PEROSH Information Exchange Workshop on Metal Working Fluids (MWF)

Paris, Jan 14th-15th 2020

Day1: Opening and presentations

Twelve scientists from 8 PEROSH Institutes (AUVA – Austria, FIOH – Finland, HSE- UK, IFA – Germany, INRS – France, SAWEE – Sweden, STAMI – Norway and Unisanté, Switzerland) participated in this workshop.

The attendance was multi-disciplinary with specialists in industrial hygiene, occupational medicine, epidemiology, chemistry and bio-hazards.

On the first half- day (Tuesday January 14th) 9 presentations were given with following topics:

- reporting on measured exposures and exposure databases (AUVA, INRS),
- exposure measurement methods (IFA),
- microbial contamination of water-based MWFs (SAWEE),
- health studies including biological monitoring and biomarkers (INRS, Unisanté, HSE),
- a study with respect to exposure reduction at the workplace (FIOH) and
- a general reflection about the exposure to MWF and the necessity to improve employers and employees knowledge, attitudes, practice (KAP) and monitoring of exposure (STAMI)

*These presentations can be viewed in the accompanying Adobe pdf file (**PEROSH_MWF_WORKSHOP_PARIS_14-15th_2019.pdf**) which contains each presentation in the order of presentation*.

The different presentations and the resulting discussions revealed that the approaches to monitoring exposure to MWFs and actions to minimise this were different in each country. These differences included how MWF mist is quantified and understood in terms of risks to health; the regulatory processes and requirement on duty holders to manage these risks; and how each country is promoting and disseminating good practice in the workplace.

The second day, chaired by Gareth Evans (HSE) was structured as follows

- reflections on learning from the preceding days presentations
- identifying knowledge gaps
- from knowledge sharing to taking actions
- reflections on the value of the workshop
- actions to propose to PEROSH

Day 2: Discussion session

1) Changes to MWFs during their use:

- The formulation of different types of MWFs evolves quickly in relation to machining technology and in response to environmental and health concerns. The main types include:
  - Neat oils composed of mineral, animal, marine, vegetable or synthetic oils which are usually solvent refined to reduce the content of carcinogenic substances such as polyaromatic hydrocarbons (PAHs).
  - Semi-synthetic fluids which from 5-30% of severely refined petroleum oils, with the remainder as water and a number of chemical additives.
  - Synthetic fluids which contain detergent-like components and other additives to help "wet" the workpiece.
  - Water mix MWFs composed of a complex mixture of oils in an emulsion (varying from ~5-50%) with organic and inorganic constituents such as surfactants, anti-foaming agents, corrosion inhibitors, pressure additives, biocides, antioxidants.
- In use water mix MWFs may contain many different micro-organisms, biocides and biocide residues, soluble metals, fine metal particles and chemical degradation products. The development of allergic respiratory conditions (asthma and hypersensitivity pneumonitis) is a particular concern for water mix MWFs because of the growth of micro-organisms.
- Water mix MWFs can also contain a range of alkanolamines, such as monoethanolamine (EA), diethanolamine (DEA), triethanolamine (TEA), methyldiethanolamine (MDEA). These are added as corrosion inhibitors and pH adjusters. They may induce asthma, respiratory irritancy and irritant contact dermatitis.
- Neat oils appear less complex but in use the oxidation and heating of the oil can release of volatile organic residues presenting risks for inhalation and skin contact.
- Impurities in neat oils were associated with historical risks for skin /scrotal cancer and bladder cancer, but after the introduction of refined oils these risks have diminished. Recent analysis of epidemiological studies by INRS in France also confirmed that whilst historical exposure to neat MWFs was associated with an increased risk of bladder cancer, the evidence for such a relationship was less for exposure to soluble and no relationship was found for synthetic MWFs.

2) Hazards in MWFs

- Used MWFs may contain a mixture of chemical and biological hazards, and during machining these are released as small droplets of fluid, fine solid particles of metal, vapours and gases.
- Failure to maintain the quality of a MWF and to minimise MWF mist is likely to increase the risk for inhalation of hazards such as microorganisms and their toxins, oxidized organic molecules, preservatives, surfactants, soluble metals and fine metal particles. These present a risk for irritant, inflammatory and allergic reactions in the upper airways, lung and skin.

