Monitoring particles and CO in occupational field

E.C. ALEXOPOULOS [(1)], L. DIAPOULI [(2)], G. GRIVAS [(2)], S. SARVANIDIS [(1)], A. HALOULAKOU [(2)]

[(1)] Occupational and Environmental Health Department, Hellenic Shipyards Co.

[(2)] School of Chemical Engineering, NTUA, 9 Heroon Polytechniou St., Zographos, Athens 157 80, Greece.

Introduction

One of the main responsibilities of occupational hygienists is to evaluate workplace exposures to potentially harmful chemical agents. This paper addresses occupational exposure in an aluminium-welding unit. Metal welding covers a range of processes in which different gases and particulates are emitted. Dust, especially, is omnipresent at these sites and causes a substantial number of complaints, both of nuisance and of health effects, by the workers.

The first aim of the present study was to monitor particulate matter with aerodynamic diameter <10μm (PM_{10}) and with aerodynamic diameter from 0,01 to 1μm (ultrafine particles) and carbon monoxide (CO) in a metal welding unit at a shipyard industry. Both pollutants are associated with adverse health effects. Exposure to PM_{10}, especially, has been associated with changes in morbidity and mortality rates, with changes in respiratory function, and with changes in cardiovascular hospital admissions in numerous epidemiological studies. (Schwartz, 1996; Neas, 1999; Peters, 2000)

Recent advances in aerosol instrument technology have made it possible to measure and log real-time aerosol concentrations with short logging intervals (up to 1 min). Such instruments offer information that cannot be obtained by gravimetric methods using current technology and can also aid in identification of activities that contribute significantly to aerosol exposure. However techniques used by real-time aerosol monitors differ significantly from validated gravimetric methods and thus it is essential that comparability of the methods has to be investigated.

The second aim of this study was therefore to evaluate monitoring techniques of short-term occupational exposure to particulate matter (PM) and carbon monoxide (CO). For this purpose simultaneous 4-hr average PM_{10} measurements made by Harvard Impactors (HI) and TSI, Inc. Model 8520 DustTrak Aerosol Monitor (DustTrak) were compared. HIs are in widespread use for regulatory compliance ambient air monitoring worldwide and are anticipated to be a very useful monitoring tool for future PM_{10} exposure studies. DustTrak is a small and portable direct-reading aerosol monitor that is intended for indoor or outdoor use as a survey instrument or as an area sampler. Moreover two different types of samplers were used to monitor CO and results were again compared.

Methods

The research was carried out at a shipyard industry. Two sites were selected for the monitoring of both PM and CO: A Metal Welding Unit (MWU) and the Occupational Health Department (OHD), as background site.

PM_{10} concentration was measured by Harvard Impactors on a 4-hr basis average value. A Gast Manufacturing Inc. pump drew aerosol with a flow rate of 10L/min and lead it through a 37mm teflon filter. Filters were weighted before and after sampling with an electronic microbalance with 0,01 mg resolution. PM_{10} concentrations were also monitored by DustTrak (TSI, Model 8520) on a continuous 1-min basis. DustTrak's nominal flow rate is 1,7 L/min and it is obtained by an internal pump integral to the sampler. The monitor is factory-calibrated for the respirable fraction of standard ISO 12103-1, A1 test dust (Arizona Test Dust), which is representative for a wide variety of aerosols.

Ultrafine particles number concentration was measured continuously by a Condensation Particle Counter (TSI, Model 3007).

CO was also monitored continuously by two different types of samplers: one Solomat MP SURVEYOR PRO (Zellweger Analytics) and three Neotox Mk5 (Neotronics, Zellweger Analytics).

All measurements were conducted in the autumn of 2002, during 4-hr period shifts. In the OHD they were put in a room which is not often used by the personnel. In the MWU they were at one end of the welding unit where most of welding activity occurs and in the same height where welding processes take place.

