Appendix 2.4 - POP emissions from mobile combustion sources

This appendix chapter provides additional information regarding the approaches applied for estimating exhaust POP emissions from mobile sources in:

- Road Transport (1.A.3.b i - iv)
- Non-road Mobile Machinery in 1.A.2.g vii, 1.A.4.a ii/b ii/c ii, and 1.A.5.b
- Railways (1.A.3.c)
- Maritime Vessels and Ships in 1.A.3.d i, 1.A.3.d ii, 1.A.4.c iii and 1.A.5.b
- Aircraft in 1.A.3.a and 1.A.5.b

Road Transport

For **exhaust emissions of Benzo[a]Pyrene, Benzo[b]Fluoranthene, Benzo[k]Fluoranthene, and Indeno[1,2,3-c,d]Pyrene** the tier2 emission factors as provided in the 2023 EMEP/EEA Guidebook in chapter 1.A.3.b (Update 2024), tables 3-18 to 3-26 have been implemented with the current submission, upgrading the estimation from a tier1- to a tier2-approach.

NFR	VEHICLE TYPE	FUEL	EURO-NORM	B[a]P	B[b]F	B[k]F	I[123cd]P	PAH 1-4
1.A.3.b i	PCs	diesel fuels	as of pre-EURO	0.000001740	0.000001950	0.000001530	0.000001620	0.000006840
		gasoline fuels	pre-EURO	0.000000480	0.000000880	0.000000300	0.000001030	0.000002690
			as of EURO1	0.000000320	0.000000360	0.000000260	0.000000390	0.000001330
		LPG	as of pre-EURO	0.000000010	0.000000000	0.000000010	0.000000010	0.000000030
		natural gas, biomethane	as of EURO4	0.000000320	0.000000360	0.000000260	0.000000390	0.000001330
1.A.3.b ii	LDVs	diesel fuels	pre-EURO	0.000002850	0.000003300	0.000002870	0.000002540	0.000011560
			as of EURO1	0.000000630	0.000000600	0.000000190	0.000000700	0.000002120
		gasoline fuels	pre-EURO	0.000000480	0.000000880	0.000000300	0.000001030	0.000002690
			as of EURO1	0.000000320	0.000000360	0.000000260	0.000000390	0.000001330
		natural gas, biomethane	as of EURO4	0.000000320	0.000000360	0.000000260	0.000000390	0.000001330
1.A.3.b iii	HDVs & buses	diesel fuels	as of pre-EURO	0.000000900	0.000005450	0.000006090	0.000001400	0.000013840
		natural gas, biomethane	as of EUROV	0.000000050	0.000000080	0.000000040	0.000000030	0.000000200
1.A.3.b iv	Mopeds	gasoline fuels	pre-EURO	0.000000096	0.000000176	0.000000060	0.000000206	0.000000538
			as of EURO1	0.000000064	0.000000072	0.000000052	0.000000078	0.000000266
	Motorcycles		as of pre-EURO	0.000000320	0.000000360	0.000000260	0.000000390	0.000001330
additional info: derivation of tier2 EF (MS Excel file)								

Due to this improvement, the reported emissions especially for B[a]P and, hence, the sum for PAH 1-4 increased rather strongly, by about %and % respectively, whereas the amounts of B[b]F, B[k]F, and I[x]P increased only slightly.

Regarding PCDD/F, a tier1 EF from (Rentz et al., 2008) [1)] is used instead.

Non-road Mobile Machinery in 1.A.2.g vii, 1.A.4.a.ii, 1.A.4.b.i, 1.A.4.c.ii and 1.A.5.b i

Table 3: Tier1 default emisison factors applied to NRMM

	B[a]P	B[b]F	B[k]F	I[...]P	PAH 1-4	PCDD/F
	[mg/TJ]					[µg/TJ]
Diesel oil	698	1.164	801	184	2,847	1.62[3]
Biodiesel[1]	806	1.343	924	212	3,284	1.87
Gasoline fuels - 4-stroke	919	919	90	204	2,131	2.76[3]
Gasoline fuels - 2-stroke[2]	919	919	90	204	2,131	57.5[3]
LPG (1.A.4.a ii only)	4.35	0.00	4.35	4.35	13.04	NE

[1] values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel
[2] no separate values available for 2-stroke-mix including 1:50 lube oil.
[3] tier1 values derived from [2)]

Railways

Table 3: Tier1 default emission factors applied to railway vehicles

	B[a]P	B[b]F	B[k]F	I[...]p	PAH 1-4[3]	PCDD/F
	[mg/TJ]					[µg/TJ]
Diesel oil	698[2]	1,164[2]	801[1]	184[1]	2,847[3]	2.09
Biodiesel	806	1,343	924	212	3,284	2.41
Lignite Briquettes	34,500	NE	NE	NE	90,000	29.80
Raw Lignite	NE					NE
Hard Coal	NE					NE
Hard Coal Coke	NE					NE