- Micro-organisms can grow in large numbers in water mix MWFs (but not straight oils) if the quality of the MWF is not maintained and contaminants (e.g., Tramp oil) minimised. It is likely that inhaled micro-organisms and their toxins increase the risk for respiratory allergy and inflammation respectively.
- The growth of microorganisms (bacteria fungi and yeast) can be monitored using different dip slides to determine the number of colony forming units per milliliter of MWF. Many slow growing bacteria (e.g., *Mycobacteria sps*) may not be detected using dip slides which generally are incubated only for a few days.
- Furthermore, the total microbial load in a MWF (live and dead organisms) is not detected using dip slides so CFU counts are likely to underestimate microbial mass in used MWFs. Furthermore, micro-organisms detected in samples of MWF taken from the machine sump may not correspond to those inhaled in MWF mist.
- The use of new methods for analyzing the microbial content of MWFs was discussed at the workshop. Colony forming culture based assays are still commonly used but have limitations. Less than 10% of viable bacteria are thought to grow under culture conditions (or on dip slides) when isolated from a MWF. Furthermore, viable organisms are thought to represent a small fraction of the non-viable organisms present in used MWF. To get around these constraints Next Generation Sequencing (NGS) of bacterial ribosomal 16s is now being used to assess the microbiome of MWF samples. This has demonstrated the complexity of microbial populations which vary in different MWFs and in relation to the treatment of MWFs. The early results suggest that the microbiome (including pathogens such as Mycobacterial sps) may be influenced by how the MWF is managed. Several of the PEROSH partners reported finding Mycobacteria in machine sumps suggesting a wider prevalence that previously reported in the Europe
- Endotoxin (lipopolysaccharide) is released into MWFs when these gram negative organisms die, and the frequent addition of biocide is likely to increase the content of this toxin. Endotoxin causes localized and systemic inflammation depending on the exposure dose and route of exposure i.e., inhalation or ingestion. As a potent pyrogen it induces inflammation and symptoms in humans at inhaled doses below ~20 ng/m^3 (~100 Endotoxin Units-EU) and published studies typically report endotoxin in excess of 10^4 EU/ml in poorly managed MWF sumps. However, studies in Sweden (SAWEE) had demonstrated concentrations of airborne endotoxin in machine workshops lower than thought to trigger effects in healthy humans.
- Biocides are commonly added to water mix MWFs to prevent uncontrolled growth of micro-organisms. However, the EU Biocide Products Regulation (BPR) has restricted the use of certain types of biocide (e.g., formaldehyde releasing) and the lubricant industry have argued that the biocides they can continue to use are known to cause immune sensitisation.
- Looking after the quality of MWFs can reduce the accumulation of hazardous chemicals and biohazards. For example, when water mix MWFs designed to operate above pH 9.0 are maintained at this high pH it restricts bacterial growth without requiring the addition of more biocides. However, sustained emersion of skin in alkaline (>9.5) MWFs may damage its protective lipid layer.

3) Exposure to MWF, MWF mist and other hazards

- High speed machining and grinding activities can release fine and ultrafine MWF mist droplets. If these are not contained and extracted, operators inhaling them are likely to be at increased risk of developing respiratory illness.
- Studies in Finland has highlighted concerns about the prevalent use of mist filtration units which return air back into workshops particularly VOCs which may escape the filter units designed to trap particles.
- Airborne particles may be released from cutting machine motors and electrical equipment, and as metal particles from cutting and grinding activities.
- During high speed machining and grinding work, volatile organic constituents (VOCs) may be released causing irritation and inflammation of mucosal surfaces (eyes, nasal passages, upper and lower airways). VOCs include aldehydes such as formaldehyde, high-boiling aliphatic hydrocarbons and sensitizing chemicals such as terpenes.
- Many studies have reported high concentrations of chemicals and biohazards in the MWFs supply systems of cutting and grinding machines. However, the airborne concentration of these hazards around these machines has not been investigated so thoroughly. Most studies of MWF mist have been undertaken for the purpose of assessing compliance with occupational exposure limits.
- Regular contact of the skin with MWFs (water miscible or neat oils) may cause allergic and irritant dermatitis. Whilst this risk is well recognised there has been less research into the mechanisms of irritant and allergic dermatitis attributable to MWF constituents.

4) Quantifying exposure to MWFs

- The PEROSH partners discussed the ranges of methods currently being used to quantify airborne exposure to MWF mist for the purpose of assessing compliance with national regulatory limits or good control practices. These methods include gravimetric (mass based) or analytical methods to quantify specific constituents added to MWFs. They are based on inhalable, thoracic or respirable sampling using either filter based, or absorbent tubes, with the sampling devices usually placed in the operators breathing or in a static position close to the operator.
- Analytical methods that have been used to quantify exposure to MWF include for example:
  - In Germany, Austria and Finland the adoption of methods for quantification of alkanolamines
  - The MDHS 95/3 boron marker used in the UK
- Some exposure limits have been set on the basis of protecting health (Germany and Austria); others as guidance values that can be used to inform good control practices. However, sustaining these analytical methods is technically challenging because of the range of MWFs, and regular changes to the formulation of MWFs.
  - During the workshop it was also stated that the measurement of alkanolamines was technically challenging and this method is not suitable for synthetic MWFs which are gaining an increasing share of the market in Germany and Austria.

