AIVC
#13,773

Control of Exposure to Welding Fumes by Ventilation and Helmet Pressurisation

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Abstract

Occupational hygiene conditions were examined in a welding shop after repairing the air-handling unit. Good indoor air quality was achieved with the new replacement ventilation system. The airborne dust concentrations varied from the detection limit of 0.1 mg/m^3 to 0.8 mg/m^3 at the stationary sites. Even the breathing zone concentrations of the welders remained below or equal to 2.1 mg/m^3. The concentrations of carbon monoxide did not exceed the level of 1 cm^3/m^3. In addition to the good efficiency of replacement ventilation during mild winter conditions, the local exhaust ventilation proved to be even more significant than pressurisation of helmets in decreasing the dust exposure of welders and other workers exposed due to dust distribution in the welding shop.

Materials and Methods

The size of the hall was 4200 m2 (Figure 1), and the number of welders about 20. The planned supply and exhaust air flows for the whole hall were 22 m^3/s. For the welding area, the planned supply air flow was 6.5 m^3/s and the exhaust air flow 7.8 m^3/s.

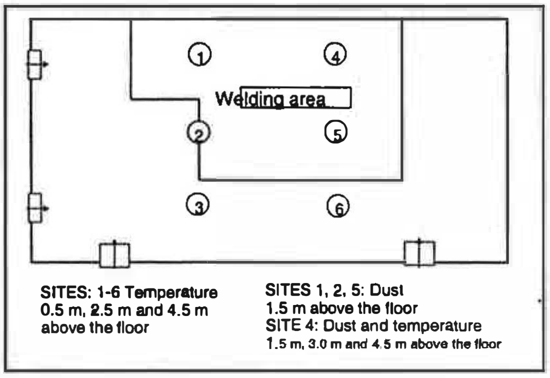

Figure 1. Stationary sampling sites

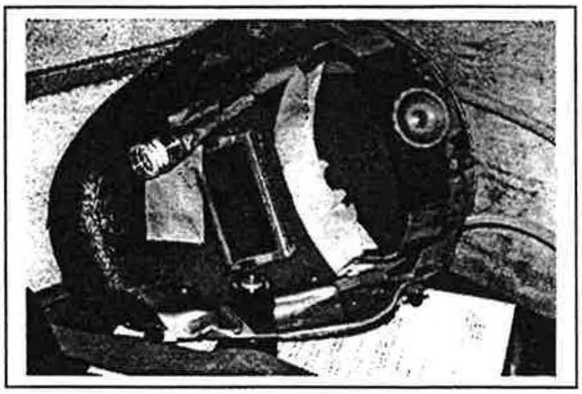

Figure 2. Samplers inside a welding helmet

Air flows in the ducts were measured using either a Pitot tube or a hot wire anemometer (Swema-Air). The temperatures of the supply and exhaust air were also measured with the hot wire anemometer. In the hall, temperatures were measured at different heights with temperature probes PT-100, and the data were collected by a computer for 15 minutes at each sampling site at the intervals of 20 seconds.

Inhalable dust was collected at the stationary sampling sites using IOM samplers (Figure 1.). The breathing zone samples were taken inside the welding helmets using 25 mm filter cassettes, because IOM samplers were found to be too big for the helmets used (Figure 2.). Both personal and stationary dust samples were collected with portable pumps (SKC 224) at air flow rates of 2 l/min on membrane filters (AAWP, Millipore), and analysed gravimetrically. The sampling time varied from 2 to 7 hours. At one stationary sampling site, dust concentrations were also measured at different heights.

The effect of a local exhaust connected to the welding pistol on the exposure of the welders was studied by measuring dust levels inside the helmet with and without the use of the local exhaust. The effect of the changing of filters in the air compressor availing fresh air to the pressurised helmets was also studied by personal dust samples. Carbon monoxide was monitored in the breathing zone of the welders with a direct reading instrument (TSI Q-Trak model 8551). Air movements were visualised by releasing smoke from a smoke generator to the hall or to the supply air ducts. The movements of the smoke inside the building were recorded by a video camera.

Results and Conclusions

Total supply airflow to the welding area was 7.33 m^3/s produced by three units and exhaust flow from the welding area was 7.14 m^3/s. Area of the welding area was about 1500 m^2, thus, an effective ventilation of 4.9 l/s m^2 (=7.33 m^3/s /1500 m^2) was obtained. The conditions maintained by one air conditioning unit at the welding area were observed to be the following:

- supply airflow 5.95 m^3/s, + 16.7 °C
- exhaust airflow 7.14 m^3/s, + 22.3 °C
- outdoor temperature + 0.7 °C
- temperature of supply air after a heat exchanger unit +16.7 °C
- temperature of exhaust air before a heat exchanger unit + 22.3 °C

The heat recovery efficiency ratio η ($\eta = (t_1 - t_{out}) / (t_2 - t_{out}) x100 \% = (16.7-0.7) / (22.3-0.7) \times 100 = 74 \%$) of the heat exchanger of the air-handling unit was 74 %.

