Effect of additive in spraying water of asphalt milling machine on the dust and quartz exposure of workers

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Abstract

Operators of asphalt milling machines are exposed to respirable quartz levels that frequently exceed the occupational exposure limit. A small scale field study was conducted in the Netherlands to determine the effect of a newly developed emission reduction system, on the exposure of the operators. This system reduces the emission of dust and quartz by spraying aerosolized water with an additive on the material. The results show that this new dust emission reduction system may reduce the respirable crystalline quartz concentration in the breathing zone of the operators to a level that is well below the Dutch occupational exposure limit of 75 µg/m^3. Further studies are recommended to clarify whether this holds for all milling and weather conditions that operators of asphalt milling machines may face throughout the year.

Keywords: emission reduction, crystalline silica, quartz, dust, milling of asphalt, road construction.

Introduction

Operators of asphalt milling machines, so called cold planers, are exposed to respirable crystalline quartz. This exposure frequently exceeds the occupational exposure limit and produces a silicosis hazard for exposed workers. Silicosis is a debilitating and sometimes fatal lung disease resulting from breathing microscopic particles of crystalline silica.
Previous attempts to reduce the quartz emission by applying local exhaust ventilation systems on the milling machines did not succeed in reducing the quartz exposure of the operators to an acceptable level (Arbouw, 2002). Recently, Geveke Zwaar Materieel BV in Amsterdam and Reproad BV in Lelystad have developed a new dust/quartz emission reduction system for various demolition applications. This system reduces the emission of dust and quartz by spraying aerosolized water containing an additive called 'Bitfoam', on the material during demolition. By applying the additive the emitted dust becomes sticky and aggregates. 'Bitfoam' contains ethoxylated alcohol (5-10%) and citrus oil (1-5%) and is non-hazardous.
A small-scaled field study was conducted among operators of an asphalt milling machine to determine the effect of spraying of aerosolized water, both with and without the additive, on dust and quartz exposure.

Methods

The measurements took place between September 2002 and December 2003 at 6 road (re)construction sites in The Netherlands: Amsterdam (2 sites), Assen, Helmond, Dokkum and Oud-Beijerland. In total, 15 personal air samples were collected during the milling of asphalt. The concentration of both respirable dust and respirable crystalline quartz was measured in the breathing zone of operators during the use of a milling machine equipped with: (i) only a cooling water system (standard procedure), (ii) a system of spraying water aerosol, and (iii) a system of spraying water aerosol with the additive Bitfoam. Both the driver on top of the milling machine, as the worker near the machine were sampled. Background concentrations, windward, were determined by stationary air monitoring on 2 of the 6 construction locations (in Dokkum and Oud-Beijerland).
All measurements took place with an asphalt milling machine produced by Bitelli, type SF202, machine number 687. This machine mills a 2 meter width strip of asphalt, with a maximum milling depth of 330 mm (see figure 1 and 2).

Figure 1. Asphalt milling machine (Bitelli SF202)

Figure 2. Asphalt milling machine equipped with new dust emission reduction system.

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The circumstances at the 6 road construction locations during measurements were registered and are presented in the appendix (table I). This included the driving speed of the cold planer (average speed: 6.2 m/min), the pressure of the machine (average of 177 bar), the milling depth (average of 8 cm), and the type of asphalt (surface layer, top layer and under layer). The average temperature during the 6 days of measurements was 8.9 °C (range: 5-17.5 °C). The average wind speed was 12.7 km/h (range: 7 – 22 km/h). On one of the six days there was a short period (less than 2 hours) of drizzle rain.
Sampling and analyses of the respirable dust samples took place according to MDHS 14/3 using a respirable dust cyclone (SKC, ∅ 25 mm) with a Mixed Cellulose Ester filter (Millipore, filter size ∅ 25 mm, pore size: 0.8 µm). The flow of the air sampling pumps was on average 2.1 L/min, the average sampling time was 254 min (range: 60 – 388 min, N=15). Respirable dust was determined by gravimetric analysis. Respirable quartz was analyzed with the infrared spectrophotometry technique according to NIOSH 7602. The detection limit of respirable dust was 0.05 mg/filter and of respirable quartz 0.1 µg/filter. Air sampling was done by an occupational hygienist. Analyses were conducted by the certified laboratory RPS Analyse in Ulvenhout, The Netherlands.

