Exposure description

Paving of conventional rolled asphalt in road construction

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1. General

The Ordinance on Hazardous Substances (GefStoffV) [1], §§ 7 and 9 requires employers to determine whether occupational exposure limit values have been complied with. This can be checked using workplace measurements or other evaluation procedures of equivalent value. If no occupational exposure limit values are available, the effectiveness of protective measures must be proven using suitable evaluation methods.

This exposure description represents such an evaluation procedure for substances without occupational exposure limit values. For the described activities a sufficient number of work area analyses with unequivocal findings are available, and no process-related changes are expected for the future either. These results may therefore be invoked directly to evaluate concentrations in the air within work areas, i.e. no further measurements are required.

This exposure description can be applied according to § 7 of the Ordinance on Hazardous Substances to evaluate hazards and determine appropriate actions. Furthermore, for the evaluation of hazards according to § 5 of the Occupational Health and Safety Act (ArbSchG) [2] and § 3 of the Workplace Safety Ordinance (BetrSichV) [3], this exposure description may also be applied. The obligations to use low-risk substances and/or processes, to observe the order of priority of the protective measures and to train and brief employees etc. remain in force.

2. Application area

This exposure description considers paving of conventional rolled asphalt in road construction. The description will establish criteria for abandonment of monitoring vapours and aerosol from bitumen during paving operations of conventional rolled asphalt for the construction of roads outdoor.

The exposure description does not apply, if binders containing tar or pitch or if diesel oil is used as a release agent. Rubber modified bitumen is also not considered in this exposure description as well as expositions of other hazardous substances.

The exposures during the application of asphalt containing viscosity reducing additives are shown in the exposure description “Paving of asphalt containing temperature reducing additives” (in progress).

3. Operating methods

In according to technical standards, conventional rolled asphalt is applied at temperatures of 160 +/- 20°C. The asphalt mix is transported by covered trucks from mixing plant to site and transferred into the hopper of the paver. The paver distributes the asphalt on the road surface by a heated screed in the required thickness and width of the screed. After paving, the asphalt layer is compacted by rollers.

4. Hazardous substances

Asphalt contains bitumen as a binder. Bitumen is residue of crude oil and is a mixture of different organic substances predominantly high molecular weight hydrocarbons. For the production of rolled asphalt the following bitumen types are predominantly used: 30/45,

50/70, 70/100 as well as polymer modified bitumen PmB 45, PmB 65 or PmB 80. Oxidized bitumen (85/25) is not used for road construction, but for industrial applications, e. g. roofing membranes.

Analyses of bitumen that are commonly used have shown that they contain between 1.2 – 2.7 mg/kg Benzo(a)pryren (BaP) [4]; there are further details on the polycyclic hydrocarbons (PAH) and S-PAH). This is more than a factor of 10 below the specific limit of this substance of 100 mg/kg BaP for classification as carcinogenic according to Annex I of the European Directive 67/548/EWG [5].

This exposure description is based on evaluations of workplace measurements during the application of conventional rolled asphalt. Vapors and aerosols released from hot bitumen were measured. The measurement process registers all organic compounds with aliphatic C – H bonds [6] and therefore also other substances like emissions from combustion engines (e.g. non-combusted fuel-components).

Diesel engine emissions may occur during the laying of asphalt. For an adequate evaluation of diesel engine emissions it is referred to the Technical Rules for Hazardous Substances (TRGS) 554 “Diesel engine emissions” [7].

5. Exposure to hazardous substances

During the years 1993 – 2007 in total 821 measurements were carried out during the application of conventional asphalt. Annex I explains the criteria, which resulted in the fact that the following analyses refer to 442 measurements (Table 1). Only measurements resulting from construction sites outdoor with an application temperature of 160 +/- 20°C were included. Paving operations with higher application temperatures are not valid for the conclusions of this exposure description. When a measured value was below the detection limit, the half detection limit was applied as measured value.

The measurements took usually place over two hours of exposure. Activities without exposure of vapors and aerosols from bitumen during paving operations are preparing of the construction site, changing the equipment, waiting time, etc.

