



Finnish Institute of
Occupational Health

WELL-BEING
THROUGH WORK

METALWORKING FLUID AEROSOL EMISSIONS HANDLING IN THE MACHINERY INDUSTRY

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Background

- During machining metalworking fluid aerosol (MWF) is formed containing both particulate and semivolatile compounds harmful to health.
 - Very complex chemical mixture
- Machinists have respiratory symptoms although the machining centres are usually equipped with air cleaners to purify the recycled air.
 - Concentrations of single contaminants, such as oil mist, are usually well below the occupational exposure limits.



Occupational exposure limits

- Commonly used OELs in metalworking processes:
 - Oil mist (5 mg/m³)
 - Particulate mass (inorganic 10 mg/m³ and organic 5 mg/m³)
- Other relevant exposures, for which Finnish OELs have been established, include
 - Alkanolamines (MEA; DEA and TEA) and formaldehyde.
 - There are no official OELs for total volatile organic compounds (VOC), bacteria and fungi, or endotoxins

Occupational exposure limits

- Target levels have been recommended in Finland by FIOH to be used for metal working aerosol exposure assessment
- Alkanolamines were chosen as an indicator for these levels
 - Based on experiences from long time [ref. *]
 - Measured as a total concentration 0,1 mg/m³
- Useful for complex mixtures where occupational exposure limit values of single substances are not applicable

Target level =
Exposure level
achievable by advanced control
technology with minimal health
and comfort effects

* Suuronen, K. (2009) Metalworking fluids – allergens, exposure, and skin and respiratory effects, People and work, Research reports, no 85, Finnish Institute of Occupational Health, Tampere, 106 p. + 93 p. app.

* Henriks-Eckerman, M-L & Suuronen, K. (2009) Metallityöstönesteiden alkanoliamiinien tavoitetasoperustelumuuisto. Tavoitetaso TY-02-2009. Työterveyslaitos (in Finnish)

The study

- This study consists of two consecutive FIOH research projects during years 2014 to 2018
- The aim:
 - to find out how the different air handling methods were performing in machining shops
 - to evaluate and test new type of air purification system for controlling MWF aerosol exposure

The study

- Studied air handling methods were:
 1. the recirculation of the local exhaust ventilation air back to the workspace after particulate filtration (**typical case in industry**)
 2. leading the air from the local exhaust ventilation directly to outdoors
 3. enhance the filtration by adding the filtration of volatile compounds to the existing air filtering systems
- Total of 19 air filtering units were studied in four machining companies and one laboratory.

Local exhaust ventilation air filtration in machining centres

- Modern machining centres have full enclosures and are normally equipped with local exhaust ventilation (LEV).
- The air from the LEV unit can be directed outside the factory or returned back to the hall after filtration.
- Mist collectors used in machining centres usually consist of multi-stage particulate filters and they can remove particles efficiently especially if HEPA filters are used.
- Volatile contaminants penetrate the air filters increasing the airborne contaminant levels.



Current solutions: Single unit with recirculation

- Pros:
 - No long ventilation ducts
 - > fire safety, flexible for factory lay-out changes
 - Energy efficiency
- Cons:
 - Recycled air is not totally clean
 - Large number of machines
 - > high cost, lot of maintenance



Current solutions: Multiple units with recirculation

- Pros:
 - Easy maintenance (except for ducts cleaning)
 - Energy efficiency
- Cons:
 - Recycled air is not totally clean
 - Long air ducts
 - > fire safety, difficulties to modifications and factory operations



Current solutions: Multiple units with leading LEV air outside

- Pros:
 - All LEV air directly outside -> clean work air
 - Easy maintenance (except for ducts cleaning)
- Cons:
 - Energy efficiency very poor
 - Long ducts -> difficulties to modifications and factory operations, fire safety



The study

Measurements were carried out for

- the aerosol mass concentration and particle size distribution
- the total concentration of alkanolamines
- the total concentration of volatile organic compounds (TVOC)
- as well as the concentration of formaldehyde.



