Discussion paper - Review of PM for Fugitive emissions (1B)

Coal mining and handling

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In the current version of the EMEP/EEA Guidebook (in the following referred to as GB) the Tier 1 EF for PM_{10}, which refers to Vrins (1999), is based on measurements in the Netherlands. The measurements cover emissions from storage and handling but do not include emissions from mining activities. Therefore it might lead to an underestimation to use this emission factor in Tier 1 for coal mining and handling.

At present the GB include a Tier 2 emission factor for storage of coal of EF_{PM10} = 4.1 ton/ha/year with reference to US EPA, 2006. This value seems to be the one included in the emission factor database. US EPA chapter 13.2.4 has been updated and this emission factor is no longer included in AP-42.

The review of the PM emission factors lead to a proposal to

- Update the Tier 1 EF for PM_{10} for coal mining and handling and to add emission factors for TSP and $PM_{2.5}$.
- Add PM emission factors for drilling and mining
- Update the PM_{10} emission factor for storage of coal and to add emission factors for TSP and $PM_{2.5}$
- Add TSP and $PM_{2.5}$ emission factors for handling of coal (scaled to the present PM_{10} EF referring to Vrins (1999)

Drilling

US EPA (1998) gives a TSP EF at 0.59 kg/hole. If the same size distribution is assumed as US EPA (2006a) gives for aggregate handling and storage (PM_{10}/TSP=0.47) the PM_{10} EF is 0.277 kg/hole. This is in line with the PM_{10} EF at 0.31 kg/hole (Australian Government, 2012), that is estimated from the US EPA emission factor for TSP combined with size distribution measurements in Hunter Valley, Australia. To maintain consistency in the GB, it is proposed to use US EPA values for all PM size fractions:

EF_{TSP} = 0.59 kg/hole (US EPA, 1998)

EF_{10} = 0.277 kg/hole (US EPA, 1998)

$EF_{2.5}$ = 0.042 kg/hole (US EPA, 1998)

Underground mining

PM emissions are assumed to be limited. EFs are not found via the literature study and therefore **no EFs are proposed** to be included in the GB.

Open cast mining

US EPA (1998) give EFs for PM from operations related to open cast mining.

Australian Government (2000) gives EFs for mining and processing of Non-metallic minerals (excavators/shovels/front-end loaders and trucks on overburden and on coal). The summarised EF_{TSP} for these operations is 0.076 kg/Mg, which is very similar to the EF based on US EPA (1998) EF_{TSP} = 0.082 kg/Mg. EFs in Australian Government (2000) include emissions from fuel combustion, which is not the case for the US EPA EFs. It is proposed to use the following summarised EFs based on US EPA (1998) (topsoil removal + overburden replacement + truck loading + truck unloading) for Tier 1:

EF_{TSP} = 0.082 kg/Mg (US EPA, 1998)
EF_{10} = 0.039 kg/Mg (US EPA, 1998)
$EF_{2.5}$ = 0.006 kg/Mg (US EPA, 1998)

Handling of coal

EFs for fugitive emissions from coal piles are given in US EPA (2006b). The EFs include emissions from loading, wind erosion, equipment traffic and load out. US EPA chapter 13.2.4 has been updated and now includes a formula for estimation of emissions from any drop related operation:

$$E = k(0.0016)\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

E: emission factor (kg/Mg)
k: particle size multiplier
U: mean wind speed (m/s)
M: material moisture content (%)

If available, country or side specific parameters should be applied. Else standard values from US EPA can be used for k and M. The following EFs proposed for the GB are based on the US EPA formula and the following assumptions:

k (PM_{TSP}) = 0.74
k (PM_{10}) = 0.35
k ($PM_{2.5}$) = 0.053
source: US EPA page 13.2.4-4

M = 4.8 % (US EPA table 13.2.4-1, Iron and steel production, Coal)

U = 6.7 m/s (upper range for the equation, which will be too high for many areas. The formula could be included in the GB chapter to enable countries to apply country specific mean wind speed, which are assumed to be available for all or at least a majority of countries.

