

2.G(a) - Fireworks

Short description

In this sub-category of 2.G(a) - *Other product use: Fireworks* Germany reports NO_x, SO_x, CO, TSP, PM₁₀, PM_{2.5}, Cu, Pb and Zn emissions from fireworks.

NFR-Code	Name of Category	Method	AD	EF
2.G(a)	Other Product use: Fireworks	CS	NS and association	D, CS

Method

In the year 2019 measurements were made by a finish laboratory for the VPI – Verband der pyrotechnischen Industrie (Association of the pyrotechnical industry) of dust emissions during the burning of fire works. The experiments were made in a container in which the whole fireworks were burned. In 2020 the VPI and the UBA had an intensive information exchange, in which the VPI presented the results of the measurements to the UBA. The different emission factors were discussed and finally based on the expert judgement it was decided which EFs shall be used for the reporting. In the next step the activity data were updated more differentiated. Further a discussion of the other EFs was made, which led to some changes in the EFs. The results are presented below. In February 2021 the VPI has published an article in the paper “Propellants, Explosives, Pyrotechnics” a description of the experiment together with the measurement results¹⁾.

Activity data

For the calculation of the activity data the following formula is used:

AR = production + import – export – disposal + return of the year before – return of the year

The **production, disposal, return from the year before and return of the year** data are yearly updated by the VPI.

Import and export: For the import and export data statistical data from the statistical federal office of Germany were taken (foreign statistics of federal office of statistics)²⁾.

The sold amounts of fireworks have increased strongly from 1990 to 1995. From 1995 to 1997 the emissions were relatively high but decreased from 1997 to 2005. Since then, the emissions have been relatively constant with small fluctuations.

Emission factors

The emission factors of SO₂, CO, NO_x, Cu, Pb and Zn are the Default-EFs derived from the EMEP Guidebook³⁾, page 22, table 3-14: Tier 2 emission factor for source category 2.D.3.i, 2.G Other solvent and product use, Other, Use of Fireworks.

Pollutants	Unit	Default-EF
SO₂	g/t product	3.020
CO	g/t product	7.150
NO_x	g/t product	260
Cu	g/t product	444
Pb	g/t product	784
Zn	g/t product	260

The emission factors for PM₁₀, PM_{2.5} and TSP are measured values from the VPI.

Pollutant	PM₁₀	PM₁₀	PM 2.5	PM 2.5	STB	STB
	Sylvester-EF	During the period-EF	Sylvester-EF	During the period-EF	Sylvester-EF	During the period-EF
	[g/t]	[g/t]	[g/t]	[g/t]	[g/t]	[g/t]
1990	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
1991	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
1992	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
1993	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
1994	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
1995	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
1996	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
1997	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
1998	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
1999	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
2000	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
2001	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
2002	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
2003	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
2004	52.002,56	62.799,96	41.463,05	49.644,24	52.002,56	62.799,96
2005	47.509,31	72.317,11	38.129,60	57.167,68	47.509,31	72.317,11
2006	45.793,40	71.986,67	36.930,61	56.906,46	45.793,40	71.986,67
2007	45.174,65	72.071,88	36.615,74	56.973,82	45.174,65	72.071,88
2008	45.955,36	71.471,31	37.390,41	56.499,06	45.955,36	71.471,31
2009	45.701,68	70.204,58	37.132,12	55.497,69	45.701,68	70.204,58
2010	44.826,79	69.253,15	36.536,80	54.745,57	44.826,79	69.253,15
2011	44.068,30	68.877,53	36.121,87	54.448,64	44.068,30	68.877,53
2012	45.566,16	69.993,91	37.527,36	55.331,16	45.566,16	69.993,91
2013	46.098,42	67.212,39	38.026,91	53.132,33	46.098,42	67.212,39
2014	46.621,17	67.680,72	38.595,22	53.502,55	46.621,17	67.680,72
2015	47.474,24	67.313,58	39.383,93	53.212,31	47.474,24	67.313,58
2016	47.523,35	66.094,38	39.539,55	52.248,52	47.523,35	66.094,38
2017	47.853,44	65.938,58	39.907,83	52.125,36	47.853,44	65.938,58
2018	48.270,00	63.519,57	39.713,09	50.213,10	48.270,00	63.519,57
2019	48.085,00	63.217,87	40.033,58	49.974,60	48.085,00	63.217,87

The EMEP Guidebook offers Default-EFs for the pollutants Ar, Hg, Ni and Cr. But the VPI has proofed that these emissions does not occur in Germany. And the VPI has further proofed that Pb emissions

does not anymore occur since 2003. See the following explanations:

AR and Hg: For Ar and Hg the members of the VPI have confirmed that Ar and Hg are not anymore used since 1980. Since 2003 the DIN EN 14035:2003 went in force, which did forbid these substances. The actual follow up norm DIN EN 15947-5 was published in February 2016 and describes the german implementation of the harmonized and in the official journal of the European union 2017, C 149/2 published norm EN 15947:2015.

