Exposure to Fumes and Aerosols of Bitumen — Industry-wide created support measures for SME

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Summary

The possible health hazards of fumes and aerosols from bitumen have been a subject of discussion for several years, not least because there is often a lack in distinction between the use of the terms “tar” and “bitumen”. In addition, the German occupational exposure limit for fumes and aerosols emitted from hot bitumen is a technical guidance value, which reflects technical feasibility and is not primarily based on toxicological findings.

A concerted effort by all the participating associations and institutions of the BITUMEN Forum has resulted in a rationalisation of the debate on classification and threshold limit for bitumen. In this contribution the starting point for the BITUMEN Forum is described as well as its completed and current work with main emphasis to the investigation of the exposure-situation on workplaces in the construction industry.

1 History

Up to now bitumen is not legally classified as a carcinogen in the European List of Hazardous Substances. In Germany the extending list of carcinogens (legally binding for the work with a substance, not for its placing on the market) is the Technical Rule for Hazardous Substances (TRGS) 905. Up to 1996 the precursor of this rule listed bitumen as a suspected carcinogen - a consequence of the automatic adoption of the classifications published by the Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area of the German Research Council (“Deutsche Forschungsgemeinschaft”). In their list of MAK (occupational exposure limit) and BAT (biological monitoring guidance) values since 1977 bitumen has been listed as a suspected carcinogen. At that time mainly based on the characteristics of mixtures of bitumen and coal tar. With coming into force of the TRGS 905 bitumen was no longer part of the legally binding list, because the toxicological data for bitumen was unclear.

The German threshold limits for bitumen fumes and aerosols - technically founded threshold limits - were assigned in autumn 1996. It was decided at that time that the threshold limit of 15 mg/m³ for work outsides would be reduced to 10 mg/m³ in year 2000 if no results of measurements were presented that were contradictory to a reduction of the limit. For work inside rooms the threshold limit was established with 20 mg/m³. The conditions for setting these threshold limits were not altogether agreeable to all parties. The database was not satisfactory and the fixing of a threshold limit on empirical grounds for a non-carcinogenic substance also caused confusion. There were signs that a similar situation was developing with bitumen as occurred with synthetic mineral fibres. There, the producers have tried judicially to prevent classification of their products. The arguments between producers, occupational safety officers and the State went through several legal proceedings up to the EU.

2 BITUMEN Forum

Resulting from this unclear situation and following encouragement from the Ministry for Labour and Social Affairs, the BITUMEN Forum was formed at the beginning of 1997. All institutions whose members have interest in or are responsible for applications of bitumen or bituminous products are represented in the Forum. These include: The producers of bitumen, the many producers of bituminous products (producers of asphalt, bitumen sheeting and foils, bituminous emulsions or solvent based bituminous products, producers of products which are linked with bitumen in the application etc.) and users of these products such as roofers, road construction and other construction companies. In addition, the relevant institutions for occupational safety and health and naturally, trade unions are also represented in the BITUMEN Forum (Fig.1).

Fig.1: Members of the BITUMEN Forum

The Forum is working on an extensive programme in order to establish the best possible basis for assessing possible health hazards arising from handling bitumen at the workplace. Alongside the work listed below which to a large extent is completed, attempts are being made through publications and presentations on bitumen to clarify the fundamental difference between tar and bitumen.

The following co-ordinated projects of the BITUMEN Forum have already been completed:

- determination of the constituents of the different bitumen produced in Germany,
- measurement of fumes and aerosols arising from work with hot bitumen,
- the search for suitable protective gloves for use in handling bituminous emulsions and solvent based bituminous products,
- the German part of a Europe-wide epidemiological study of the frequency of cancer in “bitumen workers”,
- possible absorption through the skin of bituminous constituents when dealing with cold bituminous products,
- investigation into dermal absorption of certain constituents from fumes and aerosols released from hot bitumen,
- the possibility of developing low emission application processes.

Some studies are still going on, e.g.:

- animal experiments on inhalation of fumes and aerosols from bitumen,
- effects of exposure on the respiratory system when laying mastic asphalt.

3 Fumes and aerosols from hot bitumen

Determination of the concentration of fumes and aerosols arising from handling hot bituminous substances has been one of the main priorities of the Forum’s work up to now. With the results of these measurements it was possible to show how exposures to fumes and aerosols from bitumen vary with production and different uses – rolled (road) asphalt, mastic asphalt, bitumen sheeting, joint fillers etc. (Table 1). Based on this actual, very good database on heights of exposure the splitting of the threshold limit to insides/outsides was given up and a single limit value of 10 mg/m³ is valid nowadays. This value is coupled to a certain measurement procedure which detects hydrocarbons in fume and aerosol fraction by infrared analysis [1].

