THE GERMAN BITUMEN FORUM – CO-OPERATION IN PARTNERSHIP

Reinhold Rühl, Chairman of the BITUMEN Forum
Bau-Berufsgenossenschaft Frankfurt am Main, Hungener Straße 6, D – 60331 Frankfurt

ABSTRACT

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 no clear distinction made 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 state-of-the-art 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 in the establishment of a threshold limit for fumes and aerosols from hot bitumen. The Forum is working on an extensive research programme in order to assess possible health hazards arising from handling bitumen and to establish exposure reduction measures. This paper describes the working of the BITUMEN Forum and some significant innovations arising from that research.

Keywords : Emissions, Energy saving, Exposure, Low-Temperature, PAH

1. SITUATION IN GERMANY IN THE MID 1990s

Since 1977, bitumen has been listed as a suspected carcinogen in the 'List of occupational exposure limit (MAK) and biological monitoring guidance (BAT) values' issued by the Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area of the Deutsche Forschungsgemeinschaft (German Research Council). In contrast to the current European Union (EU) lists in which bitumen is not listed, the national threshold limits and classification published in the "Technischen Regeln für Gefahrstoffe" (TRGS; Technical rules for hazardous substances) 900 and 905 are legally binding in Germany. The Ministry for Labour and Social Affairs is advised on this matter by the Ausschuss für Gefahrstoffe (AGS; Hazardous Substances Committee). For a long time, bitumen was classified in the TRGS as a suspected carcinogen, hence its inclusion in the MAK list was automatically adopted by the AGS at the start of the 1990s. By the middle of 1996, it was known that even according to EU criteria, bitumen would remain in the group of suspected carcinogens. At the same time, threshold limits in air for fumes and aerosols arising from work with hot bitumen were on the agenda for approval by the Ministry for Labor and Social Affairs in Germany.

The German threshold limits for fumes and aerosols from hot bitumen were assigned in autumn 1996. AGS decided at that time that the threshold limit in air of 15 mg/m³ would be reduced to 10 mg/m³ on Jan 1, 2000 if, by June 30, 1999, no results of measurements were presented that were contradictory to a reduction in the limit. The conditions for setting these threshold limits were not completely agreeable to all parties. The database was not satisfactory, and the fixing of a threshold limit on empirical grounds for a noncarcinogenic substance also caused confusion. There were signs that a similar situation was developing with bitumen as occurred with man made mineral fibers (MMMF). Here, the producers have tried judicially to prevent classification of their MMMF products. The arguments between producers, occupational safety officers and Germany went through several legal proceedings up to the EU [BMA, 1996].

In the case of bitumen, on one side the occupational safety officers and users of the substance wanted clarification of the possible health hazards and, on the other side, the producers repeatedly referred to various inconclusive toxicological studies which represent the basis for classification but do nothing to ensure confidence.

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: Producers of bitumen (those companies affiliated with the Arbeitsgemeinschaft der Bitumen-Industrie e.V. (ARBIT; the bitumen industries working group)), producers of bituminous products such as asphalt, bitumen sheeting and foils, bitumen waterproofings and roof waterproofings, bituminous emulsions or solventbased bituminous products, producers of products that are linked with bitumen in the application etc., and users of these products such as roofing contractors, road construction crews and other construction companies. In addition, the trade unions and the institutions for occupational safety and health are also represented in the BITUMEN Forum.

The Forum coordinates an extensive programme in order to establish the best possible basis for assessing possible health hazards arising from handling bitumen. To a large extent the work is already successfully completed, those work activities being:

- determination of the constituents of the different bitumen [Knecht et al., 1999];
- measurement of fumes and aerosols arising from work with hot bitumen [Rühl and Musanke, 2003];
- the search for suitable protective gloves for use in handling bituminous emulsions and solvent based bituminous products [Deutsche Bauchemie, 1999];
- supporting the German part of a European epidemiological study of the incidence of cancer in "bitumen workers";
- possible absorption through the skin of bituminous constituents when dealing with cold bituminous products [Drexler and Angerer, 2002];
- investigation into dermal absorption of certain constituents from fumes and aerosols released from hot bitumen [Knecht et al., 2001].

The following studies are still going on:

- effects of exposure on the respiratory system when laying mastic asphalt [Rumler and Raulf-Heimsoth, 2001] and in particular
- animal experiments on inhalation of fumes and aerosols from bitumen in order to determine any possible carcinogenic effects [Fuhst et al., 2001].

The work mentioned above is financed almost 90% by the bitumen producers. The remaining funding is provided by other members of the Forum who, by their contribution, are also actively involved in the studies [Rühl and Musanke, 2001].

