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Emission load of car service interiors

I. Vitázek[1], D. Michalíková[1], B. Vitázková[2], J. Klúčik[1]

[1]*Department of Transport and Handling, Faculty of Engineering, Slovak University of Agriculture in Nitra, Nitra, Slovak Republic*
[2]*Department of Machines and Production Systems, Faculty of Engineering, Slovak University of Agriculture in Nitra, Nitra, Slovak Republic*

Abstract

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Car service centres are specific in terms of production of pollutants. The aim of the paper is to assess the quality of indoor environment of car service interiors with respect to the safe range of oxocarbon emission limits, concentration of gaseous and solid aerosols of selected chemical pollutants and occupational noise exposure. Measurements of concentration and exposure time indicated that the permitted limits were kept. CO concentration reached values in the range from 0 to 10 ppm, CO_2 concentration was observed in the range from 493 to 967 ppm. Concentration of solid aerosol of polyester bitumen reached the maximum value of 0.37 mg/m^3, while for gaseous aerosol (e.g. toluene) it equalled 8.114 mg/m^3. Measurements of chemical factors were carried out and evaluated by companies with appropriate accreditation. Occupational Exposure Limits (OELs) were higher in case of all selected substances. OEL was not demonstrably exceeded at any chemical factor. Noise emissions approached the limit values; therefore, hearing protection is required.

Keywords: indoor environment; gaseous emissions; chemical factor; emission limits; noise

When undertaking the occupation, time spent in the workplace may add up to more than a half of the day. Suitable work environment and healthy microclimate enhance the employee job performance and focus on the tasks. Harmful effects of emissions and immissions on the human body are directly linked with the total amount of pollutants and their concentrations. The impact of an air pollutant may vary according to its composition and concentration – from virtually negligible effects and irritation to local or overall damage and general toxic influence.

Apart from the global impact on the environment as a whole, emissions also interact with the microclimate of workplaces, residential premises and other spaces. Pollutants, which arise in the workplace as a by-product of specific activities, have a harmful effect on the health of employees. When the amount of these toxic substances accumulates, proper air exchange in the area is considerably important (Michalíková, Vitázek 2014).

In addition to the exhaust gas emissions, several chemical factors pose a threat to the well-being of car service workers. Production of these factors is related to the technological procedures of particular maintenance tasks, repairs and treatment of damaged surfaces. Objective data regarding acous-

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tic pressure level should be also taken into account, because noise is considered as a harmful emission (Michalíková 2014).

The paper presents results of measurements of concentration of gaseous oxocarbon emissions, solid aerosols of selected chemical pollutants and noise level in selected areas of assessed car services. Evaluation of hygienic and safety measures with respect to the fostering of the required microclimate in these workplaces is also provided.

MATERIAL AND METHODS

Numerous car service centres varying in size can be found in Nitra, Slovakia, and its surroundings. Suitable microclimate of the specialized units may be maintained by appropriately designed and operated ventilation and heating systems. This procedure is based on optimization of parameters in terms of ecology and economy (Michalíková, Vitázek 2014).

During some technological procedures in service units, toxic substances arise and accumulate. They are dangerous for health and technical condition of the machinery. Apart from exhaust gases (mainly CO and CO_2), well-being of car service employees may be threatened by chemical factors in the air, such as emissions of organic compounds, aerosols from material treatment, etc. Therefore, it is necessary to cover all measures possible to prevent accumulation of these pollutants in the early stage of designing and constructing of the car service. This goal may be reached by installation of quality exhaust technology in the whole building.

Composition of exhaust gases. Exhaust gases from motor vehicles contain nearly 16 components (Streďanský et al. 2005):

– organic: aliphatic, aromatic and heterocyclic hydrocarbons C_xH_y, aldehydes R-CHO, phenols, ketones, tars;

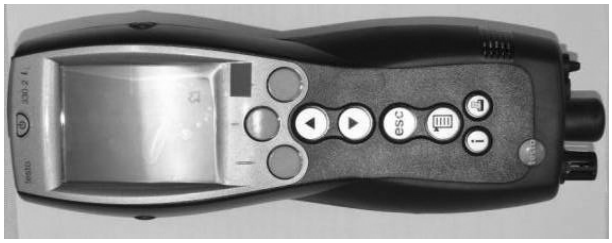

Fig. 1. Measuring device TESTO 330-2LL (Testo AG, Lenzkirch, Germany)

Fig. 2. External CO probe (Testo AG, Lenzkirch, Germany)

Fig. 3. External CO_2 probe (Testo AG, Lenzkirch, Germany)

– inorganic: oxocarbons CO and CO_2, oxides of nitrogen NO_x or N_xO_4, oxides of sulphur SO_x, lead radicals arising during combustion.

