CASE STUDY #2: POINT SOURCE - FOUNDRY

Part 1: Goal

The objective of this case study is to learn how to characterize, estimate, and report emissions for a point source category. The specific goals to be achieved by this case study are:

- To estimate emissions from a metallurgical source category;
- To use source test and monitoring data for estimating emissions;
- To document the inventory process so that the results can be duplicated.

Part 2: Problem Description

Although the air quality in the inventory region does not violate the air quality standards, industrial facilities can cause air quality problems in the region. In particular, emissions from a gray iron foundry need to be estimated. There have been no previous efforts to inventory this facility. This iron foundry emits air pollutants through stacks, processes, and fugitive emissions. Stack monitoring data are available for some sources located within the foundry.

An annual criteria pollutant emissions inventory (in Mg) for the year 2002 should be estimated for the foundry based upon equipment-level and fugitive source emissions. A brief Inventory Preparation Plan/Quality Assurance Plan should be prepared. Also, the results (including methods, data, and assumptions used) should be documented to the extent that the results can be duplicated.

Note to the student: All of the activity data and their references provided in this case study are fictitious and made up for the sole purpose of demonstrating the emissions inventory methodology. However, the emission factors and their references are based on the actual references as provided.

Operational Schedule

The overall facility operational schedule during 2002 was as follows:

- 12 hours per day
- 5 days per week; and
- 52 weeks per year.

Materials Handling

The facility uses two enclosed conveyor belts to transport and load the raw material into open storage piles. The raw materials stored are coke (used as fuel) and pellet ore. One factor affecting air emissions during materials handling is the ambient wind speed. The average wind speed in the region is 8 km/hour. Characteristics of the materials handling equipment are as follows:

- Conveyor belt #1:
  Equipment ID: CONV-1
  Material loaded: Coke
  Throughput rate: 100 Mg/month
  Control device: Baghouse with fabric filter (95% efficiency)
  Capture efficiency: 85%
  Material moisture content = 7.8%

- Conveyor belt #2:
  Equipment ID: CONV-2
  Material loaded: Pellet ore
  Throughput rate: 80 Mg/month
  Control device: Baghouse with fabric filter (95% efficiency)
  Control efficiency: 95%
  Material moisture content = 2.2%

Particulate emissions from material handling operations can be calculated using the following equation (AP-42, Section 13.2.4):

$$E = k \times 0.0016 \times [(U/2.2)^{1.3}/(M/2)^{1.4}]$$

Where:

E = Emission factor (kg/Mg of material);
k = Particle size multiplier (k = 0.35 for PM_{10} and 0.11 for $PM_{2.5}$);

U = Mean wind speed, meters per second (m/s); and
M = Material moisture content (%).

Metal Melting

Solvent degreasing is carried out for scrap metal preparation. There is no heating for scrap preparation. The degreasing booths are uncontrolled. The total annual quantity of solvent used during 2002 for degreasing was 10,000 liters/year and the volatile content of the solvent is 450 g/liter. The equipment IDs for the booths are BOOTH-1 and BOOTH-2. (Assume equal solvent usage for both the degreasing booths.) VOC emissions from the degreasing operations can be calculated using material balance.

The facility has four electric arc furnaces for metal melting. All four furnaces are enclosed type and they exhaust emissions through a common stack. The furnaces are equipped with a baghouse filter to control particulate matter (PM) emissions. The capture and control efficiencies of the filter are 100% and 90%, respectively. Stack monitoring data are available for most pollutants (but not for VOCs). Characteristics of the furnaces are as follows:

- Equipment IDs: FUR-1; FUR-2; FUR-3; and FUR-4
  Annual production: 5,000 Mg of gray iron
  (Note that annual production for each furnace is not available. Per-furnace production may be assumed as 5,000/4 [1,250 Mg]).

- PM emissions were measured by stack sampling equipment
  Stack flow rate = 507.44 dscmm (dry standard cubic meters per minute)
  Volume of gas sampled = 1.16 dscm (dry standard cubic meters)
  PM_{10} collected on filter = 0.0642 grams
  $PM_{2.5}$ collected on filter = 0.05 grams

  Emissions (kg/hr) = PM concentration (grams/dscm) × stack flow rate × 60 × (1kg/1000g)

  Where:
  PM concentration (grams/dscm) = (PM collected on filter/volume of gas sampled)
  60 = 60 minutes/hour

- SO_2 emissions were measured with a continuous emissions monitoring system

Emissions (kg/hr) = (Pollutant concentration × MW × stack flow rate × 60)/(V×10^6)

Where:

SO_2 concentration = 0.75 ppmvd (parts/10^6)
MW = molecular weight of SO_2 = 64 kg/kg-mole
Stack flow rate = 507.44 dscmm
60 = 60 minutes/hour
V = volume of one mole of ideal gas at STP (20° C and 1 Atm.) = 24.07 m^3/kg-mole

- NO_x and CO emissions were measured with a CEMS
  Emissions (kg/hr) = (Use above equation)
  NO_x concentration = 12 ppmvd (parts/10^6)
  MW of NO_2 = 46 kg/kg-mole
  CO concentration = 280 ppmvd
  MW of CO = 28 kg/kg-mole

- VOC emissions can be calculated using an emission factor of 0.09 kg VOC/Mg of iron produced (AP-42).