The most important task of the forum is at present the promotion of low temperature asphalt. The BITUMEN Forum published a status report (Sachstands-Bericht) in 2000 in which origin, aims and work of the Forum are described in detail (www.GISBAU.de).

3. FUMES AND AEROSOLS FROM WORKING WITH HOT BITUMEN

Determining of the concentration of fumes and aerosols arising from handling hot bituminous substances has been the main priority 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, fillers and others (see Table 1).

In the production of bitumen and the production and transport of asphalt products, concentrations are in part actually less than 10 mg/m³. This also is true for production and heat sealing of bitumen sheeting. The significant effect of working temperature, especially for mastic asphalt ("Gussasphalt" in German) work, becomes apparent. In road paving – with a maximum laying temperature of approximately 180°C – the highest exposures are 10.4 mg/m³. But for mastic asphalt work – with a laying temperature of approximately 250°C – the exposures are more than 50 mg/m³ (Table 2).

Table 1: Use of bitumen in Germany (per 1000 kg in 1998)

Rolled asphalt	2,500,000	(74.5%)
Bitumen sheeting, foils	700,000	(20.9%)
Cold bitumen	100,000	(3.0%)
Mastic asphalt, manual laying	32,000	(1.0%)
Mastic asphalt, mechanical laying	17,000	(0.5%)
Hot bitumen	4,000	(0.1%)
Total	3,353,000	(100.0%)

With these results now forming a very good database, the Hazardous Substances Committee passed in May 2000 a new reduced threshold limit in air for fumes and aerosols from bitumen of 10 mg/m³.

The threshold limit, however, is temporarily deferred for workers who experience the greatest exposure to fumes and aerosols from bitumen – those working with hot mastic asphalt. These workers are currently undergoing selective occupational health monitoring. A group of about 300 employees who work with mastic asphalt are being intensely examined to determine possible effects of exposure to fumes and aerosols from bitumen. This action was initiated by the BITUMEN Forum (see "Examination of employees working with mastic asphalt").

Up to now, the BITUMEN Forum has compiled eight "specifications of exposure" (see Table 2; Rühl and Musanke, 2003). 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 fumes and aerosols from hot bitumen without having to carry out measurements themselves. The exposures are primarily influenced by the working temperature of the bitumen.

Table 2: "Specifications of exposure" to fumes and aerosols from bitumen (95 percentile in mg/m³)

Production of bitumen	**3.0**
Production and transport of asphalt	
Control center	0.8
External area	0.7
Transport of asphalt	4.3
Using rolled asphalt in road building	
Paver operator	6.5
Screed operator	10.4
Roller driver	2.6
Mechanical laying of mastic asphalt	
Charger on the mixer (tapster)	56.7
Screed operator	43.1
Smoother	13.4
Manual work with mastic asphalt	
Filling in, outdoors	15.0
Filling in, indoors	38.0
Transporting in a barrow, indoors	53.2
Transporting in a bucket, indoors	12.8
Smoothing, outdoors	8.2
Smoothing, indoors	35.9
Working with joint fillers	
Charging on the kettle	4.5
Pouring of hot filler	3.9
Production of bitumen sheeting	**4.3**
Roofing work	
Torching of bitumen sheeting	8.8
Pouring of hot bitumen, outdoors	9.9

This connection makes it interesting that there is a variation in the proportion of fume to aerosol with increased laying temperature (see Figure 1). By means of Figure 1, an explanation can be given for the U.S. threshold limit of 0.5 mg/m³ being only conditionally comparable with the German limit. On no account is the U.S. threshold limit 20 times more severe than the current German limit of 10 mg/m³. Whereas the German threshold limit covers 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 U.S. limit relates only to the aerosol fraction.

