

1 Discussion note f-BC fractions for road transport

2 The data source for f-BC for road transport is the well established European COPERT emission model which
3 already makes up the basis for the emission data and calculation methodology included in the EMEP/EEA
4 guidebook for road transport. The COPERT model is being widely used by European countries as a software
5 tool for making the actual emission inventories in the road transport part.

6 Based on a comprehensive literature review made by Ntziachristos (2007), the COPERT model includes data
7 for EC fractions of PM (f-EC) as well as OM/EC ratios on a vehicle layer level suited for Tier 3 emission
8 estimations. The reported figures for OM/OC can be input for the further assessment of OC fractions of PM
9 (f-OC) in a future project.

10 A few additional studies reporting f-EC fractions have been assessed in the present study. These new
11 studies have, however, not given reason for making changes to the f-EC data proposed by COPERT. Further,
12 contacts have been made to the developers of emission factors for heavy duty vehicles, Technical
13 University of Graz, in order to obtain new BC emission information for heavy duty engines. Any new BC
14 emission data for heavy duty engines will be assessed as soon as possible.

15 In practical terms EC is assumed to be equal to BC for road transport (e.g. Battye & Boyer; May et al., 2010;
16 Flanner et al., 2007). Hence, the f-EC data suggested by COPERT and listed in Table 3-105 in the guidebook
17 will be used in the present study as data for f-BC.

18 The following references listed in Table 1 have been considered by Ntziachristos (2012) in the assessment
19 of EC and OC data as input for the COPERT model. The references for the work made by Biswas et al. (2009)
20 and Cheung et al. (2010) subsequently being assessed in the present study are also included in Table 1.

21 Table 1 List of references behind f-EC and OM/EC values included in the COPERT model

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1 Tier 3

2 The proposed f-BC values available from the COPERT model for the Tier 3 methodology are shown in Table
3 2.

4 Table 2 f-BC values from the COPERT model proposed for Tier 3

| Vehicle category | Euro standard | EC/PM _{2.5} (%) | Uncertainty (%) |
|---------------------|---------------|--------------------------|-----------------|
| Gasoline PC and LDV | PRE-ECE | 2 | 50 |
| | ECE 15 00/01 | 5 | 50 |
| | ECE 15 02/03 | 5 | 50 |
| | ECE 15 04 | 20 | 50 |
| | Open loop | 30 | 30 |
| | Euro 1 | 25 | 30 |
| | Euro 2 | 25 | 30 |
| | Euro 3 | 15 | 30 |
| | Euro 4 | 15 | 30 |
| Diesel PC and LDV | Conventional | 55 | 10 |
| | Euro 1 | 70 | 10 |
| | Euro 2 | 80 | 10 |
| | Euro 3 | 85 | 5 |
| | Euro 4 | 87 | 5 |

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|-------------|------------------------|----|----|
| | Euro 3, Euro 4, Euro 5 | 10 | 50 |
| | Euro 3, Euro 4, Euro 5 | 20 | 50 |
| Diesel HDV | Conventional | 50 | 20 |
| | Euro I | 65 | 20 |
| | Euro II | 65 | 20 |
| | Euro III | 70 | 20 |
| | Euro IV | 75 | 20 |
| | Euro IV | 75 | 20 |
| | Euro VI | 15 | 30 |
| Mopeds | Conventional | 10 | 50 |
| | Euro 1 | 20 | 50 |
| | Euro 2 | 20 | 50 |
| Motorcycles | Conventional | 15 | 50 |
| | Euro 1 | 25 | 50 |
| | Euro 2 | 25 | 50 |
| | Euro 3 | 25 | 50 |

1 For Tier 3, Table 3 below references, by vehicle category, the tables in the EMEP/EEA guidebook chapter for
2 road transport that contain emission factor information for PM.

3 In general, Tier 3 f-BC fractions corresponding with these vehicle categories and their individual emission
4 layer stratification can be found in Table 3-105 in the guidebook chapter for road transport (c.f. Table 2).

