Discussion paper – Review of consistency for mobile sources

The EMEP/EEA guidebook chapters for mobile sources are generally well worked through. The chapters have gone through substantial reviews during their development from the initial versions printed in the guidebook. The quality of the guidebook chapters for mobile sources is also reflected in the following brief comments which treat the comparable levels of particulate size provided in the chapters (TSP>=PM_{10}>=$PM_{2.5}$), heavy metal (HM) emission factor sums staying below PM emission factors. Those assessments are probably more important to make for other sources which have been given less attention and work load during the development of the EMEP/EEA guidebook.

In this note other issues of concern are also given for each of the chapters for mobile sources. These issues mainly relate to minor data errors sources for HM and PAH emission factors which have been revealed in the literature review made under Task 1.

Railways

1. TSP>=PM_{10}>=$PM_{2.5}$

It has been checked that TSP>=PM_{10}>=$PM_{2.5}$ for Tier 1 (Table 3-1) and Tier 2 emission factors (Tables 3-2, 3-3 and 3-4) in the guidebook chapter for railways.

2. ΣHM<TSP

It has been checked that ΣHM<TSP for Tier 1 (Table 3-1) and Tier 2 emission factors (Tables 3-2, 3-3 and 3-4). For railways, the Tier 1 emission factors for HM are also used for Tier 2 calculations (foot note for the Tables 3-2, 3-3 and 3-4).

3. Other issues

Due to an error the lower limit of the confidence interval for TSP, PM_{10} and $PM_{2.5}$ is in each case higher than the average emission factor value given in the Table 3-1 for Tier 1.

Errors also appear in the Tier 2 emission factor Tables 3-2, 3-3 and 3-4 for PM. The foot note for the Tables 3-2, 3-3 and 3-4 states that *"PM_{10} EFs taken from Halder et al. 2005. $PM_{2.5}$ was considered 95 % of PM_{10} and PM_{10} was considered 95 % of TSP."* The PM_{10} fraction of TSP and the $PM_{2.5}$ of PM10 that can be derived from the TSP, PM_{10} and $PM_{2.5}$ emission factors in the tables are, however, considerably smaller than stated in the table foot note. Most likely, the TSP, PM_{10} and $PM_{2.5}$ emission factors needs to be recalculated.

Navigation

1. TSP>=PM_{10}>=$PM_{2.5}$

It has been checked that TSP>=PM_{10}>=$PM_{2.5}$ for Tier 1 (Tables 3-1, 3-2 and 3-3), Tier 2 (Tables 3-4 and 3-5) and Tier 3 emission factors (Tables 3-9 and 3-10) in the guidebook chapter for navigation.

2. ΣHM<TSP

It has been checked that ΣHM<TSP for Tier 1 (Tables 3-1, 3-2 and 3-3), Tier 2 (Tables 3-4 and 3-5) and Tier 3 emission factors (Tables 3-9 and 3-10). For navigation, the Tier 1 emission factors for HM are also used for Tier 2 and 3 calculations as explained in the guidebook.

3. Other issues

HM for gasoline fuelled boats related to the fuel content for gasoline can be derived from road transport emission data in a future work.

EF information for all four PAH species for heavy fuel oil can be based on values obtained from Agrawal et al. (2008a, 2010) and Murphy et al. (2005) as an input for future update work in this area.

EF information for all HM species, except Hg, for heavy fuel oil can be based on values obtained from Agrawal et al. (2008b) as input for future update work in this area.

Aviation

1. TSP>=PM_{10}>=$PM_{2.5}$

Tier 1 and 2 EF shown in the Tables 3-3 and 3-5, respectively, miss information of TSP; the guidebook text only explains that PM10 = $PM_{2.5}$. For military aircraft, no PM emission data are available from the guidebook, and hence, particulate size distributions could not be assessed for this latter source.

2. ΣHM<TSP

For aviation, no HM emission data are available from the guidebook, and hence, HM emission assessments could not be made for this mobile source.

3. Other issues

EF information for all HM species, except As and Hg, can be based on values obtained from Agrawal et al. (2008) as input for future update work in this area.

Important for future update work in relation to PAH, Rogers et al. (2005) reports data for the exhaust emission concentration of benzo(a)pyrene and indeno(1,2,3-cd)pyrene, and benzo(b)- and benzo(k)fluoroanthene as a part of the total concentration sum of benzo(b+j+k)fluoroanthene. EF information for all four PAH species and dioxins can be found in Agrawal et al. (2008c). Apart from benzo(a)pyrene, Kinsey et al. (2010) is also a source of EF information for the CLRTAP PAH emission species.

Road transport

1. TSP>=PM_{10}>=$PM_{2.5}$

All emission factors related to road transport exhaust are well below $PM_{2.5}$.

2. ΣHM<TSP

HM emission factors in the guidebook for road transport are related to the HM content in the fuel, and hence the same HM emission data is behind HM emission estimates for Tier 1, 2 and 3.