The threshold limit however was temporarily deferred for workers with the greatest exposure to fumes and aerosols from bitumen, those working with mastic asphalt (“Gussasphalt” in German). These workers are currently undergoing a selective occupational health monitoring. A group of around 100 employees who work with mastic asphalt are being intensively examined to determine possible effects of exposure to fumes and aerosols from bitumen.

Table 1: Exposure to bitumen; published specifications of exposure are marked with an asterisk.

Working area		**Number of measurements**	**95 percentile in mg/m³**
Production of bitumen	*	17	2.6
Production of bitumen sheeting	*	37	4.3
Production and transport of asphalt	*****		
Control centre		8	0.8
External area		6	0.7
Transport of asphalt		14	4.3
Using rolled asphalt in road building	*****		
Paver operator		115	6.5
Screed operator		141	10.4
Roller driver		42	2.6
Use of hot bitumen			
Laying of foamglass outdoors		60	9.9
Roofing work			
Torching of bitumen sheeting	*	75	8.8
Pouring of hot bitumen		30	16.9
Manual work with mastic asphalt			
Filling in, outdoors		32	15.0
Filling in, indoors		30	28.9
Transporting in a barrow, indoors		49	50.9
Transporting in a bucket, indoors		30	10.9
Smoothing, outdoors		17	8.2
Smoothing, indoors		148	35.8
Mechanical laying of mastic asphalt			
Charger on the mixer (tapster)		52	61.4
Screed operator		74	40.6
Smoother		28	12.3
Working with joint fillers	*****		
Charging on the kettle		10	3.9
Pouring of hot filler		10	3.0

In the production of bitumen, bitumen sheeting and the production and transport of asphalt products, concentrations are considerably less than 10 mg/m³.

4 Construction industry

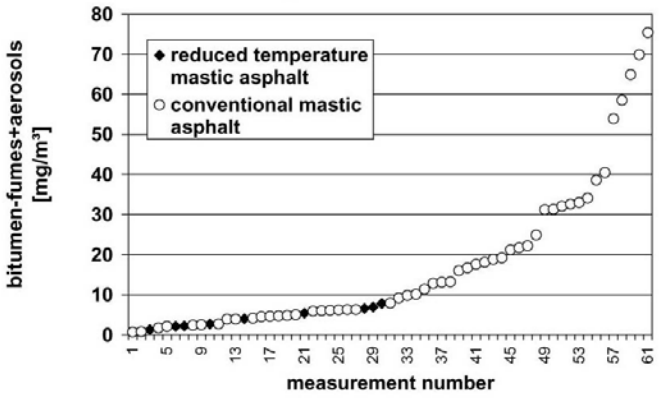
The predominant amount of bitumen is used as binder in rolled asphalt in road paving. The paver operator and the screed operator show exposures[1] of 6.46 respectively 10.4 mg/m³ (95 percentile, median 2.6 / 2.8 mg/m³ for N = 115 / 141 measurements).The roller drivers, who are quite away from the new hot surfaces, show a reduced exposure of 2.6 mg/m³.

Whereas rolled asphalt is processed with temperatures about 160 ±20 °C, mastic asphalt is used with much higher temperatures about 250 °C and more. Therefore, exposure data for work with mastic asphalt shows much higher values. Mechanical laying of mastic asphalt in road paving shows highest exposures (>50 mg/m³) for the charger on the mixer, who stays between the kettle and the screed machine. Of course influences of wind and the surroundings on the construction site may lead to a large variation in exposure data (spread see fig. 2).

Mastic asphalt is also used as attic inside buildings - then processed manually. The measurements reveal, that the technical threshold limit of 10 mg/m³ may be exceeded for nearly each work. Of course not in all cases, but e.g. for smoothing indoors 50 % of the measurements exceeded the value of 10 mg/m³.

A promising solution for this problem may be 'reduced temperature asphalt laying'. Two different techniques allow a reduction of the asphalt temperature of about 20-30 °C with a corresponding reduction of exposure height (e.g. see fig. 2).