The proposed EFs for any drop-operation:

EF_{TSP} = 1.403 g/Mg (US EPA (2006b))
EF_{10} = 0.699 g/Mg (US EPA (2006b))
$EF_{2.5}$ = 0.101 g/Mg (US EPA (2006b))

Coal piles

Toraño et al. (2007) has estimated EFs for fugitive PM emissions from coal piles under a number of assumptions regarding wind speed, friction, number of annual disturbances, pile orientation in proportion to wind direction and pressure. EF_{TSP} was estimated for different pile shapes; cone (0.014 kg/Mg), semicircular 90° (0.004 kg/Mg) and semicircular 180° (0.005 kg/Mg). The mean of the three EFs is proposed for the GB for TSP and the size composition from US EPA handling and storage is applied to estimate EFs for

PM_{10} and $PM_{2.5}$. This gives EF_{PM10} = 0.004 kg/Mg which are comparable to the PM_{10} EF for storage and handling given by Vrins (1999) at 3 g/Mg coal.

Vrins (1999) are based on measurements of concentrations in air in Rotterdam, the Netherlands and might be better applicable to European conditions than emission factors based on US EPA. It should be considered if the PM_{10} emission factor from Vrins (1999) should be maintained and TSP and $PM_{2.5}$ EFs should be added based on the size distribution from US EPA, or if it is better to use EFs based on the more recent study by Toraño et al. (2007) and US EPA. The latter would make the GB more transparent as all references are accessible on the internet and are written in English.

The following PM EFs are proposed (based on Toraño et al. (2007) and US EPA (2006a)):

EF_{TSP} = 0.008 kg/Mg (0.048 kg/m2) (Toraño et al. (2007), US EPA (2006a))
EF_{PM10} = 0.004 kg/Mg (0.023 kg/m2) (Toraño et al. (2007), US EPA (2006a))
$EF_{PM2.5}$ = 0.001 kg/Mg (0.003 kg/m2) (Toraño et al. (2007), US EPA (2006a))

Alternativel EFs (based on Vrins (1999) and US EPA:

EF_{TSP} = 0.006 kg/Mg (Vrins (1999), US EPA (2006a)) (2.114*PM_{10})
EF_{PM10} = 0.003 kg/Mg (Vrins (1999), US EPA (2006a))
$EF_{PM2.5}$ = 0.0005 kg/Mg (Vrins (1999), US EPA (2006a)) (0.151*PM_{10})

Tier 1 for coal storage and handling

A summarised set of EFs for coal storage and handling would be (based on Toraño et al. (2007) and US EPA):

EF_{TSP} = 0.009 kg/Mg (Toraño et al. (2007), US EPA (2006a, 2006b))
EF_{PM10} = 0.005 kg/Mg (Toraño et al. (2007), US EPA (2006a, 2006b))
$EF_{PM2.5}$ = 0.001 kg/Mg (Toraño et al. (2007), US EPA (2006a, 2006b))

Tier 1 for coal mining and handling

A summarised set of EFs for coal mining and handling (including storage (based on Toraño et al. (2007) and US EPA), excluding drilling) would be:

EF_{TSP} = 0.091 kg/Mg (Toraño et al. (2007), US EPA (1998, 2006a, 2006b))
EF_{10} = 0.044 kg/Mg (Toraño et al. (2007), US EPA (1998, 2006a, 2006b))
$EF_{2.5}$ = 0.007 kg/Mg (Toraño et al. (2007), US EPA (1998, 2006a, 2006b))

Abatement

The previous table 3-6 in the GB gives abatement efficiency at 90 % of TSP for use of water sprinklers and binding materials based on US EPA (2006a). This could be supplemented by abatement efficiency for use of water sprays at 50 % according to Australian Government (2000).