Exhalates of exhaust gases significantly contribute to air pollution (Uhrinová et al. 2012) and contain substances which affect mainly respiratory airways (e.g. oxides of nitrogen, dust particles), substances with toxic effects such as carbon monoxide (it blocks the capacity of haemoglobin to bind and carry oxygen) and carcinogenic substances (toluene, styrene, formaldehyde, benzopyrene) (Holubčík et al. 2014).

Experimental measurements of oxocarbon concentration. For measurements of emissions in the environment, the device Testo330-2 LL (Testo AG, Lenzkirch, Germany) was used. It is a flue gas analyser for determination of median value of CO and CO_2 with external probes (Figs 1 to 3).

The analyser Testo 330-2LL enables measuring: O_2 (0–21%), CO_2, CO (0–4,000 ppm) without compensation to H_2 or (0–8,000 ppm/30,000 ppm) with compensation to H_2 and automatic dilution, CO of the environment (0–500 ppm) through gas probe or with external probe (optional), CO_2 of the environment (0–1%) with external probe (optional), NO (0–3,000 ppm) or NO_{low} (0–300 ppm) (optional) and other quantities. The device with external probe was successfully used in the measurement of CO concentration in residential premises (Vitázek et al. 2012).

Chemical factors in workplaces. Chemical factors occurring in the workplace are hazardous to safety and health of employees.

List of pollutants: solid particles PM_{10} (particulate matter with diameter exceeding 10 μm), oxides

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of nitrogen NO_x/NO_2, nitrous oxide N_2O, oxides of sulphur SO_x/SO_2, carbon monoxide CO, carbon dioxide CO_2, and polychlorinated biphenyls (PCB).

In addition to the gaseous chemical substances mentioned above, concentration of particular substances in paint shops and mechanics' workshops should be also taken into consideration. Organic solvents – volatile liquids used in chemical syntheses – are present. They enter the body through airways and skin. The most commonly used solvents are toluene, xylene, butyl acetate, acetone and less frequently used styrene.

The next group consists of colours which contain hazardous substances such as calcium oxide, xylene and turpentine. Following compounds also pose a danger to workers: phosphoric acid used as rust remover and isopropanol and ethanol used for glass cleaning (Michalíková 2014).

Measurements of aerosols and chemical pollutants in workplaces. Measurements of harmful substances in workplaces are focused on:

(1) Measurements of solid aerosols in work environment:
   – identification of mass concentration of solid aerosols in work environment,
   – identification of employees' exposure to solid aerosols during work.
(2) Measurements of chemical pollutants in work environment:
   – identification of mass concentration of chemical substances in work environment,
   – identification of employees' exposure to chemical substances during work.

Measurements are carried out by personal or steady collection (Černecký 2005).

Collection of the solid aerosol samples in breathing zone was performed by the personal collecting pump AirChek 2000. The sample was sucked onto the filter from glass fibres FVA with diameter 25 mm (SKC Inc., Eighty Four, USA). The principle of the test was to identify the aerosol concentration gravimetrically.

Identification of gaseous aerosols concentration was realized by means of gas chromatography. Inspection of the workplace was performed prior to the measurement. Place and duration were set according to usual working practice. Collected samples were analysed in the accredited laboratory (Ekolab, s.r.o., Košice, Slovak Republic). Measured values were recalculated to normal conditions (t = 20°C; p = 101.325 kPa).

The occurrence of chemical substances is subject to monitoring by accredited companies not only when opening a new workplace but also during its operation (Pucherová 2008). The practice must adhere to the obligatory legislation based on the Law No. 67/2010 – the so-called "chemical law" which defines in detail chemical substances and their mixtures as well as duties regarding their manipulation at work. The Regional Public Health Authority is the competent state administration body in the field which is authorized to perform inspections to find out whether regulations are kept. The owner of the car service, in which the measurements were carried out, did not give the permission to publish the company name. For this reason, the paper does not provide the names of other car services as well.

