

Ewa Szpakowska Kozikowska

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Wojciech Mniszek

Wyższa Szkoła Zarządzania Ochroną Pracy w Katowicach
Katedra Inżynierii Środowiska i Higieny Pracy
ul. Bankowa 8, 40-007 Katowice

Exposure assessment of workers during road surface marking

**Ocena narażenia pracowników podczas
znakowania nawierzchni drogi**

Abstract

This article regards the descriptions of risks a worker experiences during road surface marking. In such undertakings there are several hazardous factors influencing the health of the workers. The main risks are the chemical substances and working within a traffic lane. Because of that a need for work environment examination, knowledge of material safety data sheets (MSDSs) of used chemicals and maximum allowable concentrations of substances used during marking arises. This article also describes risk prevention measures for both the risks above and those caused by working in moving traffic.

Keywords: *risks and hazards for road workers, road surface marking, measurements of harmful substances*

Streszczenie

W artykule opisano zagrożenia pracowników podczas znakowania nawierzchni dróg. W takich pracach istnieje kilka niebezpiecznych czynników wpływających na zdrowie pracowników. Główne czynniki narażenia to substancje chemiczne i praca w czynnym pasie ruchu. W związku z tym istnieje konieczność pomiarów czynników niebezpiecznych w tym środowisku pracy, znajomość kart charakterystyki i danych

dotyczących bezpieczeństwa dla stosowanych substancji chemicznych oraz najwyższych dopuszczalnych stężeń substancji używanych podczas znakowania dróg. W tym artykule opisano również środki zapobiegania ryzyku dla obu powyższych zagrożeń.

Słowa kluczowe: *zagrożenia dla pracowników drogowych, znakowanie powierzchni dróg, pomiary substancji niebezpiecznych*

Introduction

Due to a quick development of road infrastructure in Poland a need for road surface marking increases. This process comprises of a use of paints and pulps, which are applied on the road surface, either manually or with a use of hardware. The composition of the used materials includes different chemical compounds, which may pose a serious threat to a worker. Other than the chemical hazards, UV radiation, microclimate or risks associated with working in moving traffic cannot be overlooked as a health risk. Risk assessment of workers on this post has to include all of these factors collectively. If it is done solidly, it forms a base to implement prevention measures which will improve working conditions on this post.

The purpose of this article is to present the technologies used by one of the Lower-Silesian companies working in the road surface marking industry. It also describes hazards which are faced by the workers and it demonstrates the preventive measures for the aforementioned hazards.

1. Road surface marking technology

Depending on the material used, road surface marking uses different kinds of application:

- thin layer application – spray-on, air based or airless for solvent-based paints, water-based paints, two-part paints and hot spray-on pulps,
- thick layer application – extrusion method used both with two-parts cold pulps (chemically hardening) as well as thermoplastic pulps (hot).

Thin layer marking.

Thin layer marking technology uses one part acrylic solvent-based paints, with solvent content up to about 25%. It is the most popular and most widely used technology in our country. The applied layer of paint dries due to evaporation of the solvents it contains. Thickness of such a marking cannot exceed 0.8 mm, according to Detailed Technical Conditions for Road Surface Marking [1]. In order to achieve a light reflecting effect, the paint coating is covered with a specific glass granulate, so called microspheres.

Thick layer marking.

Thick layer marking technology uses materials that provide the ability to apply a coating of a thickness between 0.9 to 5 mm. In comparison to the thin layer

technology, it has a significantly greater durability and a better visibility, especially in the difficult weather conditions, such as rain, fog, etc. Chemically hardened marking can use chemically hardening two-parts pulps – the pulp and hardener mixed in 98:2 proportions – or chemically hardening two- or three-based paints mixed with a hardener in 98:2 or 1:1 proportions respectively [1]. Chemically hardening marking is characterised by longevity of the coating whilst comprising with the demanded parameters. It is mainly used in areas with a high level of traffic and areas where the life expectancy is the highest – pedestrian crossing, stop lines, give way lines, indication of traffic lanes, etc.

Both thin and thick layer marking is only possible in specified weather conditions. It is not allowed during precipitation, temperatures below 5°C or above 30°C at humidity not exceeding 85%.

Road surface marking and traffic signage workers perform their duties on roads and lanes of different purpose and type across the whole country. Occasionally, the work is undertaken on car parks. They work on open air, in variable weather conditions. Accordingly to the type of materials (paints) used, the borderline temperatures in which the work can be done are 0°C-36°C.

The task is performed in two or three man crews (e.g. marker operator – supervisor and one or two supporting workers).