Pb: As the DIN EN 14035:2003 entered into force as from 2003, which did forbid this substance, there are no Pb-emissions from fireworks from 2003 onwards. The actual follow up norm DIN EN 15947-5 was published in February 2016 and describes the german implementation of the harmonized and in the official journal of the European union 2017, C 149/2 published norm EN 15947:2015.

Cd: The members of the VPI were asked and did explain, that Cd was never used, because it has no pyrotechnical effect. Since 2013 Cd is on the candidates list of the substances of Very High Concern (SVHC), published according article 59, para. 10 of the REACH-ordinance.

Ni: The members of the VPI informed that Ni was never used, because it has no pyrotechnical effect. It is part of the harmonized assessment according the ordinance (EG) Nr. 1272/2008 (CLP). Belonging to this, it is assessed as cancerogen category 2.

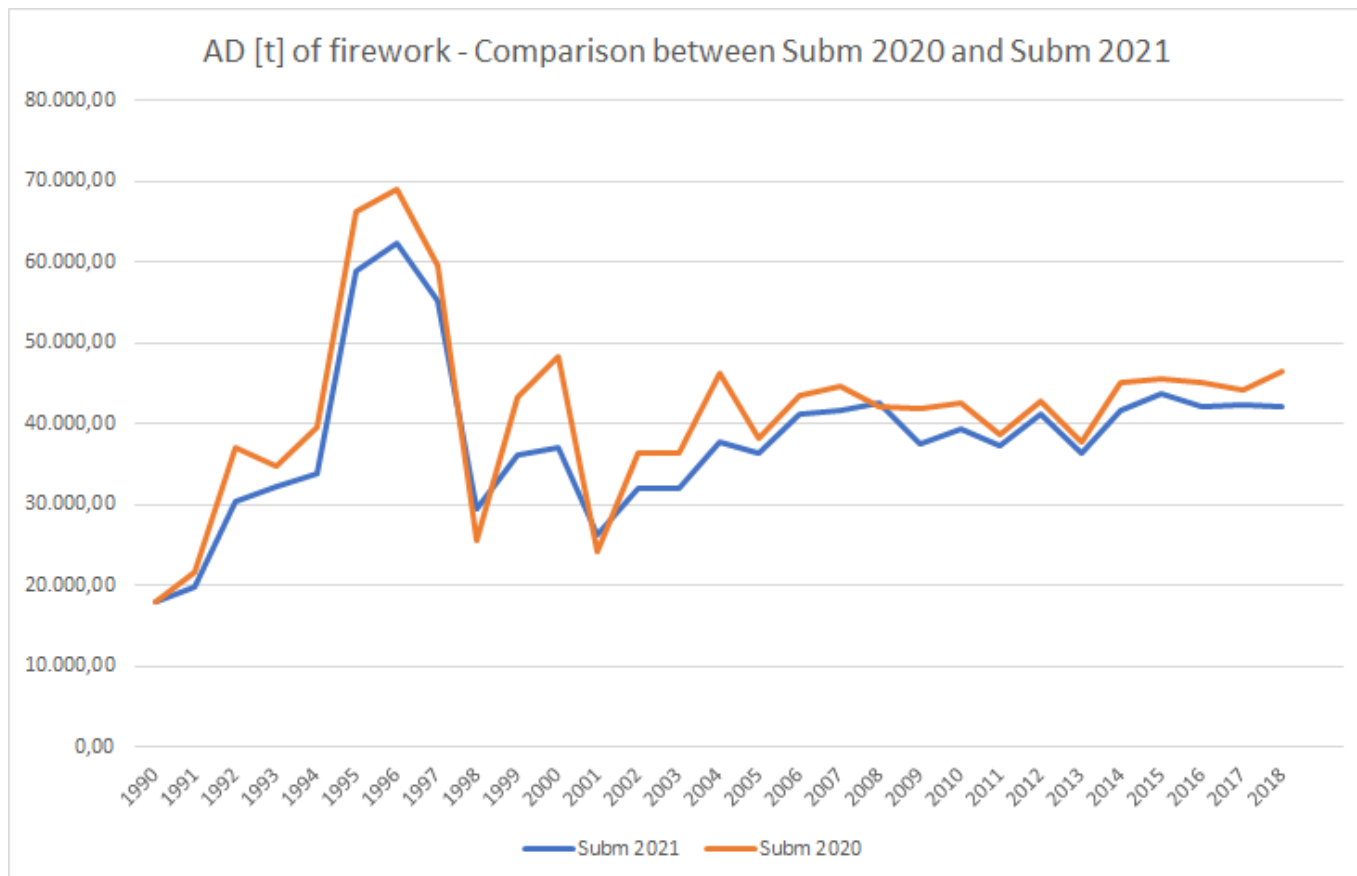
Cr: According the information from the members of the VPI Cr is not anymore used since the beginning of the 1980. Since 2012 (REACH Annex XIV (Ordinance (EU) Nr. 125/2012) Cr was implemented in the REACH Annex XIV. So from that year a permission duty is necessary. So far, none of the fireworks producers has requested for a permission.