Fig. 2: Bitumen exposure for mastic asphalt charger on the mixer



In comparison to mastic asphalt, roofing work does not show as high exposure values. Pouring of hot bitumen for sticking bitumen sheeting shows highest exposures about 16 mg/m³, whereas for torching of bitumen sheeting the threshold limit is not exceeded. The same applies for laying foamglas outsides with hot bitumen out of cans. Working out of buckets (with a larger amount and larger surface) seems to reveal higher exposure data.

1 in this paper exposure is meant as "activity-related measurement" indicating that the duration of the activity may last for a whole shift (8 hours).

5 Specifications of exposure

Up to now in the BITUMEN Forum six specifications of exposure have been compiled (marked with an asterisk in Table 1). These specifications of exposure relate to the working situation and the associated exposures of the workers. By publishing the specifications of exposures, companies have the opportunity to predict concentrations of potentially hazardous substances without having to carry out measurements themselves. The specifications not only describe the height of exposure, in addition, necessary technical, organisational or personal protective measures are confirmed.

6 Fumes and aerosols

It is interesting that there is a large variation in the proportion of fume to aerosol with increasing laying temperature. By means of figure 3 an explanation can be given for the USA threshold limit of 0.5 mg/m³ being only conditionally comparable with the German limit. On no account is the American threshold limit 20 times more severe than the current German limit of 10 mg/m³. Whereas the German threshold limit covers the sum of fumes and aerosols and it makes no difference that at different bitumen working temperatures there are marked differences in the proportions of fume to aerosol, the American limit only relates to the aerosol fraction.

Hence, at temperatures below 180°C only a small proportion of the emissions from bitumen is registered when applying the analytical methods commonly used in the USA for monitoring workplace air. As figure 3 shows, at this temperature the emission is primarily fume. In this figure it even must be considered that the aerosol concentrations for rolled asphalt often are below the detection limit.

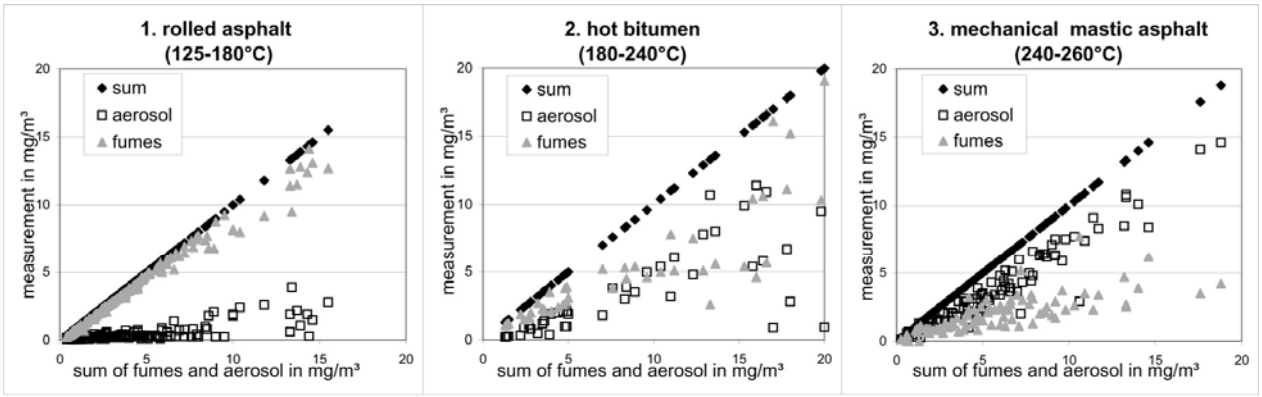


Fig.3: Comparison of the proportions of fumes and aerosol concentrations from hot bitumen. 1. Working with rolled asphalt in road paving. 2. Working with hot bitumen in pouring process. 3. Mechanical working with mastic asphalt in road paving. The diagram shows only values up to 20 mg/m³ in the cited working temperature range.

7 Outlook

On the whole, the BITUMEN Forum is an excellent example on which future solutions to specific occupational safety and health problems can be modelled. As an ‘alliance for occupational safety and health’ the Forum shows the way for similar strategies with respect to other issues.

The summary of the exposure data into specifications of exposure reveal a helpful tool especially for SME concerning their hazardous substances management. They exempt the enterprises from their duty to carry out measurements with regard to bitumen air monitoring. In the future, reduced temperature asphalt laying may lead to the necessary exposure reduction, especially for mastic asphalt, which nowadays reveals the highest exposure.

The projects on bitumen are documented in the BITUMEN Forum’s status report, which is available on the Internet: "www.GISBAU.de" at 'Aktuelles'.

References

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