- At a large engine manufacturing plant in Birmingham UK in 2004, despite the company maintaining the average MWF mist concentration below the HSE MDHS 95/3 guidance value of 1.0 mg/m^3, many employees developed respiratory disease. HSE subsequently withdrew this guidance values for water mix MWF as well as for neat oils (5.0 mg/m^3). Since then new good practice guidance values have not been set by HSE because of the challenge in determining safe levels of exposure to MWF. The continued use of MDHS 95/3 is also coming under pressure following the EU RAC classification of boric acid as a probable human reproductive toxicant. This has encouraged lubricant manufacturers to remove, or reduce, the concentration of boric acids in MWFs.

- Several PEROSH partners continue to undertake exposure measurement surveys as part of health investigations or for routine monitoring of compliance with occupational exposure limits. These data sets (such as the COLCHIC database in France) may help to identify trends (either increases or decreases) in compliance with reducing exposure to MWF mist.
- A new UK HSE research project will be investigating new ways to monitor MWF mist (such as the use of direct reading aerosol monitors -DRAM), including whether new analytical marker methods can be developed, or methods used by other countries should be adopted.
- PEROSH partners were also using different methods to sample MWF mist and vapours. These included pumped filter sampling units; impactor sampling devices (e.g., the Sioutus cascade sampler) or Coriolis cyclonic biological air sampler. Some of these methods are suited to personal exposure assessment but other only for static fixed area sampling.
- PEROSH partners were using direct reading aerosol monitors (DRAMs) such as the DataRam™ for real time monitoring of particles in machining workshop. DRAMs are used to provide a relative measurement of particles (e.g., number, mass, or surface area) for nanoparticles (<100 nm) or fine particles (1-10μm diameter). However, it is unclear how they respond to MWF mist droplets since they have been developed for solid particles and calibrated against specific types of dust.
- HSE has started to use the AQMesh sensor an outdoor environmental monitor designed to monitor traffic pollutant for particles (PM1.0, PM2.5, PM4.0 and PM 10.0), noise, humidity and pressure. This unit sends data via 3G networks to a cloud based analytical platform allowing 24 hours monitoring for months.
- Monitoring airborne exposure to MWF mist remains technically challenging because of the wide range of MWFs and their constituents (which constantly change), and the presence of contaminants in used MWFs. Obtaining representative samples of MWF which may consist of fluid droplets, particles and volatile organic chemicals, is challenging.

5) Occupational exposure limits and guidance values for MWF mist

- The setting of enforceable, or recommended, limits for MWF mist (either for water soluble or neat oils) varies between EU countries and internationally.
- Some limits are set high (5.0 to 10 mg/m^3) and others much lower. For example, the US NIOSH recommended 0.4 mg/m^3 for thoracic particulate mass as a time-weighted average (TWA) concentration for up to 10 hours per day and a 40-hour working week. The current OSHA permissible exposure limit is still set at 5 mg/m^3 for an 8-hour time weighted average (TWA) for mineral oil mist. The German standard (BGIA) is 10 mg/m^3 of oil aerosol and vapour; whereas in France (INRS) a 0.5 mg/m^3 limit applies. Swiss OELs are set at 10 mg/m^3 for the total MWF

(aerosol + vapor) and as 1.0 mg/m^3 for the aerosol (inhalable fraction) and 5 mg/m^3 for pure, highly refined mineral oils (inhalable fraction).). In Austria, the OELs for MWF and straight oil aerosol are similar to Swiss (1 or 5 mg/m^3 respectively); the OEL for the summation of aerosol plus vapor is 20 mg/m^3. In Finland the OEL for MWF is set at 5 mg/m^3 and at 1.0 mg/m^3 in Norway

6) Health effects following exposure to MWFs

7a) Lung disease

- The different PEROSH partners presented evidence about investigations of lung and skin disease in machinists working with MWFs. Many of the partners reported outbreaks as well as cases of occupational asthma (OA) and hypersensitivity pneumonitis (OHP) and dermatitis. Other respiratory conditions included chronic obstructive pulmonary disease (COPD), chronic bronchitis, and recently described cases of lymphocytic bronchiolitis.
- A high prevalence of non-specific symptoms (cough, sore throats, nasal and ocular irritation) was a common finding by the different PEROSH partners
- Investigation by FIOH in Finland had found a low number of reported cases of respiratory disease amongst machinists although this was possibly due to the diagnostic criteria that are used.
- Not all of the partners had observed a similar profile of ill health, some were observing more cases of OA and OHP, other partners (Sweden) mainly cases of OA and mostly in the larger workshops.