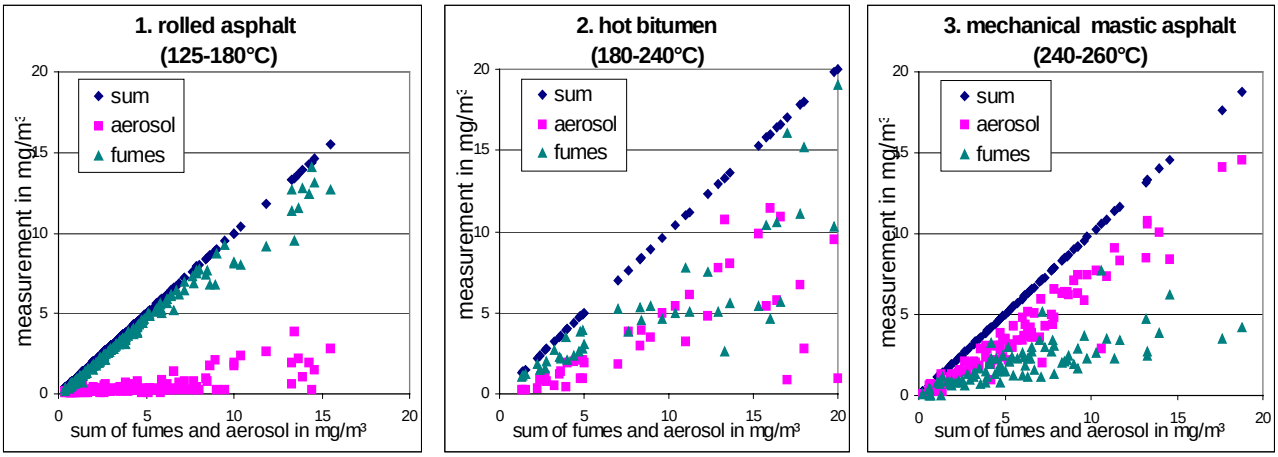


Figure 1: Comparison of the proportions of fumes and aerosol concentrations from hot bitumen. 1. Working with rolled asphalt in road paving. 2. Working with hot bitumen in pouring process. 3. Mechanical working with mastic asphalt in road paving. The diagram shows only values up to 20 mg/m³ in the cited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

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 United States for monitoring workplace air. As Figure 1 shows, at this temperature the emissions are primarily fumes. This figure also illustrates that the aerosol concentrations for rolled asphalt and heat sealing of bitumen sheeting are in many instances at or below the detection limit. Table 3 listed limit values for fumes and/or aerosols from bitumen in different countries. Figure 2 shows the results of parallel measurements with the U.S. and German procedure.

Table 3: Limit values in different countries

Denmark (file://DI/Verordnung/LGW-AUS/DK-a.htm); Bitumenrog (2000)	1 mg/m³
Finland (www.occuphealth.fi/ttl/projekti/htp/english/m-p_eng.htm)	
Organic dust (also for bitumen fumes)	5 mg/m³ (15 min-value 10 mg/m³)
Germany; fume and aerosols from hot bitumen	10 mg/m³
Great Britain, 8052-42-4 Asphalt, petroleum fumes	5 mg/m³ (15 min-value 10 mg/m³)
Spain (www.mtas.es/insht/practice/vla1.htm), 8052-42-4 Asfalto (petróleo) humos	5 mg/m³
Netherland, 8052-42-4 Asphaltrook (bitumineus)	5 mg/m³
Norway (www.lovdata.no/rsk/dat/at-361.html); 8052-42-4 Asfalt (royk)	5mg/m³
United States of America; Benzol soluble part of aerosols from bitumen	0.5 mg/m³

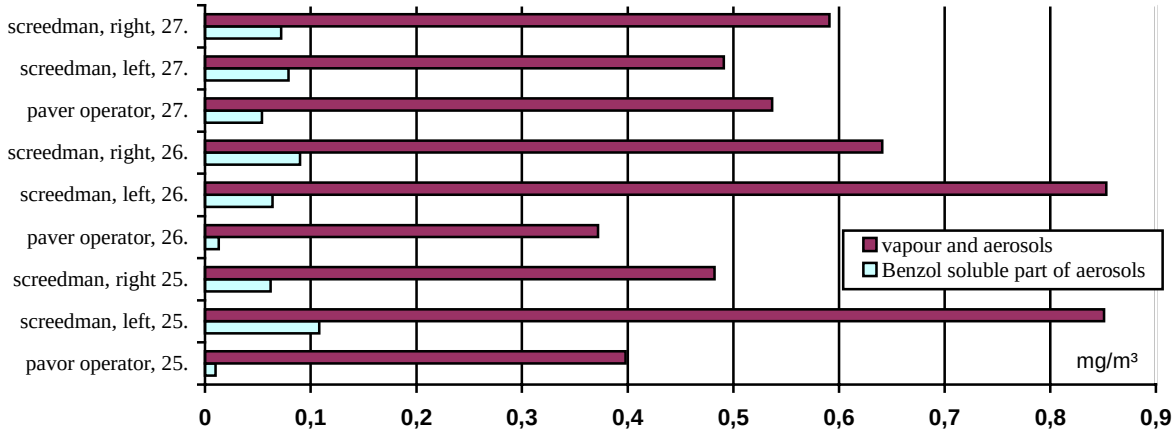


Figure 2: Measurements comparing the United States (benzol soluble part of aerosols) and the German procedure (fumes and aerosols) (asphalt temperature 160°C; Shell, 1999)

4. POLYCYCLIC AROMATIC HYDROCARBONS IN BITUMEN

Because the debate about possible hazards from fumes and aerosols emitted when working with hot bitumen is concentrated on the small quantities of polycyclic aromatic hydrocarbons (PAH) that bitumen contains, the concentrations of these substances were also determined.