Noise emissions in work environment. Noise is any unwanted sound which people consider annoying, distracting or may even have harmful impact on health. In terms of prevention and occupational safety and health, it is necessary to obtain objective data about noise exposure level in workplaces. Noise arising during operation of motor vehicles is considered as harmful emission (Kosiba et al. 2010).

High noise level causes sleep disorders, triggers depressions, hypertension and may influence human behaviour. According to German experts, noise louder than 65 decibels accounts for 2% of myocardial infarctions. In some densely populated areas, the noise level exceeds 75 dB. Long exposure to such noise may lead to hearing damage (Michalíková 2014).

The Notice of the Ministry of Health of the Slovak Republic No. 549/2009 determines the details about permitted values of noise, infrasound and vibrations and about requirements on objectification of noise, infrasound and vibrations in the environment. The Notice provides categorization of noise from the following internal and external sources:

(1) noise from internal sources in buildings:
   – noise from technical devices of buildings,
   – noise from human activities,
(2) noise penetrating from external sources:
   – noise from transport,
   – noise from other sources.

RESULTS AND DISCUSSION

Experimental measurements were performed before the noon during usual working operation. The

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premises except mechanics' workshop were closed and installed ventilation was on.

Table 1 provides results of measurements of CO_2 and CO concentration in particular car service units (with respect to the scope of the article, not all measurements are presented).

Measurements were aimed at the occurrence of gaseous emissions of CO and CO_2 in the area of selected car service. The evaluation of performed measurements specifies the maximum and minimum values of concentrations as follows:

mechanics' workshop:
- max. concentration of CO = 10 ppm; CO_2 = 967 ppm at start-up of the vehicle,
- min. concentration of CO = 0 ppm; CO_2 = 493 ppm near opened door,

tinsmiths' workshop:
- max. concentration of CO = 3 ppm; CO_2 = 804 ppm near stairs to paint shop,
- min. concentration of CO = 0 ppm; CO_2 = 498 ppm near opened door,

paint shop:
- max. concentration of CO = 4 ppm; CO_2 = 899 ppm near spray booth,
- min. concentration of CO = 0 ppm; CO_2 = 520 ppm near opened door.

Comparison of the results of the measurements carried out in the particular car service suggests that the occupational exposure limits (OELs) of CO – 30 ppm and CO_2 – 1,000 ppm were not exceeded in the case of any measurement of gaseous emissions.

Results of measurements of concentration of solid aerosols and chemical substances are shown in Tables 2 and 3. Measurements were performed by the company Ekolab, s.r.o. (Košice, Slovak Republic) which fulfils the requirements for the special equipment.

Exposure concentrations in working environment

Solid aerosol with mainly irritating effect arising during grinding and treating:

polyester bitumen: OEL_c = 5.0 mg/m^3.

Gaseous aerosol with mainly toxic effect:

toluene – average 50 ppm equals 192 mg/m^3: OEL max. value = 384 mg/m^3,

n-hexane: OEL average = 20 ppm equals 72 mg/m^3,

acetone: OEL average = 500 ppm equals 1,210 mg/m^3,

4-methylpentan-2-one: OEL average = 20 ppm equals 83 mg/m^3: OEL max. value = 208 mg/m^3.

Average solid aerosol exposure during the whole shift (8 h) of the mechanic demonstrably did not exceed OEL.

Average chemical factor exposure during the whole shift (8 h) of the mechanic demonstrably did not exceed OEL.

The max. value of OEL was not demonstrably exceeded at any chemical factor. OEL for the mixture of chemical factors, effects of which mutually incite, was kept.

Results of measurements regarding the occurrence of chemical substances in another car service provided by the Regional Public Health Authority are presented in Table 4.

Results of noise emission measurements

In addition to the unwanted effects of chemical substances and exhaust gas emissions, obtained results suggest that during most activities in car services and tire services another harmful element occurs – noise emissions. Results of noise emission measurements imply that noise poses a threat to the health of the workers in this field.

