2.G.4 - Use of Lubricants

Short description

In source category *2.G.4 - Other Product Use: Lubricants*, emissions from both stationary and mobile application of lubricants are reported.

Category Code	Method	AD	EF
2.G.4	T1, T2	NS, M	CS, D
covering emissions from:			
use of lubricants in stationary applications	T2	NS	CS
use of lubricants in mobile applications	T1	NS, M	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	**Heavy Metals**	POPs
NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	-/-	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Use of lubricants in stationary applications

Method

This sub-category comprises the entire use phase including the process stages of input and output. The products or lubricants covered here, are:

- Compressor oils
- Turbine oils
- Gear oils (automotive oils including automatic transmission fluids, industrial-gear oils)
- Hydraulic oils
- Insulating oils
- Machine oils
- Process oils
- Other industrial oils not for lubricating purposes
- Metal working fluids fluids (hardening oils, water-miscible and not water-miscible metal working fluids, anticorrosive oils)
- Greases
- Base oils
- Extracts from lubricant refining

2-stroke engine oils are excluded here as they are considered to be part of the 2-stroke fuel and are therefore burned *intentionally* in 2-stroke engines as applied in road vehicles (mopeds) and other mobile machinery (chainsaws, lawn mowers etc.). In contrast, emissions from the *unintended* co-incineration of lubricants in mobile machinery and vehicles are reported in Use of lubricants in mobile applications.

'NMVOC' is defined in keeping with the VOC definition found in the EC solvents directive. For purposes of the definition of solvents, the term 'solvent use' is also defined in keeping with the EC solvents directive.

The consumption of lubricants in stationary applicants in Germany has remained at a relatively constant level since 1990, apart from a sharp decrease in the crisis years 2009 and 2020. After a slight rebound in 2021, the **consumption of lubricants in 2023** falls to an historical low level of **533,351 t** .

Activity data

The emissions calculation method follows a Tier-2 approach. It uses national statistical data from BAFA [1)] for the quantities placed on the market specific per lubricant types as activity rate and specific emission factors for each lubricant type. It is assumed that the amount of lubricants placed on the market per year equals the lubricant use (consumption) in the same year.

Emission factors

Along the life cycle of the different lubricant types, different kinds of losses occur. Only some types of losses are of relevance with regard to air emissions and the different lubricants types differ significantly from each other. Relevant emitted pollutants identified for lubricants are NMVOC and CO_2. But only for engine oils used in machinery and in vehicles emission of both could be accounted for due to combustion of a small fraction of lubricating oils directly resulting in CO_2 emissions.

For insulating oils [2) 3)], process oils [4) 5) 6)], greases [7) 8)] and extracts from lubricant production [9) 10) 11)] no emissions are expected to arise.

All emission factors are are constant in the entire time series. They were determined in a research project (Zimmermann, 2018) [12)].

Table 1: Tier2 emission factors for specific lubricant-type groups in percent

		NMVOC	

Lubricant-type group	Proportion range of total sales since 1990	Default	Range	Reference
Compressor oils	≤ 1 %	1.5 %	1-2 %	13) 14) 15) 16) 17) 18)
Turbine oils	< 1 %	0.5 %	0-1 %	19) 20) 21)
Automotive gear oils	5-10 %	1 %	0-2 %	
Industrial gear oils	2-3 %	1.5 %	1-2 %	
Hydraulic oils	6-15 %	1.5 %	1-2 %	
Machine oils	1-7 %	2.5 %	0-5 %	22) 23) 24)
Other oils not for lubricating purposes	2-7 %	25 %	0-50 %	25) 26) 27) 28)
Metalworking fluids	5-9 %	5 %	0-10 %	29) 30) 31)
Base oils	4-16 %	10 %	5-15 %	32)

In 1995 four categories fell away/ceased to exist (Table 2) and three type groups were newly introduced due to modifications/changes in the Mineral Oil Statistics concerning lubricants. A slight adjustment of the procedure for the years 1990-1994 was needed. Table 2 shows the affected categories as well as the ways in which they were handled in the calculation procedure.

Table 2: Handling of categories in the Mineral Oil Statistics, 1990-1994

Category	Remarks concerning the procedure	EF_{NMVOC}
Other lubricating oils, specialty and other lubricating oils, non-specialty	These are handled like the “machine oils” group, which is lacking in the 1990-1994 period. This group includes various specialty and non-specialty libricationg oils.	2.5 %
Other mineral oils for special applications	This category contains no lubricating oils. It is handled like the category “Other industrial oils not used for lubrication” which is lacking in the 1990-1994 period.	25 %
Light-coloured plasticisers and extender oils	Extender oils and plasticisers are classified with the process oils. They are handled accordingly.	0 %

Uncertainties

For activity data, an uncertainty of 5 percent is assumed considering the well developed national statistics.

The emission factors are based on a broad review of literature and results from relevant research projects and have been discussed with senior lubricant experts. The experts suggested using ranges which are provided in the emission factor table 1.