Recalculations

The **activity data** has changed as follows:

Table 1: Change of AD between Submission 2020 and Submission 2021

		Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Subm2020	AR	t	17.956,90	21.740,70	37.115,80	34.781,10	39.578,70	66.271,80	69.009,60	59.560	25.604,70	43.244,30	48.355,30	24.149,60	36.461,80	36.351,70	46.347,10	38.148,13	43.487,27	44.704,70	42.228,13	41.839,47	42.651,70	38.637,53	42.856,67	37.846,70	45.164,10	45.656,30	45.208,30	44.110,70	46.461,70
Subm2021	AR	t	13.939	16.395,80	24.555,50	26.172,30	27.152,60	51.421,30	54.412,70	48.281,20	24.179,80	24.692,50	26.282,70	21.561,30	25.993,60	25.759,40	29.286,30	28.856,20	30.491,40	33.396,30	34.461,40	30.074,50	31.439,50	29.795	33.085,50	29.130,70	33.240,60	34.998,70	32.571,70	33.935,70	32.979,70
Subm2021	Firework, Sylvester	t	4.130,10	3.493,40	5.902,70	6.138	6.798,60	7.447,20	7.880,40	6.992,50	5.220,20	11.482,80	10.905,70	4.741,20	6.085	6.256,30	8.545,20	7.505,50	10.755,40	8.235,10	8.088,30	7.520,70	8.006,60	7.499	8.137,30	7.247,10	8.465,40	8.831,50	9.487,20	8.544	9.088
Subm2021	Firework, during the year	t	18.069,10	19.889,20	30.458,20	32.310,30	33.951,20	58.868,50	62.293,10	55.273,70	29.400,00	36.175,30	37.188,40	26.302,50	32.078,60	32.015,70	37.831,50	36.361,70	41.246,80	41.631,40	42.549,70	37.595,20	39.446,10	37.294,00	41.222,80	36.377,80	41.706,00	43.830,20	42.058,90	42.479,70	42.067,70
Difference	Sum AR	t	112,20	-1.851,50	-6.657,60	-2.470,80	-5.627,50	-7.403,30	-6.716,50	-4.286,30	3.795,30	-7.069,00	-11.166,90	2.152,90	-4.383,20	-4.336,00	-8.515,60	-1.786,43	-2.240,47	-3.073,30	321,57	-4.244,27	-3.205,60	-1.343,53	-1.633,87	-1.468,90	-3.458,10	-1.826,10	-3.149,40	-1.631,00	-4.394,00



The **emissions** from As, Cd, Cr, Hg and Ni were deleted. The VPI proofed that these emissions does not occur. For Pb the emissions are from 2003 onwards changed to NA because the VPI proofed that the usage of Pb is forbidden since 2003 by a DIN Norm. The emissions of CO, Cu, NO_x, SO_x, Zn and Pb are changed because of changed AD. The emissions of PM₁₀, PM_{2.5} and TSP are changed because of changed AD and new EFs from the VPI.