7b) Skin disease

- It was acknowledged by the workshop participants that the risk for developing dermatitis (irritant and allergic) in machinists is high, but practical measures to mitigate this risk were well understood. More needs to be done to promote awareness of the risk and of these mitigating actions.
- It was likely that historical cases of scrotal / skin cancer were caused by use of impure neat oils which have been replaced today with highly refined oils.

7) Monitoring exposure and health effects with biological monitoring and biomarkers

- The value of monitoring employee exposure to specific hazards was acknowledged particularly when methods such biological monitoring (BM) can assess specific hazards that may enter the body of an employee. Monitoring hazardous metals in the urine of exposed employees has been used successfully to identify individuals at risk of exposure and to identify failings in control measures. BM for metal exposure is particularly relevant to machinists but whether BM can also be used to monitor employee exposure to organic molecules in MWF needs to be demonstrated
- Biomarkers of exposure (i.e., from oxidative damage, inflammation, and tissue repair) that reflect the effects of exposure to hazards are being used to monitor exposed populations and may help to inform interventions to prevent long term ill health. Oxigenocom is an integrative study between PEROSH Swiss (Unisanté-) and France (INRS) partners to monitor exposure of a large number of machinists to MWFs. This includes biomarkers of effects released from the lung, to assess DNA damage in buccal cells, and a method to quantify the oxidative potential of MWFs.

The study will focus on "Fractional Expiratory Nitric Oxide (FENO)" a marker of airway inflammation, and bio-markers of oxidative damage and inflammation found in exhaled breath condensate. The hypothesis is that hazards in MWF mist (e.g., metal particles, oxidized oils) are likely to cause oxidative damage and activate biomarkers of oxidative stress response. The relevance of these biomarkers is yet to be established in terms of the longer term risk to lung health.

8) Recommendations

- The workshop participants would like to propose to PEROSH that a short questionnaire be developed and used across the PEROSH network to obtain data on:
  - the numbers of employees working as machinists in the different PEROSH partner countries,
  - estimates of the number of workers exposed to MWF in each country
  - number of cases of OA, OHP dermatitis etc., if this data is available through national government or occupational insurance schemes
  - national exposure databases
  - national exposure limits or guidance
  - the main types of MWF used and any trends in use of different types of MWFs
  - methods to assess exposure to MWFs.
- This information will be shared on the PEROSH website.
- PEROSH partners concluded it will be beneficial to share knowledge and expertise about the different methods being used to sample and quantify exposure to MWF mist and vapours. This could encourage greater consistency in methodology and how these methods are used to assess risks to health or to inform good control practice.
- The partners discussed the need for better access to historical and contemporary data on ill health attributable to work with MWFs, and the benefit of sharing tools used by different countries to report and investigate ill health in machinists.
- To share knowledge about research that the partners had undertaken. A summary table will be prepared containing hyperlinks to the location of relevant national / organizational reports and publications. This could be placed on the member's area of the PEROSH website.
- More needs to be done to promote awareness of the risks for skin and lung disease attributable to work with MWFs. PEROSH members were encouraged to provide examples of intervention studies to raise awareness of these risks, or that led to improved control actions.
- Some partners had been involved in the development of good practice guides either within a regulatory setting or in partnership with representative industry bodies. It was recommended that a collection of hyperlinks to websites where this guidance is available could be organized and placed on the PEROSH website.

- There was a recommendation to reconvene this meeting in the first quarter of 2021 with the specific aim of comparing the different exposure measurement methods and sampling techniques used to assess exposure to MWFs. This could lead to a PEROSH initiative for participating partners to standardise methods to assist data sharing and good practice.

List of workshop participants

Parisa Ansari	AUVA – Austria
Arto Säämänen	FIOH – Finland
Gareth Evans, Chris Barber	HSE, UK
Dietmar Breuer	IFA – Germany
Eve Bourgkard, Ronan Levilly, Pascal Wild	INRS - France
Anna Dahlman-Höglund	SAWEE - Sweden
Anne Straumfors	STAMI - Norway
Nancy B Hopf, Jean-Jacques Sauvain	Unisanté- Switzerland

Content map of day 1 presentations

Attributable health burden	Exposure measurement	Exposure Consequences	Controlling Exposure	Guidance and practice
Epidemiology	Sampling methods	Biological monitoring	Behavioural controls	Good Practice Guidance
Incident investigations	Measurement methods - chemicals	Biomarker monitoring	Engineering controls	Fit for purpose solutions
Case studies	Measurement methods - biohazards	Symptom monitoring	Personal protective equipment	Communication and influencing
Toxicology	Sensors: particles, gases, vapours	Disease monitoring	Monitoring controls	Training & standards
	Contextual data	Health data records		Record Keeping