The results of the study to determine the major constituents of bitumens used in Germany (Tables 4 and 5; Knecht et al., 1999) clearly show that there are considerable differences in the content of the PAH main constituent, Benzo[a]pyrene (BaP). However in bitumens from petroleum the content is approximately 2 mg/kg, and in tars from coal, it is approximately 5 g/kg, i.e. a factor of 2500 times greater.

The content of BaP in bitumen is maximum 2 mg/kg - 3 mg/kg, which clearly is well under the 50 mg/kg limit, which, according to the German Hazardous Substances Regulation, classifies substances as carcinogenic.

Table 4: Average content of BaP and PAH (see Table 5; Knecht et al., 1999)

Bitumen type	HB 90/100	B 45	B 65	B 80	B 200	85/25	95/35
B[a]P (mg/kg)	1.20	2.08	1.71	1.41	1.78	1.68	2.74
Σ PAH (mg/kg)	29.96	29.77	26.74	25.54	32.13	52.16	93.55

Moreover, from an occupational health and safety perspective, the content of PAH or rather BaP is less important than the quantity released while working with the material. In the earlier standard practice of using tar as the binding agent in rolled asphalt, up to 50µg/m³ BaP was released [HVBG, 1999]. Using very sensitive measuring systems, BaP maximum concentrations of only 0.1µg/m³ could be determined for work with rolled asphalt. For workers exposed to the highest levels, those working with mastic asphalt, 0.51µg/m³ was measured in an extreme case.

Table 5: PAH and sulphur-PAH in bitumen, determined by Knecht et al. (1999)

2-ring systems
- Naphthalene
- Acenaphthene
- Benzothiophene

3-ring systems
- Anthracene
- Dibenzothiophene
- Fluorene
- Phenanthrene

4-ring systems
- Benz[a]anthracene
- Benzo[b]naphtho-[2,1-d]-thiophene
- Fluoranthene
- Chrysene
- Pyrene

5-ring systems
- Benzo[a]pyrene (BaP)
- Benzo[e]pyrene
- Benzo[b + k]fluoranthene
- Dibenz[a,h]anthracene

6-ring systems
- Benzo[g,h,i]perylene
- Indeno[1,2,3-cd]pyrene

Even with milling of bituminous materials, the BaP concentrations in dust are markedly lower than those determined by the removal of substances containing tar (e.g. tar adhesive). When milling of mastic asphalt using diesel vehicles, a concentration of 0.099µg/m³ BaP was determined. On the other hand, 50µg/m³ to more than 100µg/m³ BaP was measured by the manual removal of tar-based parquet adhesive.

Overall, it can be maintained that with the current use of bituminous materials the PAH exposure is several magnitude levels lower than that with the earlier use of tar.

5. INHALATION STUDIES

The Fraunhofer Institute for Toxicology and Aerosol Research, Drug Research and Clinical Inhalation (ITA; www.item.fraunhofer.de) in Hanover has been commissioned to conduct a long-term study on the carcinogenic potential of fumes and aerosols from bitumen inhalation exposure. This study consists of a two-year exposure of experimental animals (rats) to three different concentrations of fumes and aerosols from bitumen. The test atmosphere is similar to that of a typical workplace. The chemical composition is used as a criterion for comparing the test atmosphere with typical fume exposures at workplaces. Special emphasis is placed on PAHs with high boiling points. The toxicological assessment will be based on the measurements of relevant biological endpoints effects [Fuhst et al., 2001].

The study is divided into three phases: 1) technical study; 2) 90-day subchronic study; and 3) final inhalation carcinogenicity study which lasts 24 months. The technical study, which has been completed, was designed to develop and validate a fume generation method. In summary, fumes existing in large-scale heated storage tanks was first sampled and passed through a condenser. Next, the collected fume condensate is re-aerosolized in an evaporation condensation generator. This method is particular suitable for the final inhalation study because the particle sizes can be controlled and the exposure concentrations varied. The inhalation exposure atmosphere created is thus similar to that of humans.