For Tier 3 it has been checked that the sum of HM emission factors is below the emission factor figure for PM. The check has been made by assessing fuel and technology specific HM and PM results from the Danish emission inventories using the COPERT model. The COPERT model makes up the basis for the emission data and calculation methodology included in the EMEP/EEA guidebook for road transport. During the check it is noted that the calculated HM total is only a few thousandth of the total for PM.

Tier 2 fuel consumption and PM emission factors are technology specific. Although Tier 2 factors are aggregated values to account for lack of data in terms of driving characteristics, a Tier 2 estimate of HM and PM will be very similar to the results obtained using the Tier 3 method. Consequently, the ΣHM<TSP condition is fulfilled in the Tier 2 case for road transport also.

3. Other issues

No other issues.

Road transport – non exhaust

1. TSP>=PM_{10}>=$PM_{2.5}$

It has been checked that TSP>=PM_{10}>=$PM_{2.5}$ for Tier 1 emission factors related to tyre and brake wear (Table 3-1) and road abrasion (Table 3-2). For Tier 2, the PM size fractions TSP, PM_{10} and $PM_{2.5}$ to be used for tyre and brake wear (Tables 3-4 and 3-6) and road abrasion (Table 3-8) fulfil the TSP>=PM_{10}>=$PM_{2.5}$ condition also in this case.

2. ΣHM<TSP

From Table 3-10 it appears that the sum of HM from tyre and brake wear, respectively, is only a few thousandth of total tyre and brake wear, respectively.

For road abrasion, no HM emission data are available from the guidebook, and hence, HM emission assessments could not be made for this mobile source.

3. Other issues

Important for future update work in relation to HM, Winther & Slentø (2010) reports emission factors for As in the case of tyre and brake wear. For road abrasion, Winther & Slentø (2010) reports emission factors for all other heavy metal emission species than As and Se.

Non-road engines

1. TSP>=PM_{10}>=$PM_{2.5}$

All emission factors related to non-road engines are well below $PM_{2.5}$.

2. ΣHM<TSP

HM emission factors in the guidebook for non-road engines are taken from road transport. The HM emission factors are related to the HM content in the fuel, and hence the same HM emission data is behind HM emission estimates for Tier 1, 2 and 3.

Please refer to the above section for road transport exhaust for further comments on the check of emission sums for HM vs. PM.

3. Other issues

No other issues.

References

Halder M., Löchter, A. (2005). 'Status and future development of the diesel fleet'. Rail diesel study, WP1 final report. UIC, p. 54. www.uic.org/download.php/environnement/2006-01-dieselstudy-wp1.pdf.

Agrawal, H., W. A. Welch, J. W. Miller, and D. R. Cocker (2008a), Emission measurements from a crude oil tanker at sea, Environ. Sci. Technol., 42, 7098–7103, doi:10.1021/es703102y.

Agrawal, H., Malloy, Q. G. J., Welch, W. A., Wayne Miller, J., and Cocker III, D. R, 2008b.: In-use gaseous and particulate matter emissions from a modern ocean going container vessel, Atmos. Environ., 42, 5504–5510, doi:10.1016/j.atmosenv.2008.02.053, 2008.

Agrawal, H., Sawant, A.A, Jansen, K., Miller, J.W. Cocker III, D.R. 2008c: Characterization of chemical and particulate emissions from aircraft engines, Atmospheric Environment 42 (2008) 4380–4392.

Agrawal, H., Welch, W. A., Henningsen, S., Miller, J. W., and Cocker, D. R., III: Emissions from main propulsion engine on container ship at sea, J. Geophys. Res., 115, D23205, doi:10.1029/2009jd013346, 2010.

Murphy, S.M, Agrawal, H., Soroosian, A., Padró, L.T., Gates, h., Hersey, S., Welch, W.A., Jung, H., Miller, J.W., COCKER I I I, D.R., Nenes, A., Jonsson, H.H., Flagan, R.C., Seinfeld, J.H. 2009: Comprehensive Simultaneous Shipboard and Airborne Characterization of Exhaust from a Modern Container Ship at Sea, Env. Sci. & Technology/ vol. 43, no. 13.

Kinsey, J.S., Dong, Y., Williams, D.C, Logan, R. 2010: Physical characterization of the fine particle emissions from commercial aircraft engines during the Aircraft Particle Emissions eXperiment (APEX) 1-3, Atmospheric Environment 44 (2010) 2147-2156.

Rogers, F., Arnott, P., Zielinska, B., Sagebiel, J., Kelly, K.E., Wagner, D. Lighty, J.S. Sarofim, A.F 2008: Real-Time Measurements of Jet Aircraft Engine Exhaust, *J. Air & Waste Management Association.* 55:583–593.

Winther, M. & Slentø, E. 2010: Heavy Metal Emissions for Danish Road Transport, National Environmental Research Institute, Aarhus University, Denmark. 99 pp. – NERI Technical Report no. 780.