Table 1. Results of measurements of CO and CO_2

No. of measurement	Place of measurement	CO_2 (ppm)	CO (ppm)
1	mechanics' workshop (started-up vehicle)	967	10
2	mechanics' workshop (vehicle hoist)	691	4
3	tinsmiths' workshop (in the middle)	728	2
4	tinsmiths' workshop (stairs to paint shop)	804	3
5	paint shop (in the middle)	823	1
6	paint shop (near spray booth)	899	4

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Table 2. Results of measurements of solid aerosol concentration

Sample No.	Collection details				Collected solid aerosol (l)	Concentrations (mg/m^3) ± uncertainty
	time	duration (min)	flow (ml/min)	place		
1	9:40	–	–	blind collection during grinding	–	–
2	9:35–9:51	26	2,117.4	personal collection during putty and base grinding with eccentric grinder, putty Aluminio – bonnet, door base; worker 1	55.05 = 54.08 l_n	0.37 ± 0.11
3	13:04–13:21	17	2,552.4	personal collection during putty Aluminio grinding with eccentric grinder – door, bonnet; worker 1	41.55 = 40.64 l_n	0.25 ± 0.08

l_n – volume (litre) at normal conditions (t = 20°C; p = 101.325 kPa)

Table 3. Results of measurements of gaseous aerosol concentration

Sample No.	Collection details			Place of measurement	Chemical factors	Concentrations (mg/m^3) ± uncertainty
	time	duration (min)	flow (ml/min)			
1	blind collection	–	–	in spray booth during paint and polish spraying	toluene	< 0.001
					n-hexane	0.0146
					acetone	0.01202
					4-methylpentan-2-one	< 0.001
2	11:15–11:45	30	525.2	personal collection during degreasing, paint spraying, paint-spraying pistol cleaning	toluene	8.114 ± 2.028
					n-hexane	2.531 ± 0.638
					acetone	15.178 ± 3.795
					4-methylpentan-2-one	2.415 ± 0.604
3	12:40–13:10	30	525.2	personal collection during paint and polish spraying on the mudguard and paint-spraying pistol cleaning	toluene	3.429 ± 0.857
					n-hexane	4.352 ± 1.088
					acetone	0.408 ± 0.102
					4-methylpentan-2-one	0.318 ± 0.080

Occupational safety and health covers also specific effects of noise on hearing. To enable the employee to undertake their occupation in a way that causes least harm, the following limit values of noise exposure and action values are set:

(a) limit values of exposure: $L_{AEX,8h,L}$ = 87 dB and L_{CPK} = 140 dB
(b) upper exposure action values: $L_{AEX,8h,a}$ = 85 dB and L_{CPK} = 137 dB
(c) lower exposure action values: $L_{AEX,8h,a}$ = 80 dB and L_{CPK} = 135 dB.

The results of measurements shown in the table are considered values $L_{R,AEX,8h}$ of normalised noise exposure level including the expanded uncertainty value. Considered value $L_{R,CPK}$ is the peak level C of acoustic pressure including the expanded uncertainty value.

Results of occupational noise exposure measurements are assessed according to the criterion that the limit value of noise exposure or exposure action value is not exceeded if the considered value of determining quantity (obtained by measurement or derived from it) including uncertainty value does not exceed the limit or action value of noise exposure (Regulation of the Government of the Slovak Republic No. 115/2006). The acoustic pressure level L = 130 dB approaches the pain threshold and measured values demonstrate that the occupation of tinsmith significantly affects the well-being of the employees in an unfavourable way.

As was already pointed out, permitted limits of concentration of CO and CO_2 gaseous emissions were not exceeded. Taking into account the extremely harmful effect of CO (risk of poisoning),

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Table 4. Results of measurements of chemical substances concentration

Sample No.	Collection details			Toluene (mg/m^3)	Ethyl acetate (mg/m^3)	Butyl acetate (mg/m^3)	o-xyl (mg/m^3)	m-xyl (mg/m^3)	p-xyl (mg/m^3)
	place	duration (min)	flow (l/min)						
1	paint mixing and mudguard spraying	63	0.2313	0.11 ± 0.01	< 0.98	< 12.68	< 1.25	< 0.03	<1.03
2	clear polish spraying on the mudguard	16	0.167	< 0.48 ± 0.08	< 0.98	< 12.68	< 1.25	< 1.12	< 1.03
3	front mudguard polishing of Peugeot 306	60	0.2320	0.03	< 8.01	< 12.68	–	–	–
4	front mudguard polishing of Peugeot 306	15	0.2406	< 0.8	< 8.01	< 12.68	–	–	–
OEL average limit (mg/m^3)				192	442	500	221	221	221
OEL momentary limit (mg/m^3)				384	884	700	442	442	442

OEL – occupational exposure limit; o-xyl, m-xyl, p–xyl – other observed substances

it is inevitable to ensure continual ventilation and perform regular checks of its concentration in these workplaces. The situation differs in the case of residential premises when ventilation is neglected and exhaust hood does not run in kitchens during meal preparation. Measurements confirmed the excess of permitted limits of carbon monoxide concentration (Vitázek et al. 2012).