The study

- The contaminant concentrations were measured both from the air before and after the air filtering units.
- These levels were compared to the concentrations measured at the workers' breathing zone and in the area samples in the production premises.



Results

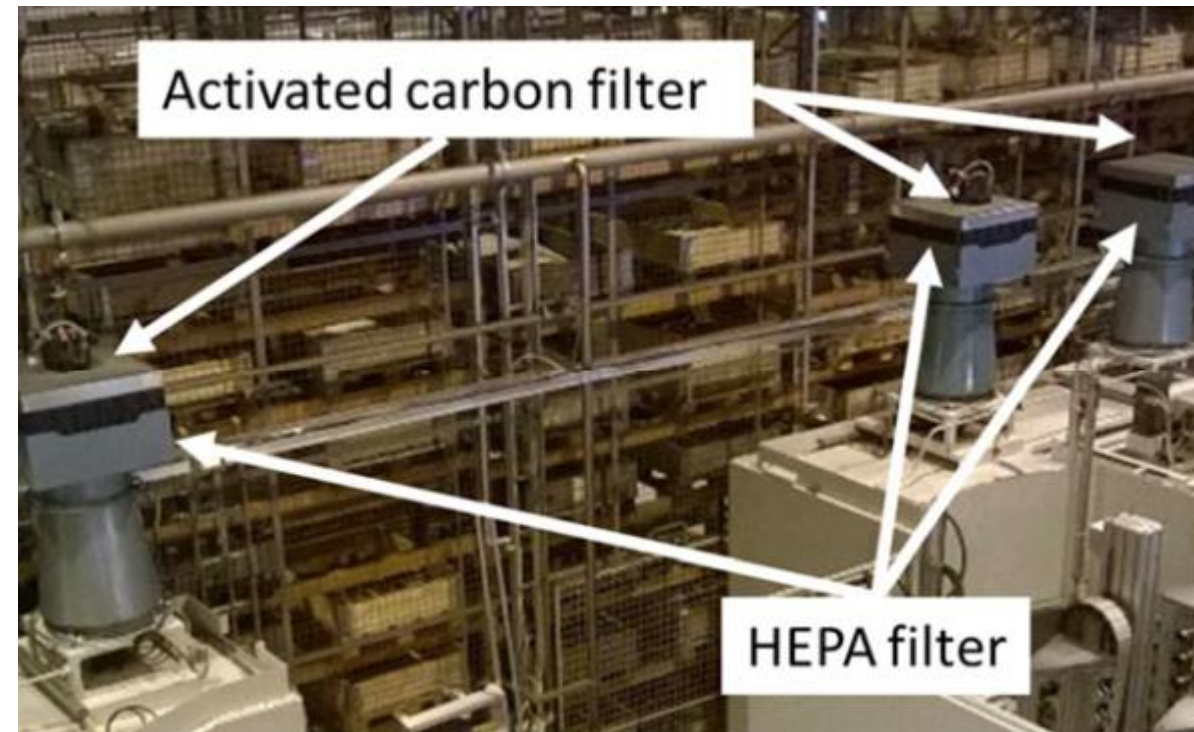
- In general, the concentrations of air pollutants in the workplaces with recirculation of LEV air were small.
- However, the total concentration of alkanolamines and VOCs made an exception.
 - The concentration of alkanolamines ranged from 0.03 - 0.74 mg/m³, the median being 0.19 mg/m³.
- The measured breathing zone concentrations were on average at the same level as those measured in the area samples.

Results

- In one factory it was possible to compare the difference between the recirculation of the LEV air back to the production hall and leading the LEV air out of the building.
- The concentrations of both alkanolamines and volatile organic compounds in workplace air decreased by 60-70% as a result of leading the LEV air out of the building.

