127, and NPRI, is based on actual production over one year

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## Screening Criteria for Reporting

### ◆ Table 2A Contaminants:

- use coal, refuse, wood, waste oil;
- name plate capacity > 3MMBtu/hr;
- use 3000+ kg/yr of solvents;
- use 3000+ kg/yr of coating materials;
- use 3000+ kg/yr of printing ink; and/or
- use 5000+ kg/yr of welding rods/wires

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## Table 2A Contaminants (kg/yr)

|                      |               |
|----------------------|---------------|
| ◆ Carbon dioxide     | ◆ 100,000,000 |
| ◆ Carbon monoxide    | ◆ 20,000      |
| ◆ HFC-134A           | ◆ 10          |
| ◆ Methane            | ◆ 5,000,000   |
| ◆ Nitrous Oxide      | ◆ 2,700       |
| ◆ Oxides of Nitrogen | ◆ 14,000      |
| ◆ Particulate Matter | ◆ 20,000      |
| ◆ PM10               | ◆ 500         |
| ◆ PM2.5              | ◆ 300         |
| ◆ Sulphur Dioxide    | ◆ 20,000      |
| ◆ Total VOCs         | ◆ 10,000      |

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## Screening Criteria for Reporting

### ◆ Table 2B Contaminants

- Total employee working hours > 20,000/yr

AND

- MPO in an amount equal to or greater than the Table 2B contaminant thresholds

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## Screening Criteria for Reporting

### ◆ Table 2C Contaminants

- MOE no longer includes Table 2C directly
  - “Table 2C consists of all contaminants listed in the most current National Pollutant Release Inventory (NPRI)”

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## NPRI – Part 4 - CACs

- ◆ NPRI now requires assessment (and reporting) for emissions of CACs if:
  - ◆ **employees worked > 20,000 hours/yr**
  - ◆ **employees worked < 20,000 hours/yr unless:**
    - substance only released from a stationary sources; and
    - cumulative capacity of equipment < 10 MMBtu/hr; and
    - only type of fuel is natural gas, liquefied petroleum gas or No. 1 or 2 fuel oil.
  - ◆ CACs exceeded the NPRI's threshold limits

OR

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## NPRI: Part 4 Reporting Thresholds

- ◆ Carbon Monoxide ◆ 20 tonnes
- ◆ Oxides of Nitrogen (as NO<sub>2</sub>) ◆ 20 tonnes
- ◆ **PM<sub>2.5</sub>** ◆ **300 kg**
- ◆ **PM<sub>10</sub>** ◆ **500 kg**
- ◆ Sulphur Dioxide ◆ 20 tonnes
- ◆ **Total Particulate Matter (TSP)** ◆ **20 tonnes**
- ◆ VOCs ◆ 10 tonnes

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## NPRI Parts 1, 2 and 3 (>20,000 hrs/yr)

- ◆ Part 1
  - Group 1 (10 tonnes);
  - Group 2 (mercury – 5 kg)
  - Group 3 (cadmium – 5 kg)
  - Group 4 (arsenic, hexavalent chromium, lead, tetraethyl lead – 50 kg)
- ◆ Part 2 – 17 PAHs (50 kg total)
- ◆ Part 3 – hexachlorobenzene and dioxins/furans (activity based)

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## General Approach to Estimating Emissions

- ◆ Emission Factor Approach

$$E_{yr} = EF * AF$$

where  $E_{yr}$  = annual emissions in kg/year

EF = emission factor of pollutant in kg/unit of activity

AF = activity factor in units/year

- ◆ Control of Emissions Approach

$$E_c = E_{yr} * (1 - C/100)$$

where  $E_c$  = controlled annual emissions in kg/year

C = control efficiency in %

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## Emission Factors

| AP-42   | Section Description                           |
|---------|---|
| 1.3     | External Combustion Sources                   |
| 1.4     | Natural Gas Combustion                        |
| 1.5     | LPG Combustion                                |
| 1.11    | Waste Oil Combustion                          |
| 3.3     | Gasoline and Diesel Industrial Engines        |
| 11.9    | Western Surface Coal Mines                    |
| 11.19.1 | Sand and Gravel Processing                    |
| 11.19.2 | Crushed Stone & Pulverized Mineral Processing |
| 13.2.1  | Paved Roads                                   |
| 13.2.2  | Unpaved Roads                                 |
| 13.2.4  | Aggregate Handling and Storage Piles          |
| 13.3    | Explosives Detonation                         |