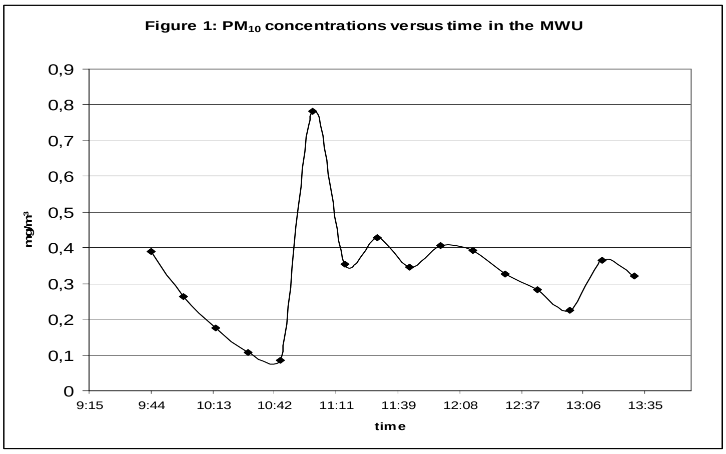
Results

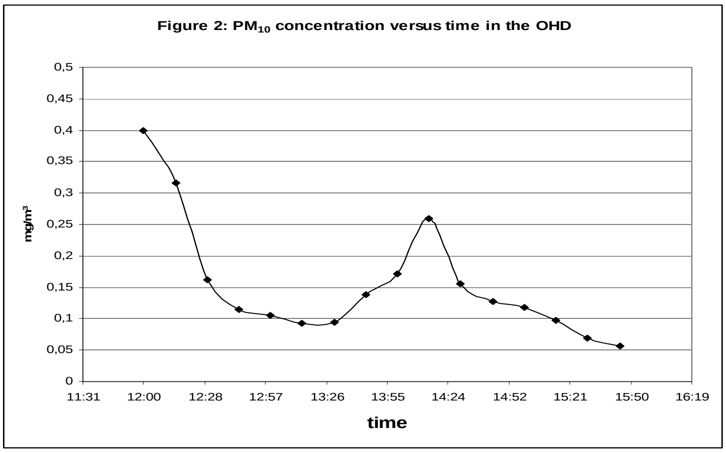
Particulate matter (PM)

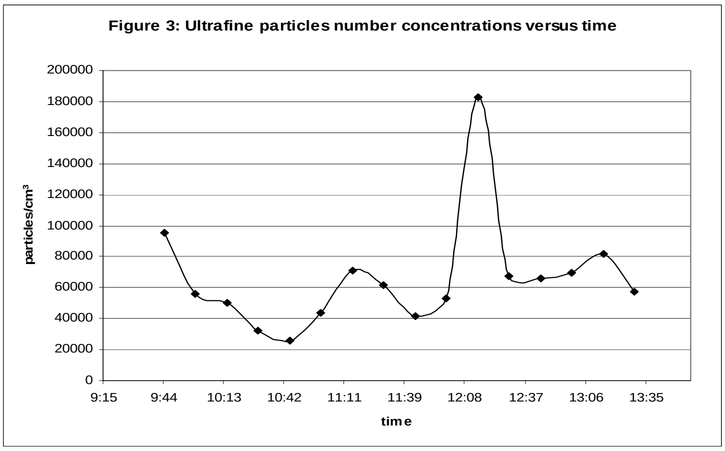
Continuous PM data were averaged on a 15-min basis. Table 1 contains the results of the PM monitoring in both measurement sites. As it was anticipated, PM concentrations in the OHD were much lower than those in the MWU. Indeed, the mean value of PM_{10} concentration in the OHD is 0,117 mg/m^3, while the respective value for the MWU is 0,440 mg/m^3. In Figure 1 and 2 the time-resolved concentrations of PM_{10}, in the OHD and in the MWU respectively, during an average 4-hr period shift, are plotted. The respective ultrafine particles concentrations are plotted in Figure 3.

Table 1: Average PM concentrations during 4-hr period shifts.