The 90-day subchronic study, in which the final doses were determined, has also been completed, and the long-term 24months study started in April of 2003.

6. HUMAN SKIN EXPOSURE STUDIES

Through human experimental trials in a test chamber, the impact of dermal resorption following exposure to aerosols and fumes from bitumen has been investigated. Commercial B65 bitumen was used for generation of the bitumen emissions. The air sampling and analysis separately recorded the aerosol and fume emission components as well as the PAH contained in these. Ten lightly-clad nonsmoking males were exposed to bitumen fumes for 8 hours; eight men had fresh air respirators, the other two where without fresh air respirators. Quantifying the dermal or the combined inhalation/dermal resorption was based on bio-monitoring the PAH-metabolites of pyrene, chrysene and phenanthrene in urine.

The measured bitumen emissions were, on average, 20.4 mg/m³ with a fume component content of approximately 88 percent. In the case of the two dermal or rather inhalation/dermal test subjects the sole dermal resorption amounted to approximately 57 percent for pyrene and chrysene and approximately 50 percent for phenanthrene [Knecht et al., 2001].

7. EXAMINATION OF EMPLOYEES WORKING WITH MASTIC ASPHALT

Determent of the new threshold limit value for employees working with mastic asphalt by AGS was under the proviso of the BITUMEN Forum providing highly focused occupational health care for these workers. A systematic examination of persons working with mastic asphalt, which includes monitoring the respiratory system or skin within the framework of occupational health care is currently being carried out.

A double track approach is being used to answer the question, “Are there objective criteria for illnesses, problems or adverse effects of the respiratory organs, which are connected with working with mastic asphalt?” In the one approach, an attempt is being made, with help of the associations, for the majority of German employees working with mastic asphalt to undergo medical examinations by the specific trade occupational health service. In the other approach, special far-reaching examinations are being carried out on 300 exposed persons and a unexposed control group.

To gather comprehensive information, doctors register the participant for examination with an anonymous standardized questionnaire. The questionnaire contains the scope of the exposed activity; a brief medical history of problems and previous illnesses; the occupational health assessment of the examining doctor with regard to bitumen fumes and lung diseases or problems; and the smoking habits of the employee. A systematic evaluation will be possible with a corresponding control group whose examination has also begun.

In a second section, 300 persons working with mastic asphalt and 150 control persons will be examined before and after a shift by the Berufsgenossenschaftliches Forschungsinstitut für Arbeitsmedizin (BGFA, BG Research Institute for Occupational Medicine; www.bgfa.ruhr-uni-bochum.de).

With this study, possible chemical irritative effects on the respiratory system and genotoxic effects from mastic asphalt fumes and aerosols when working with hot bitumen will be clarified. A detailed, specific and standardized questionnaire related to work activities and illnesses has been developed and will be used in this study. Before and after work (pre-shift and post-shift) lung function parameters of the employees flank the examination. In addition, at both times, collection of nasal lavage fluids and sputum, as well as blood samples, will determine the possible airway inflammation of the lower and upper airways and genotoxic effects induced by components of mastic-asphalt aerosols. For the genotoxic effects, two parameters (DNA strand breaks and DNA adducts) will be studied in blood samples. For

inflammatory and/or chemical-irritative effects the cellular composition and the concentration of soluble mediators of the nasal lavage fluid and sputum samples will be determined. In addition, single nucleoside polymorphisms of polymorphic enzymes involved in the metabolism of polycyclic aromatic acids will be examined.

Furthermore, the biological monitoring of urine samples will be studied for 1-OH-Pyren, 1-OH-, 2+9-OH-, 3-OH-, 4-OH- and ΣOH-phenanthrene and 6-OH-chrysen with consideration to a specific ambient monitoring.

For determination of the doses and composition of the bitumen exposure atmospheres harmonized tuning was done with the inhalation study of the Fraunhofer ITA.

8. LOW TEMPERATUR ASPHALT

The fundamental reasons for the Hazardous Substances Committee temporarily tolerating the relative high exposure of the mastic asphalt workers were its commitments to provide special intensive care for these employees and the expectation that, in the foreseeable future, marked reductions in exposure for this work are to be achieved.

The activities of the Arbeitskreis Temperaturabsenkung (AKTA; Temperature Reduction Working Group) of the Research Association for Roads and Transport (www.fgsv.de) are of tremendous significance. AKTA is endeavouring to reduce the asphalt laying temperature resulting in energy savings, a reduction in CO_2 output and lowering of emissions. Low temperature asphalt is therefore the ideal route for occupational safety and health. Low temperature asphalt may be produced in different ways. Thus not only one technology will be promoted, but there will be a market-driven competition of several successful competing technologies.