Results and Discussion

The respirable dust and quartz concentrations in the breathing zone of the milling machine operators are summarized in table 1 and figure 3. The results of the single measurements are presented in the appendix (table II). The background concentrations of respirable dust and quartz, measured at 2 locations, were low, on average 0.10 mg/m^3 and < 2 µg/m^3, respectively.

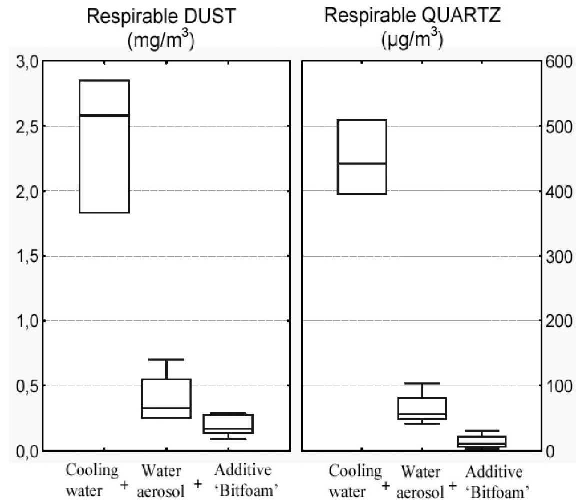

Figure 3. Box-plot (min-25%-median-75%-max) of the measured concentrations of respirable dust and crystalline quartz in the breathing zone of operators of a asphalt milling machine equipped with: (i) only a cooling water system (standard), (ii) a system of spraying water aerosol, and (iii) a system of spraying water aerosol with the additive Bitfoam.

Table 1. The concentration of respirable dust and crystalline quartz in breathing zone of operators of an asphalt milling machine.

Dust/quartz emission reduction system on asphalt milling machine	Concentration in breathing zone of asphalt millers (arithmetic mean, range): Respirable DUST (mg/m^3)		Respirable QUARTZ (µg/m^3)		Number of samples
Only cooling water	**2.4**	**(1.8-2.9)**	**449**	**(395-509)**	**3**
driver on machine	2.3	(1.8-2.9)	418	(395-442)	2
operator beside machine	2.6	-	509	-	1
Water aerosol	**0.40**	**(0.25-0.70)**	**65**	**(42-104)**	**4**
driver on machine	0.33	(0.25-0.40)	49	(42-57)	2
operator beside machine	0.48	(0.25-0.70)	80	(56-104)	2
Water aerosol with additive	**0.19**	**(0.09-0.29)**	**14**	**(4-30)**	**8**
driver on machine	0.26	(0.20-0.29)	20	(9-30)	4
operator beside machine	0.13	(0.09-0.14)	8	(4-12)	4

Background concentrations: respirable dust: 0.10 mg/m^3 (n=2) ; respirable quartz: < 2 µg/m^3 (n=2)

At the 2 construction sites where the operators used a standard asphalt milling machine (only using cooling water), we measured quartz exposure levels between 400 and 500 µg/m^3 (n=3). These concentrations are within the range of exposures reported in a review of silica exposure at constructions sites, including road construction (Flanagan et al., 2006), and within the range recently measured by the Berufsgenossenshaft (BG) Bau in Germany, using a standard comparable cold planer (not published, personal communication). However, these concentrations are about 4-fold higher than the concentrations reported by Arbouw (2002) while testing a standard asphalt milling machine of comparable size.
When spraying aerosolized water on the asphalt material during milling, we measured substantial lower quartz exposures ranging from 40 to 100 µg/m^3 (2 sites, n=4). On the days when the additive 'Bitfoam' was added to the aerosolized spraying water, quartz exposure levels in the breathing zone of the operations varied from about 4 to 30 µg/m^3 with an average of 14 µg/m^3 (3 sites; n=8). These quartz concentrations are about 4-fold lower than the concentrations measured by Arbouw (2002) during milling with a cold planer of comparable size equipped with an extensive local exhaust ventilation system. They reported an average quartz exposure level of 60 µg/m^3 (3 sites; n=27).