5 **Table 3 Tables in the guidebook that contain Tier 3 PM emission factor information**

| Vehicle category | Table no. |
|--|-------------------------------|
| Gasoline passenger cars and light duty vehicles: | Table 3-40 |
| Diesel passenger cars: | Table 3-43, 3-45, 3-46, 3-47 |
| Diesel light duty vehicles: | Table 3-56, 3-57 |
| Diesel heavy duty vehicles | Spreadsheet equations (Annex) |
| CNG buses: | Table 3-59 |
| Mopeds | Table 3-61 |
| Motorcycles | Table 3-64 |

6 Tier 1

7 In the EMEP/EEA guidebook chapter for road transport, Tier 1 emission factors (g/kg fuel) for the various
8 pollutants are calculated with the COPERT model using Tier 3 emission factors and a typical EU 1995 fleet.
9 Aggregated fuel specific emission factors are calculated for the vehicle categories passenger cars, light duty
10 vehicles and heavy duty vehicles, and for PM these factors are listed in Table 3-6.

11 In accordance with the selection of this inventory year and aggregation level, in the present project Tier 1 f-
12 BC fractions will be based on Tier 3 COPERT calculations made for the Danish fleet (Winther, 2012) using
13 the values from Table 2 as input data for f-BC.

14 Tier 2

15 In the EMEP/EEA guidebook chapter for road transport, layer specific Tier 2 emission factors (g/km) for the
16 various pollutants are calculated from Tier 3 emission factors with the COPERT model. For PM the layer
17 specific emission factors are listed in the tables 3-16, 3-18, 3-20, 3-22 and 3-24 for passenger cars, light
18 duty vehicles, heavy duty vehicles, buses and 2-wheelers, respectively.

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1 In the present project Tier 2 f-BC fractions will be based on Tier 3 COPERT calculations made for the Danish
2 fleet (Winther, 2012) using the values from Table 2 as input data for f-BC.

3 **Tyre and brake wear and road abrasion**

4 In the guidebook chapter for tyre and brake wear and road abrasion data for f-BC fractions for the wear
5 related emissions from tyres and brakes is already included in Table 3-10. The f-BC data are identical to the
6 data proposed by Kupiainen and Klimont (2004), based on reported data from Hildemann et al. (1991),
7 Garg et al. (2000), Chow et al. (1994) and Kupiainen et al. (2002). Table 3-10 also present data for OC
8 identical to those from Kupiainen and Klimont (2004), which can be used as input for the further
9 assessment of OC fractions of PM (f-OC) in a future project. For road asphalt wear no data is available from
10 the literature.

11 Table 4 Proposed f-BC fractions for wear related emissions from road transport

| Category | f-BC | +/- uncertainty (%) |
|---------------|------|---------------------|
| Brake wear | 2.61 | 50 |
| Tyre wear | 15.3 | 50 |
| Road abrasion | n.d. | - |

12 **Tier 1**

13 Table 3-1 in the guidebook chapter for tyre and brake wear and road abrasion contains Tier 1 PM emission
14 factors aggregated for tyre and brake wear. Tier 1 PM emission factors for road abrasion are given in Table
15 3-2. The PM size fractions TSP, PM₁₀ and PM_{2.5} (Tables 3-4, 3-6 and 3-8) are considered, and separate PM
16 factors are given for two-wheelers, passenger cars, light duty vehicles and heavy duty vehicles.

17 To be consistent with this level of wear related PM emission factors, in the present project Tier 1 f-BC
18 fractions will be based on COPERT calculations made for the Danish fleet in 1995 (Winther, 2012).

19 **Tier 2**

20 For Tier 2 the proposed f-BC fractions from Table 4 shall be used in connection with the TSP emission
21 factors shown in the Tables 3-3, 3-5 and 3-7 for tyre wear, brake wear and road abrasion, respectively.
22 Further, the proposed f-BC values presented in Table 4 are used for all particulate size fractions; TSP, PM₁₀
23 and PM_{2.5}.

24 **Inclusion of f-BC values in the guidebook**

25 The inclusion of the new f-BC information in the guidebook can be made in several ways and needs to be
26 agreed by the transport expert panel prior to the update of the individual chapters. For road transport and
27 tyre and brake wear and road abrasion, respectively, one approach can be to place the final version of the
28 present note as an annex to the guidebook chapter, and make references to the relevant PM emission
29 factor tables in the chapter. Another approach can be to include directly the f-BC fractions in the relevant
30 PM emission factor tables, or as foot notes to the tables. References can then be made to the annex
31 description, or alternatively a brief summary of the discussion note can be put somewhere central in the
32 chapter.

33 **Acknowledgment**

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