Table 1: Overview of the concentration of vapors and aerosols from bitumen (mg/m³) during the handling of conventional rolled asphalt

	Measurement values	**Minimal value**	**50 Percentile**	**95 Percentile**	**Maximum value**
Forman	225	0.12	2.7	12.44	20.80
Paver driver	161	0.12	2.4	8.90	17.60
Roller driver	56	0.17	0,9	2.45	3.10

The exposure during application of rolled asphalt is determined by the total of vapor and aerosol from bitumen. In some cases the BaP-concentrations were also determined. All measurements for Benzo(a)pyren obtained with the German BG Institute for Occupational Safety and Health asphalt (BGIA-)Standard System were below the middle detection limit of BaP of 0.11 µg/m³.

The environmental conditions and the wind conditions, which have an influence on measured values and exposure, are not constant during the full working time, because

- the paving area moves on at an average speed of 1 – 5 m/min and therefore continuously changes the environment,
- paving follows the course of the road and its constantly changing direction,
- the paver is often repositioned and
- direction und strength of wind varies.

The measured data were evaluated with regard to volume handled, paving width, characteristics of the mixture and the sub grade. It was not possible to prove any dependency of exposure on these parameters.

During operations in the downwind, there have been some cases of exposure of above 10 mg/m³ when the free movement of air was limited by an obstacle located directly adjacent to the paving location (e.g. noise barrier).

During measurements in France and Slovenia, similar exposure data were measured for the paver driver (0.25 – 3.8 mg/m³; 5 measured values), forman (0.4 – 9.4 mg/m³; 8 measured values) and roller driver (0.5 and 1.7 mg/m³). These measurement data are part of the collective of table 1.

5.1 Truck driver

The exposure of the truck driver who transports the asphalt from mixing plant to construction site is described in the exposure description “Manufacture and transportation of asphalt”.

5.2 Paver driver

The paver driver controls the movements of the paver. He sits on a heightened platform open to all sides. The values could lie in the upper sector of the measurements collected, if several pavers drive parallel.

Various paver types allow the driver-cabin to be closed with more or less permanently affixed windows and doors. The emissions, which rise up through the floor from the augers, accumulate in the driver cabin, because natural ventilation is interrupted (up to 19.7 mg/m³; s. Annex 1).

The values in table 1 don’t apply to trilateral or multilateral closed cabins.

5.3 Forman (screed operator), raker

The forman controls among other activities the setting of the screed. The raker carries out auxiliary tasks like repairing of defective spots, edge alignment, transitions to links etc. The forman usually takes over the activity of the raker. For this reason, the exposure data of the forman and the raker are combined.

In some cases there were occurrences of exposure > 10 mg/m³ under environmental conditions, e.g. activities exclusively in the downwind, obstruction of the free air circulation or during work between two tightly staggered finishers during parallel laying.

5.4 Roller driver

The roller driver directs the roller behind the pavers on the freshly laid layer.

6. Results

The measurements confirm that it is possible to work during the handling of conventional rolled asphalt during road construction while performing activities for eight hours without further protective measures provided that

- Laying temperature 160 +/- 20 °C, which foreseen in part Three, are adhered to;
- The ventilation of the paver platform isn’t hampered with a trilateral or multilateral barrier;
- No diesel, old oil or similar is used as release agent;

- No rubber asphalt is used;
- The paving operation is not taken place in tunnels.

The higher exposure values of the screed operator were under unfavorable environmental conditions (obstacles like noise barriers) caused in connection with time in the down draft vane and negative wind direction.

7. Recommendations

7.1 Recommendation for the laying of asphalt

Exposure measurements are not necessary because of the available results. It is generally possible to work up to eight hours encountered to exposures without further protection measures.

Therefore, the temperature of the bitumen mixture during paving needs to be within the temperature range of 160 +/- 20°C, which is outlined in part 3. The cabin of the paver control may not be closed by windows, curtains or similar, because the free air circulation will be obstructed and arising emissions may accumulate.

The use of diesel fuel as a release agent is not allowed. Diesel fuel may contain aromatic hydro carbons, which probably have a carcinogenic effect [7] and may be breathed in during its use as a release agent.

Unfavorable environmental conditions are described under section 5.3 and need to be regarded as an exception. If employees feel disturbed by these conditions, filtering half masks A2P2 may be used, supplied by the employer. This is in reference with the specific industrial medicine-based preventative measures according to the German BG (institution for statutory accident insurance and prevention for trade and industry) principle G 26 “Respiration equipment”.

It is recommended to consider the use of low temperature asphalt [8].

7.2 General measures

Direct skin contact with hot asphalt leads to burned skin, therefore workers should always avoid skin contact. If required it is recommended to wear heat-resistant protection gloves, e.g. made of leather.