Table 2: Change of emissions between Submission 2020 and Submission 2021

	Schadstoff	Quellgruppe	Einheit	1990	1995	2000	2005	2010	2015	2016	2017	2018
Subm2020	As		t	0,02388268	0,08814149	0,06431255	5,07E-02	0,05672676	0,06072288	0,06012704	0,05866723	0,06179406
Subm2021	As	Feuerwerk, Silvester	t	0	0	0	0	0	0	0	0	0
Subm2021	As	Feuerwerk, unterjährig	t	0	0	0	0	0	0	0	0	0
Difference	As		t	-0,02388268	-0,08814149	-0,06431255	-0,05073702	-0,05672676	-0,06072288	-0,06012704	-0,05866723	-0,06179406
Subm2020	Cd		t	0,02657621	0,09808226	0,07156584	5,65E-02	0,06312452	0,06757132	0,06690828	0,06528384	0,06876332
Subm2021	Cd	Feuerwerk, Silvester	t	0	0	0	0	0	0	0	0	0
Subm2021	Cd	Feuerwerk, unterjährig	t	0	0	0	0	0	0	0	0	0
Difference	Cd		t	-0,02657621	-0,09808226	-0,07156584	-0,05645924	-0,06312452	-0,06757132	-0,06690828	-0,06528384	-0,06876332
Subm2020	CO		t	128,391835	473,84337	345,740395	272,759153	304,959655	326,442545	323,239345	315,391505	332,201155
Subm2021	CO	Feuerwerk, Silvester	t	99,66385	367,662295	187,921305	206,32183	224,792425	250,240705	232,887655	242,640255	235,804855
Subm2021	CO	Feuerwerk, unterjährig	t	29,530215	53,24748	77,975755	53,664325	57,24719	63,145225	67,83348	61,0896	64,9792
Difference	CO		t	0,80223	-52,933595	-79,843335	-12,7729983	-22,92004	-13,056615	-22,51821	-11,66165	-31,4171
Subm2020	Cr		t	0,28012764	1,03384008	0,75434268	0,59511088	0,66536652	0,71223828	0,70524948	0,68812692	0,72480252
Subm2021	Cr	Feuerwerk, Silvester	t	0	0	0	0	0	0	0	0	0
Subm2021	Cr	Feuerwerk, unterjährig	t	0	0	0	0	0	0	0	0	0
Difference	Cr		t	-0,28012764	-1,03384008	-0,75434268	-0,59511088	-0,66536652	-0,71223828	-0,70524948	-0,68812692	-0,72480252
Subm2020	Cu		t	7,9728636	29,4246792	21,4697532	16,9377712	18,9373548	20,2713972	20,0724852	19,5851508	20,6289948
Subm2021	Cu	Feuerwerk, Silvester	t	6,188916	22,8310572	11,6695188	12,8121528	13,959138	15,5394228	14,4618348	15,0674508	14,6429868
Subm2021	Cu	Feuerwerk, unterjährig	t	1,8337644	3,3065568	4,8421308	3,332442	3,5549304	3,921186	4,2123168	3,793536	4,035072
Difference	Cu		t	0,0498168	-3,2870652	-4,9581036	-0,7931764	-1,4232864	-0,8107884	-1,3983336	-0,724164	-1,950936
Subm2020	Hg		t	0,00102354	0,00377749	0,00275625	0,00217444	0,00243115	0,00260241	0,00257687	0,00251431	0,00264832

