RAPIDC
Regional Air Pollution in Developing Countries

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Malé Declaration 1ST emissions inventory workshop

AIT, Bangkok, 3rd – 5th July 2006

Part 4 Compilation of emissions for Industrial Processes (Sector 6)

Harry Vallack,

Stockholm Environment Institute (SEI)

University of York, UK

Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia

Industrial Process Emissions

Air pollutants can be emitted by a variety of industrial processes that chemically or physically transform materials. These non-combustion emissions are termed process emissions.

The industry categories covered in the Manual are:

- **Mineral Products,**
- **The Chemical Industry,**
- **Metals Production,**
- **The Pulp and Paper Industries,**
- **Alcoholic Beverages Production,**
- **Food Production,**
- **(Fugitive emission of PM from major building construction activities)**

Emissions are calculated as:

(Annual rate of production) x (Process emission factor)

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Industrial Process Emissions – *activity data*

International reference sources for industrial activity data by year and by country:

- ***United Nations Industrial Commodity Statistics Yearbooks***
- ***United States Geological Survey (USGS)* (for metals and minerals)**
- ***International Iron and Steel Institute (IISI) Steel Statistical Yearbook* (for pig iron production)**
- ***Food and Agriculture Organisation's (FAO) on-line database FOASTAT* (for production of pulp and paper, fertilizers)**

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Emissions from Industrial Processes - *Mineral Products*

	Emission factors (kg per tonne product output)						
Sub-sector/Process	**SO_2**	**NO_x**	**CO**	**NMVOC**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**
Mineral products (ISIC Division 26)							
Cement production:							
Wet process kiln (uncontrolled)	0.3 [a]	NA	NA	NA	NA	16 [b]	4.64 [b]
Wet process kiln with ESP	0.3 [a]	NA	NA	NA	NA	0.33 [b]	0.25 [b]
Dry process kiln with fabric filter	0.3 [a]	NA	NA	NA	NA	0.084 [b]	0.045 [b]
Lime production							
Coal-fired rotary kiln (uncontrolled)	NA	NA	NA	NA	NA	22 [b]	2.57 [b]
Coal-fired rotary kiln (with ESP)	NA	NA	NA	NA	NA	2.2 [b]	0.62 [b]
Asphalt roofing production	NA	NA	0.0095 [c]	0.046 [c]	NA	0.6 [c]	-
Asphalt blowing	NA	NA	0.014 [b]	0.66 [d]	NA	0.33 [e]	-
Road paving:							
Asphalt plant - Batch Mix Hot Mix, (uncontrolled)	NA	NA	NA	0.018 [b]	NA	2.25 [b]	0.14 [b]
Asphalt plant- Batch Mix Hot Mix, (fabric filter PM control)	NA	NA	NA	0.018 [b]	NA	0.0135 [b]	0.0042 [b]
Asphalt plant -Drum Mix Hot Mix, (uncontrolled)	NA	NA	NA	0.016 [b]	NA	3.25 [b]	0.75 [b]
Asphalt plant - Drum Mix Hot Mix, (fabric filter PM control)	NA	NA	NA	0.016 [b]	NA	0.0115 [b]	0.0015 [b]
Liquefied asphalt - rapid cure (RC)	NA	NA	NA	170 [f]	NA	NA	NA
Liquefied asphalt -medium cure (MC)	NA	NA	NA	140 [f]	NA	NA	NA
Liquefied asphalt - slow cure (SC)	NA	NA	NA	50 [f]	NA	NA	NA
Brick manufacturing							
Grinding and screening (dry material; uncontrolled)	NA	NA	NA	NA	NA	0.26 [b]	-
Coal-fired kiln (uncontrolled)	NA	NA	NA	NA	NA	0.68 [b]	0.44 [b]

Emissions from Industrial Processes - *Chemical Industry*

	Emission factors (kg per tonne output)						
Sub-sector/Process	**SO_2**	**NO_x**	**CO**	**NMVOC**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**
Chemical industry (ISIC Division 24)							
Ammonia	0.03[a]	NA	7.9[a]	4.7[b]	2.1[a]	NA	NA
Nitric acid	NA	12[c]	NA	NA	0.01[d]	NA	NA
Adipic acid	NA	8.1[a]	34.4[a]	9[a]	NA	0.5[a j]	-
Carbon black	3.1[e]	0.4[e]	10[e]	40[e]	NA	6.56[a j]	-
Urea (uncontrolled)	NA	NA	NA	NA	11.8[f]	125.6[f]	-
Urea (wet scrubbber)	NA	NA	NA	NA	11.8[f]	0.71[f]	-
Ammonium nitrate	NA	NA	NA	NA	29 – 63[g]	4.7-9.0[g j]	-
Ammonium phosphate	0.04[h]	NA	NA	NA	0.07[h]	0.34[h j]	-
Sulfuric acid	0 – 48[i]	NA	NA	NA	NA	NA	NA
Titanium dioxide	14.6[e]	NA	NA	NA	NA	-	-
Other (user specified)							