[1] tier1 default from [3)], chapter: 1.A.3.b i-iv - Road transport: exhaust emissions: tier1 value for diesel vehicles
[2] tier1 default from [4)], chapter: 1.A.3.c - Railways
[3] sum of tier1 default value applied for B[a]P, B[b]F, B[k]F, and I[...]P

As the EMEP/EEA GB 2019 does not provide a tier1 value for **PCDD/F**, the EF applied here has been derived from a study carried out by Rentz et al. (2008) [5)] for the German Federal Environment Agency. Furthermore, both **HCB** and **PCBs** emissions are stated as *not applicable* in [6)], chapter 1.A.3.c Railways, Table 3-1 Tier 1 emission factors for railways.

Inland Vessels and Ships in 1.A.3.d ii

Table 4: Tier1 default emission factors applied to inland ships and vessels

	B[a]P	B[b]F	B[k]F	I[...]p	PAH 1-4[2]	HCB	PCBs	PCDD/F
	[mg/TJ]							[µg/TJ]
Diesel oil	698[4]	1,164[4]	801[5]	184[5]	2,847	1.86[3]	0.88[3]	93.0[7]
Biodiesel[1]	806	1,343	924	212	3,284	1.02	2.15	107

[1] similar EF for biodiesel applied for all mobile sources; due to lack of better information EF values are derived from conventional diesel oil but taking into account the specific NCV of biodiesel
[2] sum of tier1 default values applied for B[a]P, B[b]F, B[k]F, and I[1,2,3-c,d]P
[3] tier1 defaults from [7)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Tables 3-1 and 3-2
[4] tier1 defaults from [8)], Chapter: 1.A.3.c Railways: Diesel, Table 3-1
[5] tier1 defaults from [9)], Chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv - Road transport, Table 3-8: HDV, Diesel

Maritime Vessels and Ships in 1.A.3.d i, 1.A.3.d ii, 1.A.4.c iii and 1.A.5.b iii

The following table provides the tier1 EF applied for POPs from ships and vessels in both civil and military operation in NFR categories 1.A.3.d i -International Maritime Navigation, 1.A.3.d ii - National Navigation (Shipping), 1.A.4.c iii -Fisheryand 1.A.5.b iii - Other: Military Navigation.

Table 4: Tier1 default emission factors applied to maritime ships and vessels

	B[a]P	B[b]F	B[k]F	I[...]p	PAH 1-4[2]	HCB	PCBs	PCDD/F
	[mg/TJ]							[µg/TJ]
Diesel oil	698[4]	1,164[4]	801[5]	184[5]	2,847	1.86[3]	0.88[3]	93.0[7]
Biodiesel[1]	806	1,343	924	212	3,284	2.15	1.02	107
Heavy Fuel oil[6]	741	1,235	849	195	3,020	3.46	14.1	98.7

[1] similar EF for biodiesel applied for all mobile sources; due to lack of better information EF values are derived from conventional diesel oil but taking into account the specific NCV of biodiesel
[2] sum of tier1 default values applied for B[a]P, B[b]F, B[k]F, and I[1,2,3-c,d]P
[3] tier1 defaults from [10)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Tables 3-1 and 3-2
[4] tier1 defaults from [11)], Chapter: 1.A.3.c Railways: Diesel, Table 3-1
[5] tier1 defaults from [12)], Chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv - Road transport, Table 3-8: HDV, Diesel
[6] derived from default for fossil diesel oil, but adapted to specific NCV of heavy fuel oil
[7] tier1 value derived from [13)]

Aircraft in 1.A.3.a and 1.A.5.b ii

The EMEP/EEA GB 2016 (July 2017) does not provide specific defaults for POP emissions from the combustion of jet kerosene and aviation gasoline, stating that for for aviation gasoline these emissions are *not estimated* (NE):

Therefore, the inventory compiler decided to apply the tier1 EF for **PAHs** from gasoline fuel used in non-road mobile machinery here, too. Furthermore, both **HCB** and **PCBs** emissions are stated as *not applicable* in [14)], chapter 1.A.3.a, 1.A.5.b Aviation, Table 3.3 Tier 1 emission factors for NFR 1.A.3.a.ii.(i): Civil aviation (domestic, LTO).

As the Party assumes that POP emissions from the combustion of jet kerosene are unlikely to occur, these emission are reported as *not applicable* (NA).

Table 5: Tier1 default emisison factors applied to aircraft, in mg/TJ

	B[a]P	B[b]F	B[k]F	I[...]p	PAH 1-4	PCDD/F
Kerosene	NA	NA	NA	NA	NA	NA
Aviation gasoline	126	182	90	205	602	NE

---

1), 2), 5), 13) Rentz et al., 2008: Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, January 2008 - URL: https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer
3), 4), 6), 7), 8), 9), 10), 11), 12), 14) EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, Copenhagen, 2019.