	Schadstoff	Quellgruppe	Einheit	1990	1995	2000	2005	2010	2015	2016	2017	2018
Subm2021	Hg	Feuerwerk, Silvester	t	0	0	0	0	0	0	0	0	0
Subm2021	Hg	Feuerwerk, unterjährig	t	0	0	0	0	0	0	0	0	0
Difference	Hg		t	-0,00102354	-0,00377749	-0,00275625	-0,00217444	-0,00243115	-0,00260241	-0,00257687	-0,00251431	-0,00264832
	Schadstoff	Quellgruppe	Einheit	1990	1995	2000	2005	2010	2015	2016	2017	2018
Subm2020	Ni		t	0,538707	1,988154	1,450659	1,144444	1,279551	1,369689	1,356249	1,323321	1,393851
Subm2021	Ni	Feuerwerk, Silvester	t	0	0	0	0	0	0	0	0	0
Subm2021	Ni	Feuerwerk, unterjährig	t	0	0	0	0	0	0	0	0	0
Difference	Ni		t	-0,538707	-1,988154	-1,450659	-1,144444	-1,279551	-1,369689	-1,356249	-1,323321	-1,393851
Subm2020	NOx		t	4,668794	17,230668	12,572378	9,91851467	11,089442	11,870638	11,754158	11,468782	12,080042
Subm2021	NOx	Feuerwerk, Silvester	t	3,62414	13,369538	6,833502	7,502612	8,17427	9,099662	8,468642	8,823282	8,574722
Subm2021	NOx	Feuerwerk, unterjährig	t	1,073826	1,936272	2,835482	1,95143	2,081716	2,29619	2,466672	2,22144	2,36288
Difference	NOx		t	0,029172	-1,924858	-2,903394	-0,46447267	-0,833456	-0,474786	-0,818844	-0,42406	-1,14244
Subm2020	Pb		t	14,0782096	51,9570912	37,9105552	29,9081365	33,4389328	35,7945392	35,4433072	34,5827888	36,4259728
Subm2021	Pb	Feuerwerk, Silvester	t	10,928176	24,8087995	4,75514695	0	0	0	0	0	0
Subm2021	Pb	Feuerwerk, unterjährig	t	3,2379984	3,59298757	1,9730928	0	0	0	0	0	0
Difference	Pb		t	0,0879648	-23,5553041	-31,1823154	-29,9081365	-33,4389328	-35,7945392	-35,4433072	-34,5827888	-36,4259728
Subm2020	PM 10		t		6.621,88	4.831,66	3.811,76	4.261,76	4.561,98	4.517,21	4.407,54	4.642,45
Subm2021	PM 10	Feuerwerk, Silvester	t		2.674,04	1.366,77	1.370,94	1.409,33	1.661,54	1.547,92	1.623,94	1.591,93
Subm2021	PM 10	Feuerwerk, unterjährig	t		467,683873	684,87754	542,776071	554,482233	594,479838	627,050634	563,379267	577,265866
Difference	PM 10		t		-3480,1554	-2780,01648	-1898,04731	-2297,94362	-2305,96094	-2342,24645	-2220,22203	-2473,25708
Subm2020	PM 2.5		t		3.442,16	2.511,57	1.981,41	2.215,33	2.371,39	2.348,12	2.291,11	2.413,22
Subm2021	PM 2.5	Feuerwerk, Silvester	t		2.132,08	1.089,76	1.100,28	1.148,70	1.378,39	1.287,87	1.354,30	1.309,73
Subm2021	PM 2.5	Feuerwerk, unterjährig	t		369,710572	541,40517	429,071993	438,325876	469,944536	495,692201	445,359104	456,336653
Difference	PM 2.5		t		-940,362639	-880,408132	-452,066627	-628,304647	-523,057419	-564,556656	-491,450477	-647,158392
Subm2020	SO2		t	54,229838	200,140836	146,033006	115,207363	128,808134	137,882026	136,529066	133,214314	140,314334
Subm2021	SO2	Feuerwerk, Silvester	t	42,09578	155,292326	79,373754	87,145724	94,94729	105,696074	98,366534	102,485814	99,598694
Subm2021	SO2	Feuerwerk, unterjährig	t	12,472902	22,490544	32,935214	22,66661	24,179932	26,67113	28,651344	25,80288	27,44576
Difference	SO2		t	0,338844	-22,357966	-33,724038	-5,39502867	-9,680912	-5,514822	-9,511188	-4,92562	-13,26988
Subm2020	TSP		t	1.972,21	7.278,63	5.310,86	4.189,81	4.684,44	5.014,43	4.965,23	4.844,68	5.102,89
Subm2021	TSP	Feuerwerk, Silvester	t	724,863616	2.674,04	1.366,77	1.370,94	1.409,33	1.661,54	1.547,92	1.623,94	1.591,93
Subm2021	TSP	Feuerwerk, unterjährig	t	259,370121	467,683873	684,87754	542,776071	554,482233	594,479838	627,050634	563,379267	577,265866
Difference	TSP		t	-987,97259	-4136,90893	-3259,2175	-2276,09531	-2720,62196	-2758,41487	-2790,2607	-2657,35906	-2933,69253
	Schadstoff	Quellgruppe	Einheit	1990	1995	2000	2005	2010	2015	2016	2017	2018
Subm2020	Zn		t	4,668794	17,230668	12,572378	9,91851467	11,089442	11,870638	11,754158	11,468782	12,080042
Subm2021	Zn	Feuerwerk, Silvester	t	3,62414	13,369538	6,833502	7,502612	8,17427	9,099662	8,468642	8,823282	8,574722
Subm2021	Zn	Feuerwerk, unterjährig	t	1,073826	1,936272	2,835482	1,95143	2,081716	2,29619	2,466672	2,22144	2,36288
Difference	Zn		t	0,029172	-1,924858	-2,903394	-0,46447267	-0,833456	-0,474786	-0,818844	-0,42406	-1,14244

Uncertainties

The uncertainty for the AD is given as 10%.

Planned improvements

The Link to peer reviewed publication of the research results of the VPI will be added as soon as the report is published.

¹⁾ <https://onlinelibrary.wiley.com/doi/epdf/10.1002/prep.202000292>

²⁾ Statistisches Bundesamt (51000-0013): Aus- und Einfuhr (Außenhandel), URL:

https://www-genesis.destatis.de/genesis/online/data;sid=D7FC9DA10C87E483A48EA26969FF80CF.GO_1_5?operation=abruftabelleAbrufen&selectionname=51000-0013&levelindex=0&levelid=1552378849838&index=13

³⁾ EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019, Copenhagen, 2019.