* **Emission factors for sulphuric acid production range from 0 - 48 kg/tonne depending on the $SO_2 \rightarrow SO_3$ conversion efficiency. Assume 17 kg/tonne for single contact process; 3.4 kg/tonne for double contact process.**

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Emissions from Industrial Processes - *Metal production*

	Emission factors (kg per tonne output)						
Sub-sector/Process	**SO_2**	**NO_x**	**CO**	**NMVOC**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**
Metal production (ISIC Division 27)							
Pig iron production	3 [a]	0.076 [d]	1.34 [c]	0.12 [c]	NA	0.05 [i]	-
Aluminum production	15.1 [e]	2.15 [e]	135 [d]	0.02 [d]	NA	47 [b]	-
Copper smelting (primary)	2120 [f]	NA	NA	0.03 [d]	NA	230 [f]	193 [f]
Lead smelting (primary)	320 [g]	NA	NA	NA	NA	0.43 [k]	-
Lead smelting (secondary)	40 [h]	NA	NA	NA	NA	162 [h]	-
Zinc smelting (primary)	1000 [g]	NA	NA	NA	NA	293 [j]	-

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Emissions from Industrial Processes - *Pulp and Paper Industries*

	Emission factors (kg per tonne output)						
Sub-sector/Process	**SO_2**	**NO_x**	**CO**	**NMVOC**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**
Pulp and Paper Industries (ISIC Division 15)							
Kraft or Alkaline soda pulping	3.8 [l]	1.5 [m]	5.6 [m]	3.7 [m]	NA	92 [p]	81 [p]
Acid sulphite pulping	30 [m]	NA	NA	NA	NA	1.5 [o]	1.3 [o]
Neutral sulphite semi-chemical (NSSC)	-	0.5 [n]	NA	0.15 [n]	NA	-	-

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Emissions from Industrial Processes - *Food and Drink (Alcoholic beverages)*

Sub-sector/Process	Emission factors (kg per tonne or hectolitre output)						
Food and Drink (ISIC Division 29)	**SO_2**	**NO_x**	**CO**	**NMVOC [a]**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**
Alcoholic Beverages							
Beer	NA	NA	NA	0.035	NA	-	-
Red wine	NA	NA	NA	0.08	NA	-	-
White wine	NA	NA	NA	0.035	NA	-	-
Wine (unspecified)	NA	NA	NA	0.08	NA	-	-
Malt whiskey	NA	NA	NA	15	NA	-	-
Grain whiskey	NA	NA	NA	7.5	NA	-	-
Brandy	NA	NA	NA	3.5	NA	-	-
Other Spirits (unspecified)	NA	NA	NA	15	NA	-	-

***Hectolitre (hl) = 100 litres**

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Emissions from Industrial Processes - *Food and Drink (Food production)*

Sub-sector/Process	Emission factors (kg per tonne or hectolitre output)						
Food and Drink (ISIC Division 29)	**SO_2**	**NO_x**	**CO**	**NMVOC [a]**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**
Food Production							
Meat, fish and poultry	NA	NA	NA	0.3	NA	-	-
Sugar	NA	NA	NA	10	NA	-	-
Margarines and solid cooking fats	NA	NA	NA	10	NA	-	-
Cakes, biscuits and breakfast cereals	NA	NA	NA	1	NA	-	-
Bread	NA	NA	NA	4.5	NA	-	-
Animal feed	NA	NA	NA	1	NA	-	-
Coffee roasting	NA	NA	NA	0.55	NA	-	-

***All processes in the food chain which occur after the slaughtering of animals or harvesting of crops. (Excludes vegetable oil extraction and tobacco).**

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Emissions from Industrial Processes - *Emission controls*

The use of control equipment or low-emission techniques can be accounted for in the calculations by using appropriate (lower) emission factors.

In Nitric acid production, for example:

- **Default NOx emission factor (where process details are not known) = 12 kg/tonne acid**
- **For the *"low pressure process"* emission factors range from 10 - 20 kg/tonne acid.**
- **For the *"direct strong acid process"* emission factors range from 0.1 - 1.0 kg/tonne acid**

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Compilation of emissions for Industrial Processes (Sector 6)

Practical session 6:

1. Filling in workbook with dummy data *(see practical session 6 notes)*
2. Plenary session – *sharing problems encountered etc.*