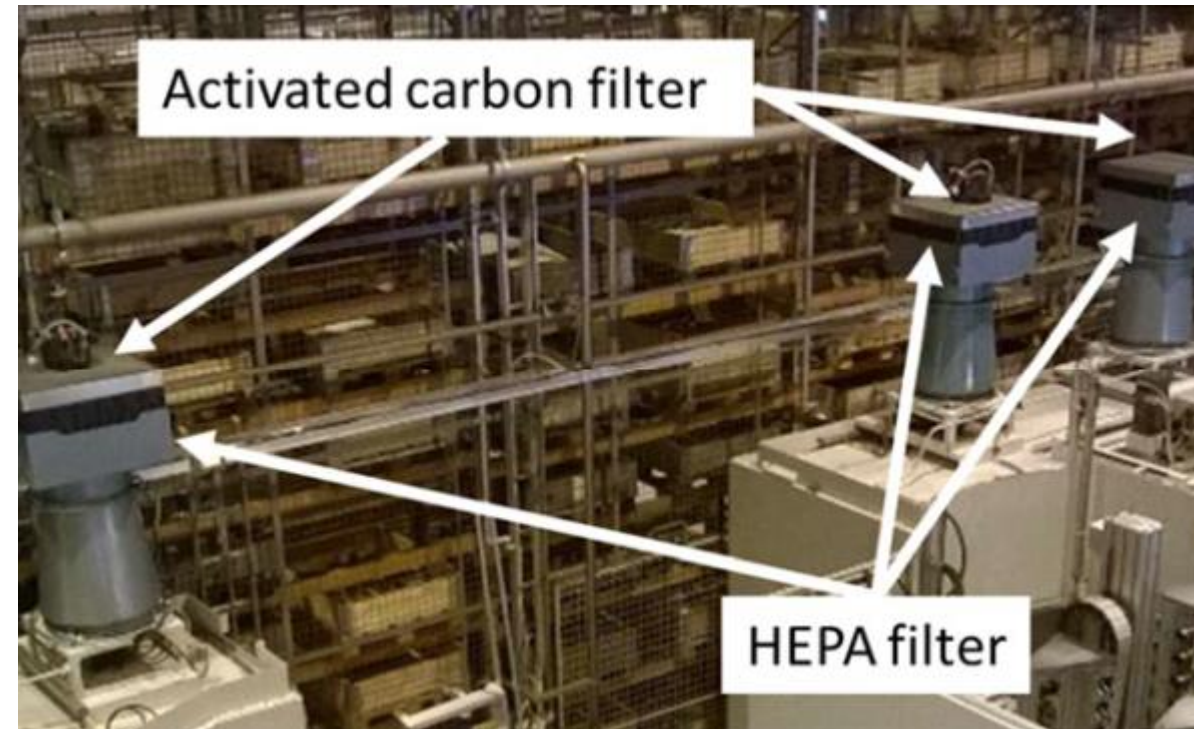
Results

- The influence of **activated carbon** filters added to the existing air filtration units was examined.
- When the activated carbon filters were new, they removed also the gaseous air pollutants such as alkanolamines and volatile organic compounds.



Results

- However, after a few weeks, the activated carbon filters overloaded and began to penetrate impurities.
- A need for multi-stage particulate filtration combined with treatment of gaseous contaminants was highlighted.



Results

- An idea for a new type of air handling unit was developed in this study
- This integrated air handling unit can be used in combination with traditional filtration units.
- It is based on various parts: cooling, heating, condensation and molecular filter.
 - This unit can reduce the loading of the activated carbon filter
 - The impurities in the gas phase were able to filter out even better.
- A spin-off company was established to start the development of this system.

Results

Other factors:

- The exhaust air flow rates from a single machining center varied greatly and were often quite low.
 - Too low air flow rate cannot prevent the aerosol generated during machining spreading out from the enclosure of the machining center.
- Low air flow rates also caused that the air velocities in the exhaust ducts were often too small causing the accumulation of a thick layer of dirt inside the ductwork. This may in turn result in e.g. a risk of fire.
- The maintenance of the metalworking fluid also affects workers' exposure to airborne contaminants.

Conclusions

- Current typical air filtration units are not satisfactory method for control of metalworking fluid aerol exposure.
- Volatile contaminants penetrate the air filters increasing the airborne contaminant levels.
- The results showed that the new type of multi-stage particulate filtration combined with treatment of volatile contaminants might be the best choice for the cleaning of the exhaust air of the machining centres.



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Thank You!



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