Coke production

The GB chapter 1.B.1.b holds emission factor for coke production. The Tier1 and Tier 2 EFs are identical and lack EFs for Cr, Cu, Se and Zn. EFs for PM refer to EC, 2001, EFs for HM refer to Theloke et al., 2008 and EFs for PAH refer to Berdowski et al., 1995.

AP-42, 12.2:

Source	Controls	TSP	PM_{10}	$PM_{2.5}$	unit	Reference	Note
Oven leaks and charging	Uncontrolled:	1.24			kg/Mg coke*	AP-42, 12.2	Filterable + condensable PM
Oven leaks and charging	Pre-NESHAB:	0.05			kg/Mg coke*	AP-42, 12.2	Filterable + condensable PM
Oven leaks and charging	Post_NESHAB:	0.01			kg/Mg coke*	AP-42, 12.2	Filterable + condensable PM
Coke oven pushing	Uncontrolled	0.86			kg/Mg coke*	AP-42, 12.2	Filterable PM
Coke oven pushing	Hood and FF control	0.30			kg/Mg coke*	AP-42, 12.2	Filterable + condensable PM
Coke oven pushing	Hood and scrubber	0.27			kg/Mg coke*	AP-42, 12.2	Filterable + condensable PM
Quenching **	Uncontrolled, dirty water	3.4			kg/Mg coke*	AP-42, 12.2	Filterable PM
Quenching **	Dirty water, tall tower and/or poor maintenance	1.8			kg/Mg coke*	AP-42, 12.2	Filterable PM
Quenching **	Clean water, normal tower, proper maintenance	0.2			kg/Mg coke*	AP-42, 12.2	Filterable PM

* Conversion factor:
AEAT-6270 Issue 2: 1.6 Mg coal charged / Mg coke produced
EIPCC BREF, Iron and steel production: 1.22 – 1.35 Mg coal charged / Mg coke produced
Applied: 1.3 Mg coal charged / Mg coke produced (based on EIPCC BREF)
** Selected controls are included, representing upper, lower and middle range

EC, IPCC BREF, Iron and steel production, draft version 2012:

Source	TSP	Unit	Reference
Overall	15.7 – 298	g/Mg coke	EC (2012)
Charging	0.3 – 10	g/Mg coke	EC (2012)
Door leaks	0.3 – 6	g/Mg coke	EC (2012)
Lid leaks	0.2 – 1	g/Mg coke	EC (2012)

Ascension pipes (off-takes)	< 0.2	g/Mg coke	EC (2012)
Quenching	10 - 50	g/Mg coke	EC (2012)

Passant et al. (2000): UK fine particle emissions from industrial processes

EFs for coke production based on Environment Agency's Pollution Inventory for UK coke plants in 1998:

	EF	Unit
TSP	116	g/Mg coke produced
PM_{10}	63	g/Mg coke produced

Weitkamp et al. (2005) is based on measurements carried out in 2002, and is supposed to be representative for coke production under European conditions. The study included both PM, HM, OC and EC, and can thereby contribute to increase the consistency of emission factors for coke production.

$EF_{PM2.5}$ was estimated from the measured and calculated SO_2 emission, as the inventory for SO2 was assumed to be more certain than for PM2.5. Further, the concentration of PM2.5 to PM10 was measured. By combining these data the following PM EFs was estimated:

Pollutant	EF, g/Mg of coke produced	Uncertainty, g/Mg coke produced
$PM_{2.5}$	40	+-20
PM_{10}*	48	+-24**

* $PM_{2.5}$ contributes 84 ±14 % of PM_{10}
** Combined uncertainty = $\sqrt{(20^2+14^2)}$

The EFs in the tables above are largely different. EFs from US EPA are significantly lower than EFs from the EC BREF report. For quenching the largest EF from US EPA for a worst case scenario is approximately 1/3 of the lower value given in EC BREF.