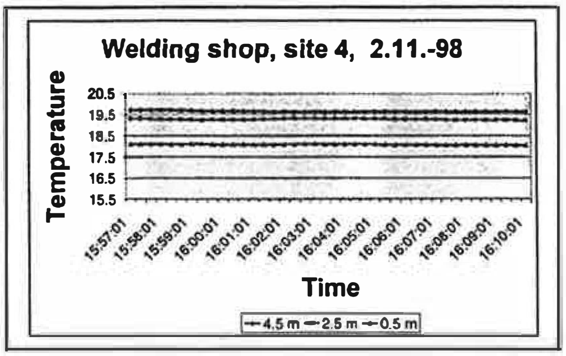

Figure 3. Temperature distribution at three heights above the floor (t_{out} was +0,7 °C)

The heat production of the welding process cannot be simply estimated because other units with higher temperatures than 16.7 °C of supply air also served the same welding area. Air temperatures in the welding shop during a mild winter day (t_{out} was + 0.7 °C) were observed to increase vertically in a way which is typical for the replacement ventilation (Figure 3).

The second wintertime measurements conducted at a very cold day (t_{out} was -27 °C) revealed that stable temperature layers were no more formed above the height of 3 meters from the floor (Figure 4a.). The air handling unit operated at the 2/3-effectiveness. Dust concentrations (Figure 4b.) were measured at the same points as temperatures and the maximum concentration was detected at the height of 3 meters.

Dust did not seem to spread far from the welding sites 1 and 4 (Figure 5a.) in horizontal direction.

The effectiveness of the local exhaust ventilation and the change of the filters in the breathing air compressor could be observed in the dust concentrations at breathing zone samples of four workers (Figure 5b.). The helmets of workers 1 and 2 were not pressurised when they welded in the same way, however, the dust exposure of worker 2 was prevented more effectively because there existed also local exhaust in his welding area. The both helmets of workers 3 and 4 were pressurised. In addition, the filter of air compressor was changed before measurement of the negligible dust exposure of the worker 4.

The carbon monoxide (CO) concentrations in the breathing zone of the workers did not exceed the value of 1 cm^3/m^3 measured during the welding period.

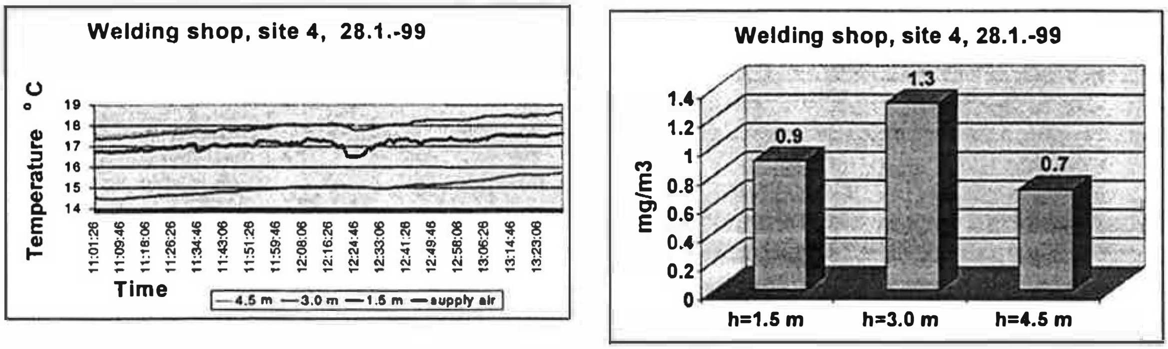

Figure 4. a. Temperature layers and b. dust concentrations at the three heights of the stationary site 4 in the welding shop (t_{out} was -27 °C)

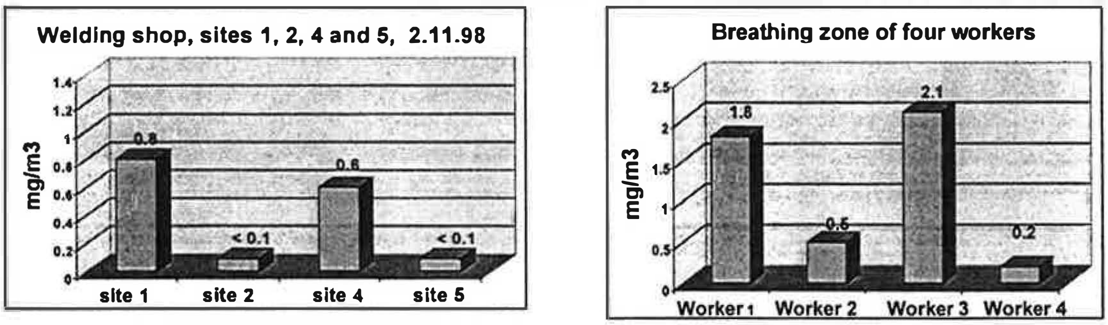

Figure 5. Dust concentrations mg/m^3 a. at different stationary sites b. in breathing zone of four workers (t_{out} was +0.7 °C)

The replacement ventilation proved to be efficient due to expected temperature distribution in the welding shop when the outdoor temperature was not very cold. Local exhaust ventilation played a significant role in decreasing the dust exposure of welders and other workers exposed due to dust distribution in the welding shop.