One technique, based on the addition of zeolithes, which contain chemically bonded water and lower the mixing and laying temperature, is also promoted by the Federal Department of the Environment in Germany ('Mixing and laying of low temperature asphalt in comparison with asphalt at normal temperatures'). The zeolithes are the same as used in large quantities as substitutes for phosphate in washing powder. Zeolithes release steam at temperatures between 100°C to 200°C. This leads to a foaming effect, which improves asphalt's pliability. By this way, rolled asphalt may be laid at considerably lower temperatures (about 30°C) as usual. Measurements with laying operations show exposures partly well below 5 mg/m³ for finisher operators and heated blade (screed) operators (without use of engineering controls on the finishers) [Barthel, 2001].

Other ways to lower the laying temperature are based on admitting organic substances like amid-waxes or paraffins. These methods may be used for rolled asphalt as well as for mastic asphalt. With that, mastic asphalt may be processed at temperatures below 210°C.

These temperatures lead to a very significant exposure reduction for the employees, especially for mastic asphalt (Figure 3), to an extent which seemed to be impossible a few years ago. Even if the German limit value is only empirically founded - there being no statement about the associated health hazard - it is very significant that with the use of low temperature asphalt laying, the exposure of the mastic asphalt workers is then reduced to the same order of magnitude as for all other bitumen workers.

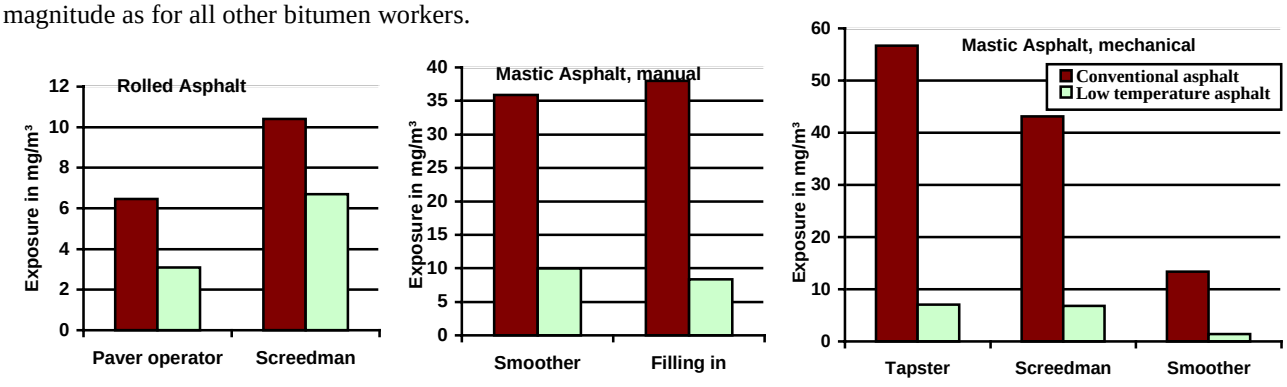


Figure 3: Exposure to fumes and aerosols from bitumen by laying normal and low temperature asphalt

Lower mixing temperatures mean less stress for the mixing plant and lead to less ageing of the bitumen. Energy requirement reduces about 30% when the mixing temperature is decreased by about 30°C or 35°C. For a mixing plant normally needing 8 litres fuel oil per tonne asphalt it achieves a reduction of 2.4 litres per tonne. In view of an asphalt production of 63 million tonnes in Germany, there results an overall reduction potential of 150 million litres fuel oil yearly.

With that there is an enormous potential to reduce CO_2-emissions. The production of 63 million tonnes of asphalt in Germany leads a formation of 1.6 million tonnes of CO_2. Low temperature asphalt would lead to 400,000 tonnes less CO_2. [Barthel, 2001].

On construction sites with low temperature asphalt laying there is no 'blue smoke' any longer, nevertheless the asphalt product achieves at least the same finished quality. Low temperature asphalt has better utilisation characteristics [Damm, 2003], and for mastic asphalt, durability is increased up to 60% [Schellenberg, 2003].

Moreover, there are additional reasons for using low temperature asphalt, e.g.