A description of typical activities on the job site is as below:

- placement of traffic cones on the road that is to be marked,
- clearing of the asphalt surface using a brush,
- marking out/layout,
- preparing of templates in case of manual marking,
- paint application, either mechanically or manually,
- scraping,
- finishing works (cleaning of tools and templates using machine cleaning fluid).

Figure 1 below shows a typical mechanical marker during road surface marking.



Fig. 1. Markings are mechanically applied on the road [author's photograph].

Rys. 1 Mechaniczne znakowanie stosowane na drogach [zdjęcie własne]

Exposure time to harmful agents is typically 5/6 hours per day. The remaining time constitutes of a commute to and from the job site, preparation works, finishing works and breaks.

Because of the fact that the work is undertaken on open air, the worker stays in a naturally ventilated environment.

2. Risks present and their sources

Occupational risk assessment is a process of identifying factors posing a hazard to workers' health as well as of analysing work conditions when exposed to those hazards. It is a continuing process and its main objective is to thoroughly explore the characteristics of the hazardous agents capable of causing damage and to undertake appropriate precautions to minimise the risk.

Chemical substances present at workplace form a group of hazardous agents that are constantly linked to a specific occupational risk.

An analysis of the ingredients of the materials used when marking a road surface allows determining that potential chemical agents posing a threat to workers health are as follows: toluene, xylene, acetone, ethyl acetate, butyl acetate, butan-2-one, butyl acrylate, methyl methacrylate, naphtha. Based on the evidence gathered (mainly information from material safety data sheets) regarding the chemical agents, the conclusion is that a worker is exposed to different levels of irritation of airways, eyes, skin and central nervous system.

Other than chemical agents present at the workplace, the worker is also exposed to: microclimate, natural UV radiation, hot pulp burns, overtime due to a need to finish a job within a specified (often too short) timeframe, unpredictable behaviour of road users during the process of road surface marking (i.e. violence, partial/complete damage to the work done).

Solar radiation has a beneficial influence on human health; however in case of an overly high intensity it becomes harmful. Ultraviolet (UV) radiation, which is a part of the sunlight spectrum, can be particularly dangerous. Ultraviolet radiation affects the external body parts, i.e. skin and eyes.

UV excess leads to a premature skin ageing, precancerous and cancerous skin conditions, keratitis and conjunctivitis, clouding of eye lens (cataract) and weakening of the immune system, which leads to increased possibility of becoming ill [2].

A person can work in a broad, although limited, surrounding temperature spectrum. Work done in microclimate conditions that are outside a specified spectrum is linked to a risk of health damage, lowering of physical and psychological performance, as well as work efficiency.

Road surface marking process is undertaken in positive temperatures; hence employees on such posts are exposed to environmental heat. This, in turn, may lead to: heatstroke, heat exhaustion caused by dehydration and desalination due to perspiration, which results in overall weakening, headaches and nausea. Road surface marking worker performs most of his tasks on public roads, both urban and rural. These roads are usually open and with moving traffic. Because of that the worker is at

risk of: getting hit and getting run over, which can lead to different kinds of injuries, ranging from cuts and bruises, through broken bones and in extreme cases may result in death.

3. Preventive actions

An employer of workers manning the said posts has to provide the employee with an occupational risk assessment, MSDSs of all chemicals used, chemical agents measurements on such posts and to inform the road surface worker about any preventive measures available.

By looking on the MSDSs provided, the conclusion is that a worker is subjected to different harmful substances. Along others, a type of a chemical agent and any hazards caused by its presence in the workers environment can be found in those sheets.

The analysis of the MSDSs used on posts raises a need to assess the exposure of workers to harmful effects of the ingredients of paints, diluters, hardeners and solvents that are commonly used.

In order to assess said exposure, concentration measurements are taken for the substances present in the air. Based on the results, exposure indicators can be calculated and then compared to a value of the maximum allowable concentrations (MAC), maximum allowable instantaneous concentrations (MAIC) given in a corresponding regulation.

Results of those measurements are shown in tables 1-4 below.

The measurements were conducted by the accredited Environmental Measurement Laboratory EKOlogis in Wrocław. Measurement location was on open air work post. An individual type of measurement was chosen and direct method of measurement was used.

The measurements were done in two rounds. Xylene, butyl acetate, butan-2-one, butyl acrylate, methyl methacrylate, naphtha done on 26/03/2010 (Table 1) and 05/07/2011 (Table 3) and toluene, acetone, ethyl acetate and butan-2-one on 27/04/2010 (Table 2) and 13-14/05/2011 (Table 4).

