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Session 4: Compilation of emissions for Fugitive emissions from fuels (Sector 5) and Industrial Processes (Sector 6)

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

Summary of emission source categories used in the manual

Energy sources:

- 1 Combustion in the Energy Industries
- 2 Combustion in Manufacturing Industries and Construction
- 3 Transport
- 4 Combustion in Other Sectors
- 5 Fugitive emissions from fuels

Other source sectors:

- 6 **Industrial Processes**
- 7 **Solvent and Other Product Use**
- 8 **Agriculture**
- 9 **Vegetation Fires & Forestry**
- 10 **Waste**

Emissions for Energy sources – Sector 5: *Fugitive emissions from fuels*

This sub-sector covers all *non-combustion* activities related to fossil fuel:

- extraction (oil well drilling, oil/gas production, venting and flaring);
- processing (coke production, oil refining);
- storage (natural gas, crude oil and petroleum products); and
- distribution and handling (loading crude onto tankers, pipeline transport of oil/gas, gasoline emissions from service stations);

Emissions for Energy sources – *Fugitive emissions from fuels*

The use of oil and gas to provide energy for internal (own) use in fuel extraction and processing are not considered to be fugitive emissions.

Also excluded are evaporative emissions from vehicles as these are included under ‘Transport’.

This category forms a major component of national NMVOC emissions in many countries.

Not all fugitive emissions from fuels are NMVOCs. For example, PM₁₀ arise from coke production and SO₂, NO_x and CO are emitted during oil refining.

Compilation of emissions for Energy sources - *Fugitive emissions from fuels (Sector 5)*

Practical session:

1. Filling in workbook with dummy data (see *Exercise 5c notes*)
2. Plenary session – *sharing problems encountered etc.*

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)

Industrial Process Emissions

– *activity data*

International reference sources (all on-line) for industrial activity data by year and by country:

- ❖ ***UN Industrial Commodity Statistics Database (Online)***
- ❖ ***United States Geological Survey (USGS) Minerals yearbooks (online) for metals and minerals***
- ❖ ***Worldsteel association (online) database for pig iron production also called ‘blast furnace iron’ (BFI)***
- ❖ ***Food and Agriculture Organisation’s (FAO) database FOASTAT for production of pulp and paper, fertilizers***

Emissions from Industrial Processes - Mineral Products

Sub-sector/Process	Emission factors (kg per tonne product output)						
	SO ₂	NO _x	CO	NM VOC	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

Sheet: 1.6.1 Particulate matter (PM₁₀) combustion emission factors (kg/tonne fuel)

Sector: Energy - Fuel combustion activities

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Sub-sector: Sub-sub-sector:		Manufacturing Industries and Construction									
		Non-metallic minerals ^r		Chemicals		Pulp, Paper and print		Mining and Quarrying		Construction	
			Default ^a		Default ^a		Default ^a		Default ^a		Default ^a
Fuel type Coal	Coking Coal										
	Other Bituminous Coal & Anthracite		4.23 ^c or 0		4.23 ^c		4.23 ^c		4.23 ^c		4.23 ^c
	Sub-Bituminous Coal										
	Lignite										
	Patent Fuel										
	Coke Oven Coke										
	Gas Coke										
	BKB										
	Coke Oven Gas										
	Blast Furnace Gas										
Gas	Gas Works Gas										
	Natural Gas		0.104		0.104		0.104		0.104		0.104
Oil	Crude Oil										
	Natural Gas Liquids										
	Refinery Gas										
	Liquefied Petroleum Gases										
	Motor Gasoline										
	Aviation Gasoline										
	Gasoline type Jet Fuel										
	Kerosene type Jet Fuel										
	Kerosene		0.148 ^m or 0		0.148 ^m		0.148 ^m		0.148 ^m		0.148 ^m
	Gas/Diesel Oil		0.142 ^m or 0		0.142 ^m		0.142 ^m		0.142 ^m		0.142 ^m
Heavy Fuel Oil		1.09 ^l or 0		1.09 ^l		1.09 ^l		1.09 ^l		1.09 ^l	
Petroleum coke		4.23 ^j or 0		4.23 ^j		4.23 ^j		4.23 ^j		4.23 ^j	
Other Petroleum Products											

^r These 'non-metallic minerals' default factors should be set to zero if the default factors given for mineral processes (Sheet 2.1) are used which include combustion emissions already (as well as process PM emissions).

Emissions from Industrial Processes - *Chemical Industry*

Sub-sector/Process	Emission factors (kg per tonne output)						
	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 ^{aj}	-
Carbon black	3.1 ^e	0.4 ^e	10 ^e	40 ^e	NA	6.56 ^{aj}	-
Urea (uncontrolled)	NA	NA	NA	NA	11.8 ^f	125.6 ^f	-
Urea (wet scrubber)	NA	NA	NA	NA	11.8 ^f	0.71 ^f	-
Ammonium nitrate	NA	NA	NA	NA	29 – 63 ^g	4.7-9.0 ^{gj}	-
Ammonium phosphate	0.04 ^h	NA	NA	NA	0.07 ^h	0.34 ^{hj}	-
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 SO₂ → SO₃ conversion efficiency. Assume 17 kg/tonne for single contact process; 3.4 kg/tonne for double contact process.

Emissions from Industrial Processes - *Metal production*

Sub-sector/Process	Emission factors (kg per tonne output)						
	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	-

Emissions from Industrial Processes - *Pulp and Paper Industries*

Sub-sector/Process	Emission factors (kg per tonne output)						
	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	-	-

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

Sub-sector/Process	Emission factors (kg per tonne or hectolitre output)						
	SO ₂	NO _x	CO	NMVOC ^a	NH ₃	PM ₁₀	PM _{2.5}
Food and Drink (ISIC Division 29)							
<i>Alcoholic Beverages</i>							
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

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

Sub-sector/Process	Emission factors (kg per tonne or hectolitre output)						
	SO ₂	NO _x	CO	NMVOC ^a	NH ₃	PM ₁₀	PM _{2.5}
Food and Drink (ISIC Division 29)							
<i>Food Production</i>							
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).**

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 NO_x 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

Fugitive emissions of particulate matter from major building construction activities.

Sheet: 2.7 Fugitive emissions of particulate matter from major building construction activities.

Sector: Industrial processes

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A	B		C	D		E
Activity rate^a (total hectare-months)	PM₁₀ emission factor (t/ha/month of activity)		PM₁₀ emissions (tonnes)	PM_{2.5} emission fraction (% of PM₁₀)		PM_{2.5} emissions (tonnes)
		Default^b	(C = A x B)		Default	(E = C x D)
		2.69	0		Default	0

^a This is the sum of the individual hectare-months (area of construction site (hectares) multiplied by duration of activity during inventory year (expressed in months)) for each major building construction project

Compilation of emissions for Industrial Processes (Sector 6)

Practical session:

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