The modifications of the Mineral Oil Statistics in 1995 show no impact of overall amount of lubricants. Only a reclassification of lubricants from unspecified application categories to specified application categories was made. The emissions for the years 1990-1994 could therefore be just up to 25% to high.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

No category-specific improvements are planned.

Use of lubricants in mobile applications

In sub-category *2.D.3.i - Other product use: Use of lubricants in mobile applications*, the German air pollutant emisisons inventory includes emissions from the unintentional co-incineration of lubricants in mobile sources.

As emissions from the use of lubricants in stationary machinery result mostly from the evaporation whereas emissions from mobile machinery result mostly from the unintentional co-incineration within the engine, the methods for emission calculation differ widely.

Therefore, the approaches for estimating emissions from these two areas of lubricant application are looked at in separate sub-chapters linked below.

Methodology

Activity data

Basically, the amounts of lubricants unintentionally co-incinerated in engines other than 2-strokes is estimated from the annual amounts of fuels used in these engines, excluding the amounts of fuels used for international aviation and navigation.

Here, the majority of lubricant co-incineration takes place in road vehicles. These related amounts of co-incinerated lubricants are calculated directly within TREMOD [33)].

Table 1: Annual amounts of lubricants co-incinerated in mobile vehicles and machinery - excluding 2-stroke engines, in terajoules

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
1,400	1,601	1,713	1,757	1,804	1,922	1,951	1,977	1,985	1,999	1,770	1,801	1,803	1,811

source: own estimations and TREMOD [34)]

The **emission factors** are derived from chapter *1.A.3.b.i-iv Road transport 2023*, Table 3-87 of the EMEP/EEA air pollutant emission inventory guidebook 2023 [35)].

Table 3-87: Heavy metal emission factors for all vehicle categories in ppm/wt lubricant

Category	Pb	Cd	Cu	Cr	Ni	Se	Zn	Hg	As
Passenger cars, petrol	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
Passenger cars, diesel	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
LCVs, petrol	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
LCVs, diesel	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
HDVs, petrol	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
HDVs, diesel	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
L-category	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0

These default values were transferred via a NCV of 0.03985 GJ/kg into the following energy-related values:

Table 2: tier1 emission factors for heavy-metal emissions from co-incinerated lubricants, in g/TJ

As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
0.00	114	482	19,523	0.00	800	0.81	114	11,297

Discussion of emission trends

With default emission factors applied, emissions' trends depend solely on the amounts of unintentionally co-incinerated lubricants (see Table 1).

Table 3: Annual heavy-metal emissions from co-incinerated lubricants, in metric tonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
As	NA													
Cd	0.16	0.18	0.20	0.20	0.21	0.22	0.22	0.23	0.23	0.23	0.20	0.20	0.21	0.21
Cr	0.67	0.77	0.83	0.85	0.87	0.93	0.94	0.95	0.96	0.96	0.85	0.86	0.87	0.87
Cu	27.3	31.3	33.4	34.3	35.2	37.5	38.1	38.6	38.8	39.0	34.6	34.7	35.4	35.4
Hg	NA													
Ni	1.12	1.28	1.37	1.41	1.44	1.54	1.56	1.58	1.59	1.60	1.42	1.42	1.45	1.45
Pb	0.0011	0.0013	0.0014	0.0014	0.0015	0.0016	0.0016	0.0016	0.0016	0.0016	0.0014	0.0014	0.0015	0.0015
Se	0.16	0.18	0.20	0.20	0.21	0.22	0.22	0.23	0.23	0.23	0.20	0.20	0.21	0.21
Zn	15.8	18.1	19.3	19.9	20.4	21.7	22.0	22.3	22.4	22.6	20.0	20.1	20.5	20.5

Recalculations

Activity data (annual amounts of unintentionally co-incinerated lubricants) have been revised slightly for the entire time series.

Table 4: Revised annual amounts of unintentionally co-incinerated lubricants, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	1,400	1,601	1,713	1,757	1,804	1,922	1,951	1,977	1,985	1,999	1,770	1,801	1,803
previous submission	1,400	1,601	1,713	1,746	1,792	1,916	1,946	1,971	1,977	1,990	1,765	1,778	1,812
absolute change	0.14	0.04	0.08	11.1	11.3	6.23	5.27	5.47	8.33	8.54	4.86	23.0	-9.31
relative change	0.01%	0.00%	0.00%	0.64%	0.63%	0.33%	0.27%	0.28%	0.42%	0.43%	0.28%	1.30%	-0.51%

On the other hand, the tier1 **emission factors** applied so far, remain unaltered compared to last year's submission.

Therefore, the canges in the **emission estimates** reported for this sub-category result solely from the named revisions in activity data.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations.

Planned improvements

Although there are no improvements planned for this specific sub-category, several routine model revisions are scheduled for mobile sources with impact on fuel consumption data and, hence, the amounts of unintentionally co-incinerated lubricants.

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