Table 1. The measurements and exposure assessments

Tabela 1. Wyniki pomiarów i ocen narażenia

No.	Chemical agent	Exposure indicator [mg/m ³]	MAC [mg/m ³]	MAIC [mg/m ³]	MAC multiple
1.	Xylene – isomers mixture^A (1,2-; 1,3-; 1,4-) CAS [95-47-6; 108-38-3; 106-42-3; 1300-20-7]	0,36 (±0,007)*	100	No standard available	0,00
2.	Butyl acetate CAS [123-86-4]	0,31 (±0,007)*	200	950	0,00
3.	Butyl acrylate^{BA} CAS [141-32-2]	0,24 (-)*	11	30	0,02
4.	Methyl methacrylate^{BA} CAS [80-62-6]	0,31 (-)*	100	300	0,00
5.	Butan-2-one* CAS [78-93-3]	0,73 (±0,11)*	450	900	0,00
6.	Naphtha* CAS [8008-20-6]	4,58 (±0,83)*	100	300	0,05

Where (the symbols refer to tables 1-4):

- (*) - a number in the brackets is an extended uncertainty calculated for expansion coefficient $k=2$, which correlates with a confidence level of 95%
- Exposure indicator - this is a weighted average exposure indicator for all measurements done throughout the day
- MAC - maximum allowable concentrations
- MAIC - maximum allowable instantaneous concentrations
- # - measurements marked with this symbol were conducted by the subcontractor EKO-Serwis Research Plant

Table 2. The measurements and exposure assessments

Tabela 2. Wyniki pomiarów i ocen narażenia

No.	Chemical agent	Exposure indicator [mg/m ³]	MAC [mg/m ³]	MAIC [mg/m ³]	MAC multiple
1.	Xylene – isomers mixture ^A (1,2-; 1,3-; 1,4-) CAS [95-47-6; 108-38-3; 106-42-3; 1300-20-7]	1,74(±0,38)*	100	No standard available	0,02
2.	Butyl acetate ^A CAS [123-86-4]	1,07 (±0,25)*	200	950	0,01
3.	Butyl acrylate ^{BA} CAS [141-32-2]	1,38 (-)*	11	30	0,13
4.	Methyl methacrylate ^{BA} CAS [80-62-6]	0,79 (-)*	100	300	0,01
5.	Butan-2-one ^A CAS [78-93-3]	1,17 (±0,27)*	450	900	0,00
6.	Naphtha ^{BA} CAS [8008-20-6]	10,85 (-)*	100	300	0,11

Table 3. The measurements and exposure assessments

Tabela 3. Wyniki pomiarów i ocen narażenia

No.	Chemical agent	Exposure indicator [mg/m ³]	MAC [mg/m ³]	MAIC [mg/m ³]	MAC multiple
1.	Acetone ^A CAS [67-64-1]	1,77 (±0,39)*	600	1800	0,00
2.	Ethyl acetate ^A CAS [141-78-6]	0,73 (±0,16)*	200	600	0,00
3.	Toluene ^A CAS [108-88-3]	4,26 (±0,91)*	100	200	0,04
4.	Butan-2-one * CAS [78-93-3]	0,07 (±0,01)*	450	900	0,00

Table 4. The measurements and exposure assessments

Tabela 4. Wyniki pomiarów i ocen narażenia

No.	Chemical agent	Exposure indicator [mg/m ³]	MAC [mg/m ³]	MAIC [mg/m ³]	MAC multiple
1.	Acetone ^A CAS [67-64-1]	1,77 (±0,39)*	600	1800	0,00
2.	Ethyl acetate ^A CAS [141-78-6]	0,73 (±0,16)*	200	600	0,00
3.	Toluene ^A CAS [108-88-3]	4,26 (±0,91)*	100	200	0,04
4.	Butan-2-one * CAS [78-93-3]	0,07 (±0,01)*	450	900	0,00

According to the measurements done in 2010, the MAC values were not exceeded on the day the measurements took place.

The employer repeated the concentration measurements a year after the first analysis.

The results have shown that the measurements undertaken a year after did not exceed the maximum allowable concentrations.

4. Personal protective equipment (PPE) on a given post

The protection against the harmful effects of chemical agents on road surface marking post starts with conveying information about the presence of said chemicals in the work environment.

Alongside a risk assessment (a protocol) an employee is familiarized with MSDSs of used substances. These are the sources of information about the protective measures applied to this kind of work. The highlights of those are available in Table 5 below.

Table 5. Personal protective equipment for road workers [3]

Tabela 5. Ochrony osobiste pracowników drogowych [3].