Iron Refining

Magnesium is added to molten metal to produce ductile iron at this facility. The equipment/process ID for iron refining is FUG-1.

Particulate emissions from iron refining and magnesium treatment can be calculated using the following emission factors:

Operation	PM[a] Emission Factor (kg/Mg)
Iron refining	2
Magnesium treatment	0.2

Source: U.S. EPA, 1995 (Table 12.10-6, AP-42).
[a] PM_{10} size fraction to be 49% of total PM and $PM_{2.5}$ size fraction to be 24% of total PM (Table 12.10-8, AP-42).

Mold and Core Production

Two sand handling units operate at the facility. Each unit handles 3,000 Mg of sand annually. The operations involved are sand shakeout, sand handling, and baking (core making). The sand handling equipment IDs are SAND-1 and SAND-2.

Emission factors for the above described mold and core production operations are as follows:

Operations	PM[a] Emission Factor (kg/Mg)
Shakeout	1.6
Sand handling	1.8
Baking	0.6

Source: U.S. EPA, 1995 (Table 12.10-6, AP-42).

[a] PM_{10} size fraction to be 70% of total PM and $PM_{2.5}$ size fraction to be 42% of total PM (Table 12.10-8, AP-42).

Casting and Finishing

Casting and finishing involves pouring of metal into the casts and finishing processes. The equipment/process ID for casting and finishing is FUG-2. Emission factors for calculating emissions from casting and finishing operations are as follows:

Operation	PM[a] Emission Factor (kg/Mg)
Pouring	2.1
Finishing	0.05

Source: U.S. EPA, 1995 (Table 12.10-6, AP-42).

[a] PM_{10} size fraction to be 49% of total PM and $PM_{2.5}$ size fraction to be 24% of total PM (Table 12.10-8, AP-42).

Part 3: Planning

A brief Inventory Preparation Plan/Quality Assurance Plan for the gray iron foundry emissions inventory should be prepared. The contents of the Inventory Preparation Plan/Quality Assurance Plan are outlined as follows:

- Background and purpose of the inventory;
- Inventory area status;
- Inventory scope (area/facility, pollutants of concern, base year, temporal resolution);

- Data quality objectives;
- Inventory resources;
- Emissions estimation methodologies; and
- QA/QC procedures
  - Internal QC procedures;
  - External QA/QC procedures (to be conducted in Step 6 by exchanging solutions with another group, and completing the QA Checklist).

Student Team Exercise: Complete the following information.

Inventory Preparation Plan/Quality Assurance Plan preparation:

Background and purpose of the inventory:

Inventory area status:

Inventory scope:

Facility processes	**Pollutant**
a.	
b.	

Temporal Resolution:

Data Quality Objectives:

1.

2.

Inventory Resources:

1. Team
2. Overall project manager
3. Team manager
4. Data evaluator

Emission Estimation Methodology:

Complete Table 1, include equation for converting hourly emissions to annual emissions, and identify equations to calculate controlled emission or pollutants for processes that are controlled.

Table1. Emission Estimation Methodology: Uncontrolled Emissions

Process	Pollutant	Methodology	Equation	Data needed
Materials Handling:				
2 Conveyor belts				
Metal Melting:				
Degreasing – 2 booths				
Metal Melting:				
4 Electric Arc Furnaces				
Metal Melting:				
4 Electric Arc Furnaces				
Metal Melting:				
4 Electric Arc Furnaces				
Iron Refining				
Iron Refining				
Magnesium treatment				
Mold and Core Production:				
Shakeout				
Sand handling – 2 units				

Baking Casting and Finishing: Pouring Finishing

What units have hourly emissions that need to be converted? What is equation to convert hourly emissions to annual?

What is equation to calculate controlled emissions?

Complete Table 2 to calculate controlled emissions.

Table 2. Control Emissions Data

Process	Unit	Pollutant	Control Equipment	Capture Efficiency (%)	Control Efficiency

QA/QC procedures:

1.

2.

3.

Emission Calculations

Surface Coal Mining:

Process	Pollutant	Emission Factor	Units of Emission Factor	Mine Activity Data	Units of activity data	Annual Emissions (kg/yr)
Blasting	PM2.5					
Truck Loading	PM 2.5					
Bulldozing coal	PM 2.5					
Bulldozing overburden	PM 2.5					
Dragline	PM 2.5					
Storage Pile Wind erosion	TSP					

Utility Boiler: Pulverized coal, dry bottom, wall-fired

Pollutant	Emission Factor	Units of Emission Factor	Mg coal burned	% Ash	% Sulfur	Emissions (kg/yr)
SOx						
NOx						
CO						
PM10						
PM2.5						

Provide outline for documentation report

Exchange calculations and outlines for documentation report. Perform QA on results of different teams.