8. Application recommendations

The user of this exposure description needs to verify the assumptions and resquirements and has to document the results if any working procedures change, otherwise regularly, at least once every year. This also includes the validity of this exposure description. Such verification can take place in the scope of hazard assessment according to § 5 German Occupational Health and Safety Act (ArbSchG), § 7 of the Ordinance on Hazardous Substance (GefStoffV) or alternative § 3 of the Workplace Safety Ordinance (BetrSichV).

This exposure description provides employers with best practice-based advice on how to meet their obligations, especially according to § 9 sect. 8 of the German Ordinance on Hazardous Substance. Even if this exposure description is applied, other requirements of the Ordinance on Hazardous Substances remain in force, especially concerning the data determination and hazard assessment (§7), the use of substances and/or processes with low risk (as well as the documentation of a possible rejection of a substitute, §9 sect. 1), the obligation to observe the order of priority of protective measures (§9 sect. 2) as well as the obligation to instruct and brief employees and prepare written directives (§14).

9. Review

This exposure description was first adopted in October 1999, according to the implementation of the revised Ordinance on Hazardous Substance (GefStoffV), the description was revised in March 2005 and updated in March 2008. It is checked annually. Essential changes will be published.

Literature

1. German Ordinance of Hazardous Substances (GefStoffV) from December 23, 2004. BGBl (2004) Part 1 Nr. 74 from December 29, 2004, p. 3758 et sqq
2. Legislation concerning of the implementation of occupational safety measures to improve the safety health protection of employees during the performance of work (Labor Protection Act – ArbSchG) from August 7, 1996 (BGBl. 1, p. 1246 et sqq)
3. Regulation about security and health protection at allocation of working appliance and whose use at work, about security at service supervision installation and about the organization of the related labor protection (German Ordinance of Working place Safety – BetriebsSichV), Art. 1 of the Regulation from September 27, 2002 (BGBl 1, p. 3777 et sqq)
4. Knecht, U.; Stahl, S.; Woitowitz, H.-J.: Commercial grade bitumen types: PAH mass fraction and temperature-dependent emission behavior under standardized Conditions. Gefahrstoffe – Reinhaltung der Luft 59 (1999) 429 – 434
5. Directive 67/548/EWG for the adaptation of the legal and administrative regulations for classification, packaging and labeling of hazardous substances, Annex 1; www.baua.de/nn_5846/de/Themen-von-A-Z/Gefahrstoffe/Rechtstexte/EG-Richtlinien_content.html_nnn=true
6. BIA-Arbeitsmappe “Measurements of hazardous substances” republished by BG-Institute for Occupational Safety and Health – BGIA, Sankt Augustin, Erich Schmidt Verlag Bielefeld
7. Technical rules for hazardous substances, TRGS 554 “Dieselmotoremissionen” (BArbBl) 3/1999, 54-62
8. German Bitumen Forum (www.gisbau.de/bitumen.html)

This exposure description was compiled in co-operation with the

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- Berufsgenossenschaft der Bauwirtschaft, Berlin
- German Asphalt Institute (Deutsches Asphaltinstitut (DAI) e.V.), Bonn
- German Asphalt Association (Deutscher Asphaltverband (DAV) e.V.), Bonn
- Federation of the German Construction Industry (Hauptverband der Deutschen Bauindustrie) e.V., Berlin
- Trade Association of the Construction Industry (Industriegewerkschaft Bauen – Agrar – Umwelt IG BAU), Frankfurt
- Central Federation of the German Building Trade (Zentralverband des Deutschen Baugewerbes (ZDB) e.V.), Berlin

Annex 1

Exposure data conventional rolled asphalt

During the years 1993 – 2007, 821 measurements were carried out during paving of conventional asphalt. In 55 cases, vapors and aerosols from Bitumen were not measured, but PAK, aldehyde, etc. In 22 cases the test device was not working properly and in 27 cases it was not possible to allocate the measurements to a job description.
(821 – (55 + 22 + 27) = 717)

41 measurements were carried out in an unloaded environment of the construction site to estimate the influence of road traffic on asphalt workers expositions (Table 1.1).
(717 – 41 = 676)

Table 1.1: Emission in unloaded environment of construction site (mg/m³ vapours and aerosols of bitumen