No.	Name of the substance	PPE
1.	LINER HS WHITE	Protective clothing made of antistatic, infusible materials in case of a fire; Protective gloves , class 2 chemically resistant (in case of a prolonged and repeated contact class 6 protection gloves); Chemically resistant goggles with acetate glasses, anti-fog
2.	LINER HS YELLOW	SAB
3.	LINER HS RED	SAB
4.	LINER HS BLACK	SAB
5.	WPZ 11 Road surface marking paint diluter	SAB
6.	PLASTMAL WHITE	SAB (caoutchouc butyl gloves are recommended)
7.	PLASTMAL RED	SAB (caoutchouc butyl gloves are recommended)
8.	Plastmal hardener	SAB (caoutchouc butyl or PVC gloves are recommended)
9.	NAVIGATOR	SAB (caoutchouc nitrile gloves are recommended)
10.	Road machines cleaning fluid / degreasing diluter	SAB (caoutchouc nitrile gloves are recommended); Half masks with complex combined filter (dust/organic vapors) class 2 (P2A2)
11.	NITRO Solvent	Protective clothing made of antistatic materials coated with viton; Neoprene shoes; Protective gloves made of polyvinyl alcohol; Goggles protecting from liquid drops; Type A gas filters with a mask or a half mask. When using do not eat or drink, avoid: inhalation of vapors and contact with liquids

For every worker within moving traffic it is absolutely vital that he is spotted early, especially when the lighting conditions, regardless if it is a public or private road, are poor.

High visibility clothing serves a purpose of visually signalling the presence of its user in a place and situation that can potentially create a health or life threats. This signalling has to be effective at any time of a day and night, in darkness – with light coming from vehicles, torches or spotlights, as well as street lights, i.e. on urban roads.

Reflective material used in clothing appropriate for a road surface marking enables early noticing of people at dusk and in darkness, which protects them from serious accidents. Application of reflective material on PPE makes the user more visible, therefore safer.

Due to working in a moving traffic lane a work area has to be set out and marked. If the formal conditions (approval of the owner of the road) allow it, the section of the road that undergoes works should be closed off. If it is not possible, a section of the road should be enclosed so that the worker within is not exposed to any danger caused by others using the reworked road – traffic cones and a warning car are used for this.

5. Conclusion

A worker is exposed to multiple factors causing a hazard to his life and health when in a work environment.

Road surface marking worker undertakes his work in an open air, on sections spanning over several miles, often in rural areas. A situation when worker is simultaneously exposed to hazardous both chemical and physical factors may occur. Psychosocial factors such as stress due to working on tight deadlines, working in a direct neighbourhood of a moving traffic lane shouldn't be ignored.

Based on the analysis of chemical agents conducted above, it is clear that the maximum allowable concentrations of substances were not exceeded. It is mainly due to the natural ventilation in which the worker is, as well as the limited exposure time of about 5-6 hours per workday.

For all the chemical agents the employer put appropriate personal protection equipment in place. The workers have special protective gloves, masks protecting respiratory system, visors covering eyes and aprons, which protect from the hot thermoplastic pulp.

The worker is also exposed (beside the chemical agents) to the natural UV radiation (physical factor), which is minimised with the use of work clothing (trousers and a long-sleeved shirt) and use of headgear (a baseball cap).

The microclimate conditions measurements (WBGT values) by which the worker is surrounded during road surface marking were not undertaken. However, based on the analysis of accidents and conversations with the workers it is clear that the level of acclimatisation to these working conditions is sufficient to avoid any health defects. The workers are wearing a light shirt, trousers and have a constant access to drinking water.

Because of the traffic related hazards caused by the work in a moving traffic lane, the workers set out a working zone by closing off the section of traffic or marking it appropriately, which should prevent any possible risks.

The employer has to inform his employees about health and safety risks caused by the chemical agents. This can be done with training courses, familiarisation with MSDSs and risk assessment forms.

The workers are provided with appropriate PPE, which are:

- chemically resistant gloves,
- respiratory system protection measures,
- visors and aprons,
- high visibility clothing with reflective stripes.

In case of failure, a code of conduct is available.

The employer performs the concentrations of harmful chemicals measurements.

All workers undergo HSE trainings.

They also have to undergo health examinations, which are of a general nature. However, due to the exposure to the chemical agents on road surface marking posts, it is advised that the frequency of these examinations is increased to annual, with more focus on the respiratory system and skin. It can also be of use to add auxiliary tests, such as complete blood cell count and chest X-ray. These tests would allow a more thorough monitoring of the workers' exposure to the chemical agents present in a work environment.

LITERATURE

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