	OHD	MWU
ULTRAFINE (particles/cm^3)	-	65949
PM_{10} (DustTrak) (mg/m^3)	0,155	0,328
PM_{10} (HI) (mg/m^3)	0,078	0,496





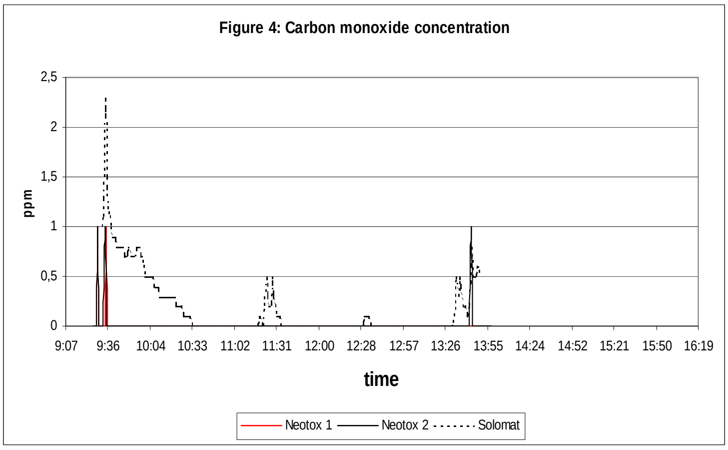


From the above results come up the following findings:

- PM_{10} concentration varies from 0,085 to 0,782 mg/m^3 in the MWU, with a large peak at 11:00 am, and from 0,056 to 0,399 mg/m^3 in the OHD. The measured concentrations show greater variability in the MWU than in the OHD.
- Ultrafine particles concentrations measured in the MWU vary from 26053 to 183080 particles/cm^3, with a large peak at 12:15 pm.
- The pattern of concentrations of PM_{10} and ultrafine particles is, most of the time, very similar. For each particle fraction, the average time-resolved concentrations during the 4-hr period shifts show one characteristic, predominant peak, at 11:00 am for the PM_{10} and at approximately 12:00 pm for the ultrafine particles; thus there is an one hour lag time period between the two fractions, which can be attributed to the different successive stages of the whole welding process.
- The comparison of the average concentrations measured simultaneously by HI and DustTrak in the MWU shows that DustTrak underestimates PM_{10} concentration by a factor of approximately 30%.

Carbon Monoxide (CO)

At all times CO did not rise in the OHD. In the MWU CO concentration ranges from 0 to 2,3 ppm. Solomat measured an average of 0,18 ppm while the two Neotox gave an average of 0,009 ppm. Results are plotted in Figures 4.



By examining, the plots it is observed that:

- CO concentration levels are extremely low.
- Solomat gives a more precise image of the concentration profile, compared to Neotox.
- The two Neotox show a good agreement.

Conclusions

The present study presents only some initial results on PM and CO concentration levels in an industrial environment. The major conclusion regarding the exposure of workers is that PM_{10} concentration very often exceeds the environmental standard of 0,150 mg/m^3. So, it is of importance, scientific community to set a TWA-TLV for occupational exposure. In our study CO concentration levels were insignificant and far below the 8-hrTLV of 50 ppm.

The variability of PM concentrations with time, especially in the MWU, suggests that exposure to PM is highly influenced by the different tasks performed. The final results could also be influenced by some other parameters such as: the air-exchange rate in the room and the intensity of activity and movement of workers. These results underline the need for more extended measurements along with a well-designed diary where the different tasks performed will be recorded and related to the measured PM concentrations.

In respect to the evaluation of the different monitoring methods, the results seem positive. The comparison between DustTrak, which is a direct-reading aerosol monitor, and HI, which offers a reliable gravimetric measurement, gives a fairly good agreement. Eventhough DustTrak seems to underestimate the PM_{10} concentrations, a joint use of these two instruments could provide valuable information in occupational exposure: HI can give precise PM concentration levels while DustTrak offers the great advantage of providing time-resolved data which can be extremely useful in identifying tasks that contribute most to exposure and prioritizing activities for control.

Two different types of CO monitors are also compared. Solomat shows a more precise variation of the CO concentration, well explained by its principle of operation. Nevertheless, Neotox is small and very simple to use and can provide a good first estimate of CO concentrations levels since it is intended for occupational exposure studies in places where high CO concentrations are expected. Solomat on the other hand is more sensitive and can be easily affected by external factors. What is also important is a good agreement between the two Neotox.

These results show off that the choice of appropriate technique and the type of supplementary data needed is not an easy case eventhough are prerequisites in a reliable risk assessment of exposure in harmful substances. Finally, environmental monitoring combined with personal and biological surveillance and study of practices, habits and ethics in various occupational settings could contribute largely in prevention policy in different enterprises, economic sectors and countries.

References

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