	Measurement values	Minimal value	50 Percentile	95 Percentile	Maximum value
Outdoor	40	0.07	0.30	1.72	2.30
Tunnel	1	5.60			

In 11 cases, the emission was measured immediately at the emission source (just above the auger; table 1.2). (676 – 11 = 665)

Table 1.2: Emission at the emission source (mg/m³ vapours and aerosols of bitumen)

	Measurement Values	Minimal value	50 Percentile	95 Percentile	Maximum value
Emission recourse	11	6.00	29.70	94.55	146.80

Vapors and aerosols exposure from bitumen with an unusual quotient aerosol/vapor (< 0.1) were detected in some measurements. This could be an indication of an influence of another exposure, like release agents containing diesel. If in addition to this unusual quotient aerosol/vapor further indications of influences by other exposures (like separating agents) were received, the corresponding measurements were taken out of the data set (10 measurements on 9 construction site). (665 – 10 = 655)

34 measurements were carried out during paving of rubber asphalt on 7 construction sites (Table 1.3; 655 – 34 = 621).

Table 1.3: Summary of measurements during paving of rubber asphalt (mg/m³ vapours and aerosols of bitumen)

	Measurement values	Minimal value	50 Percentile	95 Percentile	Maximum value
Forman	17	0.25	4.30	12.92	17.40
Paver driver	14	1.10	3.15	5.16	6.20
Roller driver	1	1.20			
Miscellaneous	2	3.30 –7.20			

10 measurements were carried out at one construction site where the paving temperature was over 200 °C (621 – 10 = 611).

The remaining 611 measurements were carried out during paving of conventional asphalt in road building with ≤200 °C paving temperature (table 1.4).

Table 1.4: Summary of Measurements during paving of conventional asphalt with ≤200 °C paving temperature (mg/m³ vapours and aerosols of bitumen)

	Measurement values	Minimal value	50 Percentile	95 Percentile	Maximum value
Forman	303	0.12	2.80	13.58	28.80
Paver driver	213	0.12	2.50	13.08	19.90
Roller driver	77	0.17	1.00	3.10	8.80
Feeder driver, compact asphalt	5	0.22	-	-	5.30
Feeder driver, others	7	0.50	-	-	9.60
Winder driver	4	0.14 – 0.22 – 0.4 – 0.8			
Truck advisor	2	0.5 – 1.0			

Some measurements were realized on Winder drivers at paving of conventional asphalt (4; backup of paver driver), feeder drivers (7) and truck advisors (2) at laying of conventional asphalt (last three lines in table 1.4), for example at paving a water support basin (Picture 1.1). (611 – (4 + 7 + 2) = 598).

Picture 1.1: Winder (ahead), feeder (middle) and paver and roll (below) at paving a water support basin

124 Measurements were carried out during paving of conventional rolled asphalt on 11 tunnel construction sites (Table 1.5; 598 – 124 = 474).

Table 1.5 Summary of measurements at paving of conventional rolled asphalt on tunnel construction sites (mg/m³ vapours and aerosols of bitumen)

	Measurement values	Minimal value	50 Percentile	95 Percentile	Maximum value
Formen	72	0.23	3.20	18.45	28.80
Paver driver	34	0.80	2.65	18.57	19.90
Roller driver	18	0.70	1.30	7.19	8.80

9 measurements were carried out on paver drivers on 5 construction sites, whose driver's cabins were closed. (474 – 9 = 465)

Table 1.6: Summary of measurements on paver drivers in closed driver cabins during the laying of conventional asphalt (mg/m³ vapours and aerosols of bitumen)

	Measurement values	**Minimal value**	**50 Percentile**	**95 Percentile**	**Maximum value**
Paver driver	9	5.6	-	-	19.7

18 measurements were carried out with a paving temperature over 180 – 200°C during the laying of conventional asphalt in road building outside, 5 measurements on feeder drivers by laying compact asphalt.

Therefore, 442 measurements remain at paving temperature with 160 +/- 20°C (table 1.7; identical with table 1, page 2). The statements of this exposure description concern these 442 measurements.

Table 1.7: Overview about vapor and aerosols concentration from bitumen (mg/m³) during paving of conventional asphalt

	Measurement values	**Minimal values**	**50 Percentile**	**95 Percentile**	**Maximum value**
Forman	225	0.12	2.7	12.44	20.8
Paver driver	161	0.12	2.4	8.90	17.6
Roller driver	56	0.17	0.9	2.45	3.1