This source might need further review to decide if the reference to the PM EFs should be changed. But for now the proposal is to continue to use the BREF document by the European Commission as reference for the PM_{TSP}. Though, the EF should be updated to values in the recently adopted BREF for Iron and steel production. EC (2012) given dust emissions from European coke oven plants in the interval 15.7 – 298 g/Mg coke. This is an increase since the previous version EC (2001), which had 17 – 75 g/Mg LS (corresponding to 51 – 223 g/Mg coke. A new EF for TSP could be EF_{TSP} =½*298 = 150, as it seems to be in agreement with the relationship between lower range upper range and the geometric mean used in the present version of the GB. The upper and lower values might be applies as the range of the 95 % confidence interval (lower range = 15.7 g/Mg coke and upper range = 298 g/Mg coke).

To estimate EFs for PM_{10} and $PM_{2.5}$ the size fractions for moderate control based on Passant et al. (2000) and US EPA (2000) as quoted in Klimont et al. (2002) are applied. $PM_{2.5}$ can be estimated as 40 % of TSP and PM10 can be estimated as 54 % of TSP. The proposed EFs are supported by the EFs for PM_{10} and $PM_{2.5}$ by Passant et al. (2000) and the EFs for PM_{10} and $PM_{2.5}$ by Weitkamp et al. (2005) as these are of comparable size.

Tier 1 EFs for solid fuel transformation proposed for the GB:

Coke oven plant	EF, g/Mg coke	lower	upper	Reference
TSP	150	15	300	EC (2012)
PM_{10}*	80	8	160	EC (2012), Klimont et al. (2002)
$PM_{2.5}$*	60	6	120	EC (2012), Klimont et al. (2002)

* In agreement with the uncertainties for TSP, the lower range is 10 % of EF and the upper range is 200 % of EF.

As the PM EFs cover the whole process of coke production, it is not possible to include abatements at different stages. Therefor the Tier 1 EFs are proposed for Tier 2 as well, like is the case in the present GB chapter.

1B2a iv – Refining/storage

All EFs with reference to CONCAWE are verified in the latest version of the report (CONCAWE (2009)). No inconsistencies are found in the EFs according to the standard checks ($\sum TSP > \sum pm_{10} > \sum pm_{2.5} > \sum HM$ and $\sum pm_{2.5} > \sum PAH$).

Kupiainen & Klimont (2004) gives emissions from refineries of TSP, PM_{10} and PM_1. Based on the size distribution from that study EFs for TSP and PM_1 can be estimated from the present PM10 EF in the GB. According to Kupiainen & Klimont (2004) PM_1/PM_{10} = 42 % and PM_{10}/TSP = 98 %.

For now, no data on $PM_{2.5}$ is found and the assumption $PM_{2.5} = PM_1$ is applied. Further, the same size distribution will be applied for all sources (catalytic cracking and Fluid coking units) if more appropriate data are not found.

1B2c – Venting and flaring

All EFs refer to CONCAWE 2007. The values are verified in the latest version of the report (CONCAWE (2009)). No inconsistencies are found in the EFs according to the standard checks ($\sum TSP > \sum pm10 > \sum pm2.5 > \sum HM$).

The present version of the GB lacks EFs for TSP and $PM_{2.5}$ for enclosed flaring in oil refineries. CONCAWE (2009) does not include neither emission factors for TSP and $PM_{2.5}$ nor ratios between different particle fractions. EC (2012) include emission ranges of TSP, PM_{10} and $PM_{2.5}$ for 4-43 European refineries. Based on these emission ranges EFs for TSP and $PM_{2.5}$ can be estimated from the $EF_{PM2.5}$ from CONCAWE (2009).

The following EFs are proposed to be included in the GB for enclosed flaring in oil refineries:

	EF, g/GJ*
TSP	11
PM_{10}	0.89
$PM_{2.5}$	0.24

* EFs based on EFPM2.5 from CONCAWE (2009) and shares of TSP and $PM_{2.5}$ to PM_{10} based on EC (2012)

Further it is proposed to change the reference from CONCAWE 2007 to CONCAWE (2009).

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