Moreover, the health of car service employees is confronted on a daily basis with other hazardous substances – gaseous and solid aerosols and chemical air pollutants. Therefore, the aim of the paper was to compare the exposures of chemical substances in this environment.

Measurements of chemical factors obliged by law prior to the launch of the car service are performed and evaluated by companies with appropriate accreditation. For the purpose of this experiment, the measurements were carried out and assessed by the company Ekolab, s.r.o. Košice. Results were processed in tabular form and compared to the data provided by the Regional Public Health Authority in Nitra.

Table 5. Results of noise level measurements in car services and tire services

Occupation	$L_{R,AEX,8h}$ (dB)	$L_{R,CPK}$ (dB)
Mechanic	81.4	123.3
	78.3	119.9
	75.6	118.9
	80.1	125.0
	77.2	118.3
	82.6	121.4
Tinsmith	83.2	127.0
	88.1	123.1

$L_{R,AEX,8h}$ – measured noise exposure level including uncertainty value ; $L_{R,CPK}$ – peak level of acoustic pressure including uncertainty value

The majority of obtained values is considerably low, except for one instance (Table 3) when toluene reached the value of 8.114 ± 2.028 mg/m^3. Other substances also indicated slight increase in this case. Nevertheless, OEL was still not exceeded.

Regarding the small and closed space of spray booth, the highest concentration of chemical substances may be assumed to occur directly inside of it. However, results of the measurements prove the opposite. Measured values of chemical substances in this small area are substantially lower than values obtained in the premises of the paint shop. This fact confirms the functionality and suitable design of the exhaust technology in the car service.

Slight increase in values was observed in other areas of the paint shop, yet they still meet the general requirements. OELs in the whole area of car service were kept, in line with the Regulation of the Government of the Slovak Republic No. 355/2006.

Measurements of acoustic pressure were performed in order to evaluate and objectify the work environment with respect to noise exposure. These measurements were carried out in three car services and three tire services. Results were processed at the Laboratory Practice Department of the Regional Public Health Authority in Nitra (Michalíková 2014). Comparison of results of individual measure-

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ments and limit values reveal that noise emissions, the most frequent hazardous factor arising in car services and tire services, approach the max. values. Consequently, this occupation presents risk to the health of employees. Usage of protective equipment (hearing protection) is therefore vital. Measurement of acoustic pressure during operation of tractor and loader is dealt with in the work of Kosiba et al. (2010). The maximum level of acoustic pressure in the experiment reached 88.1 dB.

The obtained data prove that car services equipped with effective exhaust systems are able to meet the limits set for the content of pollutants in indoor environment and ensure healthy working conditions.

CONCLUSION

Apart from chemical substances, employees encounter numerous hazardous factors at their workplace. Car service centres are specific in terms of production of pollutants from vehicles which are being repaired. These pollutants have to be exhausted by devices designed and installed for this particular purpose. Otherwise, the practice contradicts with regulations of occupational safety and health.

In specialized workplaces as car services, a variety of chemical factors including pollutants from exhaust gases is present. The composition of air in mechanics' workshops is characteristic of dangerous volatile substances (toluene indicated the highest values). Therefore, it is necessary to provide these workplaces with appropriate exhaust technology in order to foster effective air exchange and the max. indoor air quality possible. Suitable technical apparatus (suction systems, separate spray booth, etc.) plays an important role in eliminating the effects of harmful factors on both the health of employees and the machinery. In addition, noise has also a negative impact on the human body. Usage of personal protective equipment is considerably important particularly for workers on the position of tinsmith.

Results of measurements in selected car services point out the functionality of installed exhaust technology and satisfactory work environment which meets the basic hygiene standards and is in line with tendencies toward preventing harm from any hazardous factors arising in the workplace.

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Corresponding author:

doc. Ing. Ivan Vitázek, CSc., Slovak University of Agriculture in Nitra, Faculty of Engineering, Department of Transport and Handling, Trieda A. Hlinku 2, 949 76 Nitra, Slovak Republic; e-mail: ivan.vitazek@uniag.sk