Conclusions

Despite the small scale of this field study (only 15 personal air samples were collected at 6 road construction sites), these results strongly indicate that the application of aerosolized water with the additive Bitfoam is a very promising method for the reduction of both dust and quartz emissions during asphalt milling. The results show that this new dust emission reduction system may reduce the respirable crystalline quartz concentration in the breathing zone of the operators to a level that is well below the Dutch occupational exposure limit of 75 µg/m³ (SZW, 2007)[1]. Further studies are recommended to clarify whether this holds for all milling and weather conditions that operators of asphalt milling machines may face throughout the year.

[1] In 2006, the 8 hour TWA threshold limit value for respirable crystalline silica (alpha quartz and cristobalite) in USA is lowered from 50 µg/m3 to 25 µg/m³ (ACGIH, 2006).

References

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Appendix

Table I. Circumstances during measurements

Location of road construction site	date	Milling conditions (Bitelli – type SF202)					Weather conditions		
		driving speed (m/min)	pressure of machine (bar)	milling depth (cm)	Milled surface (m²/day)	type of asphalt layer	wind speed (km/hour)	Temperature (°C)	Rain
Amsterdam	6-9-'02	5	180	5-15	5000	top layer	22	17.5	no
Assen	18-11-'02	5	200	2.5 to 6	6000	top layer	10	7.3	no
Helmond	25-11-'02	5	100	5 to 18	3000	top layer	9	6.9	no
Amsterdam	10-11-'03	5	200	6	3000	top layer	7	6.9	no
Dokkum	24-11-'03	5	180	9.5	1200	under layer	14	5	no
Oud-Beijerland	1-12-'03	12	200	6	2700	surface layer	14	9.8	Yes*

*drizzle rain (during 2 hrs)

Table II. Results of single measurements

Dust emission reduction system	*Location*	*date*	*function*	*respir. Dust (mg/m³)*	*respir. Quartz (µg/m³)*	*Quartz content in dust (%)*
only cooling water	Amsterdam	6-9-'02	driver	2.9	442	15.5
only cooling water	Helmond	25-11-'02	driver	1.8	395	21.6
only cooling water	Helmond	25-11-'02	operator beside machine	2.6	509	19.7
water aerosol	Assen	18-11-'02	driver	0.25	42	16.5
water aerosol	Assen	18-11-'02	operator beside machine	0.25	56	22.0
water aerosol	Helmond	25-11-'02	driver	0.40	57	14.3
water aerosol	Helmond	25-11-'02	operator beside machine	0.70	104	14.9
water aerosol *with* additive	Amsterdam	10-11-'03	driver	0.29	30	10.5
water aerosol *with* additive	Amsterdam	10-11-'03	operator beside machine	0.14	12	8.6
water aerosol *with* additive	Amsterdam	10-11-'03	driver	0.27	18	6.6
water aerosol *with* additive	Amsterdam	10-11-'03	operator beside machine	0.14	4	3.1
water aerosol *with* additive	Dokkum	24-11-'03	driver	0,28	9	3.1
water aerosol *with* additive	Dokkum	24-11-'03	operator beside machine	0.14	4	2.9
water aerosol *with* additive	Oud-Beijerland	1-12-'03	driver	0.20	24	12.2
water aerosol *with* additive	Oud-Beijerland	1-12-'03	operator beside machine	0.09	11	11.8
Background (windward)	Dokkum	24-11-'03	stationary air sample	0.12	< 1.8	< 1.5
Background (windward)	Oud-Beijerland	1-12-'03	stationary air sample	0.07	< 1.2	< 1.7

note: detection limit : respirable Dust: 0.05 mg/filter; respirable crystalline Quartz : 0.1 µg/filter