- Low temperature asphalt has been used on two highway-bridges near Cologne (1997 and 2001), because the temperature sensitive coating of the steel bridges did not allow higher working temperatures.
- The landing runway of Frankfurt airport is being replaced. In 300 nights between 22:30 and 6:00 short sectors of the landing strip will be broken off and replaced by new asphalt in 60 cm thickness. Since aeroplanes must be able to take off and land from 6:00 again, the asphalt must not exceed a temperature of 80°C at that time. This can only be achieved using low temperature asphalt (www.kirchhoff-heine.de/aktuelles/Fraport/Seiten/Fraport1.html)

The urgent task of BITUMEN Forum is at present the promotion of the low temperature asphalt. Thus, reduced temperature asphalt laying is not only the ideal way for safety at work, but it is also the key innovation for the laying of rolled asphalt and mastic asphalt. The BITUMEN Forum promotes utilisation of low temperature asphalt mainly by disseminating corresponding information and by performing air monitoring on the construction sites. For example the level of exposure has now been measured for employees laying low temperature asphalt in France (Figure 4).

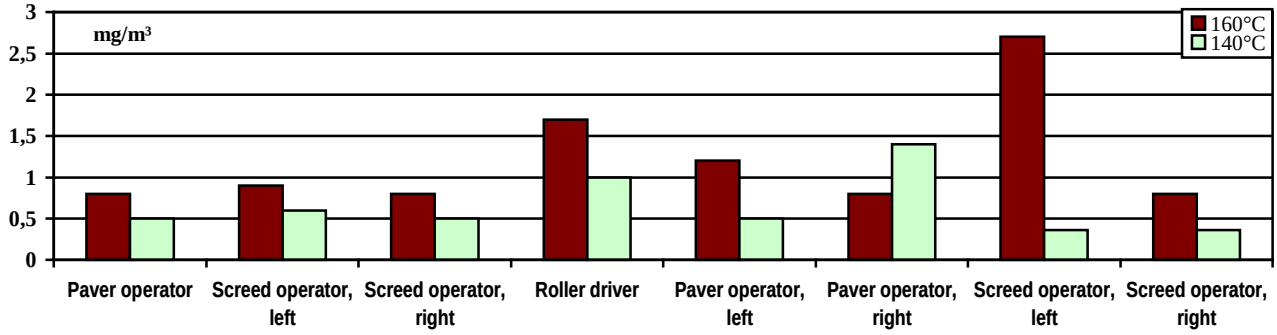
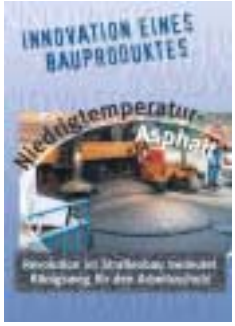


Figure 4: Comparison of exposure to fumes and aerosols from bitumen by laying normal and low temperature asphalt at a construction site in France

In August 2002 there was a visit of a delegation of the American National Asphalt Paving Association (NAPA) and the American National Institute of Occupational Safety and Health (NIOSH) to Germany. They wanted to get information about low temperature asphalt laying from members of the German asphalt association and the BITUMEN Forum. On a return invitation of NAPA, members of the BITUMEN Forum reported about the state of the art concerning low temperature asphalt at the 48th general meeting of NAPA in San Diego in January 2003 [Cervarich, 2003], (www.fhwa.dot.gov/pavement/wma.htm).

Low temperature asphalt is the ideal way to protect the employees working with hot asphalt not only from the point of view of health and safety at work. Through developing low temperature asphalt, the asphalt industry expects to achieve

- less fumes and aerosols at the laying process;
- less emissions on the mixing plant;
- reduced energy consumption;
- reduction of CO_2 formation;
- less wear of the plant;
- hardly any ageing of the binder;
- improved product utilisation characteristics.



The industry has developed the technology, now the customers have to enable its implementation, even if low temperature asphalt has yet not become definitive part of the road specification. It is up to the customers now, especially the road construction authorities, to make the necessary practical applications possible for the new technologies.

The BITUMEN Forum was distinguished 2003 for the promotion of the low temperature Asphalt with the Good Practice Award of the European Agency for Safety and Health at Work (http://agency.osha.eu.int). The forum informs with a folding sheet over the Good Practice Award and low temperature asphalt.

9. CLASSIFICATION OF BITUMEN

In the mid 1990s there was a contentious debate about a classifying bitumen as a suspected carcinogen. This debate was surprising because bitumen had, in fact, many years previously been classified as a suspected carcinogen. From a labor inspector's point of view, classification as a suspected carcinogen (C3) is, in any case, of little consequence. In principle, the same precautions are stipulated for a material that is not suspected of being carcinogenic. Frustration in the debates occured because definitive studies did not refute the suspicion of causing cancer – while the one incriminating study was originally not disputed. In the study, prepared condensates of fumes and aerosols from American bitumen at 232°C and 316°C, respectively, were dissolved in solvent and over a long period brushed onto the shaved skin of laboratory animals. As a result, isolated carcinomas formed on the animal skin. However, it is now accepted that such condensates no longer correspond to current developments in technology. The National Institute for Occupational Safety and Health (NIOSH) in the United States, which had carried out this work, now makes a clear distinction and considers that the results from then are no longer generally applicable to current bitumen [NIOSH, 2000].