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## Typical Emission Factor ... 1

- ◆ **Blasting**
  - TSP (kg/blast) =  $0.00022 (A)^{1.5}$ 
    - ◆ where A = horizontal area (m<sup>2</sup>) with blasting depth ≤ 21 metres
- ◆ **Truck Loading**
  - TSP (kg/Mg) =  $0.580/M^{1.2}$ 
    - ◆ where M = material moisture content in %
- ◆ **Bulldozing**
  - TSP (kg/hr) =  $2.6 * s^{1.2}/M^{1.3}$ 
    - ◆ where s = material silt content in %

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## Typical Emission Factor ... 2

- ◆ Dragline
  - TSP (kg/m<sup>3</sup>) =  $0.0046 * d^{1.1} / M^{0.3}$ 
    - ◆ where d = drop height in metres
- ◆ Grading
  - TSP (kg/VKT) =  $0.0034 * S^{2.5}$ 
    - ◆ where S = mean vehicle speed in kph
- ◆ Active Storage Pile
  - TSP (kg/ha/hr) =  $1.8 * u$ 
    - ◆ where u = wind speed in m/second

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## Typical Emission Factor ... 3

- ◆ Vehicle Traffic (unpaved roads)  
for industrial sites
  - $E = k (s/12)^a (W/3)^b$ 
    - ◆ where E = size specific emission factor in lb/VMT
    - ◆ s = surface material silt content in % (1.8 – 25.2)
    - ◆ W = mean vehicle weight in tons (2 – 290)
    - ◆ k, a and b are empirical constants

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## Typical Emission Factor ... 4

### INDUSTRIAL ROADS

| Constant   | TSP  | PM <sub>10</sub> | PM <sub>2.5</sub> |
|------------|------|------------------|-------------------|
| k (lb/VMT) | 4.9  | 1.5              | 0.15              |
| a          | 0.7  | 0.9              | 0.9               |
| b          | 0.45 | 0.45             | 0.45              |

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## Typical Emission Factor ... 5

### ◆ DIESEL ENGINES

- typically emissions of PM and NO<sub>x</sub>
- emission factor has the units of kg/VKT
  - ◆ VKT = Vehicle Kilometre Travelled
  - ◆ applies to:
    - construction trucks
    - front end loaders
    - excavators
    - product delivery trucks
- generators in units of g/hp-hr

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## Control of Emissions

- ◆ control at source
  - engines
  - processing equipment
- ◆ control of dust
  - watering of roads
  - applying surface sealers (roads and storage piles)
  - wind breaks
  - vehicle speeds
  - dust barriers
  - pit retention

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## Pit Retention

(Thompson, 1994)

- ◆ a pit behaves in a way that traps some particulate matter based on its gravitational settling velocity, the speed of the wind and the concentration of dust in the pit
- ◆ also depending upon the shape and size of the pit and the speed of the wind, the emission point for dust can move upwind

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## Vegetation Screening

(Watson and Chow, 2000)

- ◆ showed that ~75% (range 60-90%) of suspended  $PM_{10}$  remains within 1-2 metres above the ground
  - means that a 2 metre barrier can block atmospheric transfer of a substantial amount of PM
- ◆ also showed a 90% reduction in  $PM_{10}$  after about 100 metres of travel
  - landscaping reduces dust dramatically: for example in a 5 m/second wind: TSP by 95%,  $PM_{10}$  by 75% and  $PM_{2.5}$  by 22% after 52 metres of travel

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## Summary

### SURFACE MINING

- ◆ there are codified industry sector focused calculation programs that the MOE has accepted (such as ECHO 127 for the aggregate sector)
- ◆ there are many cost effective ways to reduce emissions leaving the property

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