Initiated by the BITUMEN Forum, the Bitumen Industries study group has finally commissioned an animal study to help clarify the situation by using a common bitumen species. The fumes and aerosols from bitumen used in hot processing and not the bitumen itself are to be assessed. The Fraunhofer ITA has already completed the fume-generation and validation study. In this study, enough condensate was sampled to conduct a 90-day inhalation study with experimental animals, which has also been completed. The results of this study form the basis for the final decisive 24 month study, which started in april of 2003.

In addition to the histopathological examinations, one main part of the Fraunhofer ITA study consists in analyzing blood and lung cells of the exposed rats. The results of these analyses will then be used for an extrapolation with human biological endpoints that were prepared by the BGFA. Hopefully, the results of such an extrapolation will form the scientific basis for specifications for bitumen exposure.

10. FUNDAMENTAL PRINCIPLES OF THE BITUMEN FORUM

Through the collaboration of all concerned associations and institutions in the BITUMEN Forum, the forum is an ideal industry regulator as it is now constituted to solve proposed specific occupational safety and health problems, not only in the area of hazardous substances [Rühl et al., 2002]. The advantage of this strategy is that all parties know what they are capable of and must take upon themselves. This can occur more purposefully in this type of industry regulator than when the government intervenes. However, industry regulator is not a competitor to the Hazardous Substances Committee (AGS), which has the last word in the area of hazardous substances. Sector-driven regulation will always be more effective than governmental interventions alone to ensure factory-floor compliance.

The BITUMEN Forum is not limited to a voluntary agreement within the industry as has repeatedly been promoted in recent years in the sphere of environmental politics. In a study by the Zentrums für Europäische Wirtschaftsforschung (ZEW; Research Centre for European Industrial Research) the following critical points about purely voluntary agreements were found [Bergman et al., 1996]:

- ☹ there are deficiencies in involvement of groups concerned
- ☹ the real objective is often watered down
- ☹ there is often a lack of control contingencies
- ☹ an offences against agreements in the voluntary pledge often remains without legal consequences
- ☹ often harsh economic instruments are shied away from
- ☹ there is frequently a lack of commitment and enforcement

A study on industry agreements [N.N., 1999] sponsored by the EU also comes to the conclusion that "with clever wording, the executives of several industrial sectors themselves can hold several back doors open." According to the authors of the study, faster results often are achieved with less rigid agreements than with tedious legal intentions.

The BITUMEN Forum has taken these findings into consideration by ensuring that:

- ☺ all groups concerned with a topic are included
- ☺ the objective of an improvement in the information position of bitumen is transparently and verifiably designated
- ☺ regular meetings of the forum ensure that undesirable trends are identified and immediately and collectively counteracted; studies will uncover possible deficiencies in the present classification or protective measures
- ☺ with the many institutions that support the industry regulator a withdrawal from the forum is more difficult because dealing with the adopted measures would then mean a greater effort for all others
- ☺ tough cost-intensive aspects, such as the financing of studies with several million dollars and considerable developments to reduce the laying temperature of asphalt are included
- ☺ the listed items are made mandatory through regular publications and reports to AGS.

AGS forms the institutional framework for the industry regulator. Much of the Forum's work is clearly acknowledged by AGS and the Ministry for Labour and Social Affairs through its reference in the TRGS 420 or in the justifications for threshold limits for fumes and aerosols from bitumen. Through the cited papers and, above all, the decision to be made by AGS on a possible reclassification of bitumen (after completion of the animal studies), there is a possibility to react immediately to any shortcomings of the industry regulator.

In addition to this adherance to the national standard, the appointment of dates and documentation of what was achieved with the possibility of showing any deficiencies as required in the ZEW study should be adopted in similar future strategies.

11. OUTLOOK

On the whole, the BITUMEN Forum is an excellent example on which future solutions to specific occupational safety and health problems can be modeled. As an alliance for occupational safety and health the forum shows the way for similar strategies with other issues. From this aspect, the implementation of the adopted measures will also, because of the collaboration of the many institutions involved, certainly lead to success.

The most important part of the work of the BITUMEN Forum is in the future the promotion of the low temperature asphalt.

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