Chemicals and Materials

Metalworking Fluids

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What are metalworking fluids?

Metalworking fluid (MWF) is the name given to a range of oils and other liquids that are used to cool and/or lubricate metal workpieces when they are being machined, ground, milled, etc. MWFs reduce the heat and friction between the cutting tool and the workpiece, and help prevent burning and smoking. Applying MWFs also helps improve the quality of the workpiece by continuously removing the fines, chips, and swarfs from the tool being used and the surface of the workpiece. (Swarfs are the small pieces of metal removed from a workpiece by a cutting tool.)

Are there different types of MWFs?

Yes. While there are many different components and additives in MWFs, there are four basic classes.

1. **Straight Oils**: Also called "cutting" or "neat" oils. This type is made up of mineral (petroleum), animal, marine, vegetable or synthetic oils. Today, the mineral oils are "severely solvent refined" or "severely hydrotreated". These terms refer to refining processes that help reduce the amount of polynuclear aromatic hydrocarbons (PAHs). Straight oils are not diluted with water but other additives may be present.

2. **Soluble Oils (emulsifiable oils)**: This category contains 30 to 85 percent severely refined petroleum oils, as well as emulsifiers to disperse the oil in water.
3. **Semi-synthetic fluids**: This category contains 5 to 30 percent severely refined petroleum oils, 30 to 50 percent water and a number of additives.
4. **Synthetic fluids**: This category does not contain petroleum oils. Instead, they use detergent-like components and other additives to help "wet" the workpiece.

Although each class will vary greatly in composition, each may contain additives such as

- Sulphurized or chlorinated compounds.
- Corrosion inhibitors (e.g., calcium sulfonate, sodium sulfonates, fatty acid soaps, amines, boric acid).
- Extreme pressure additives (e.g., sulfurized fatty materials, chlorinated paraffins, phosphorus derivatives).
- Anti-mist agents (e.g., polyisobutylene polymer).
- Anti-weld agents.
- Emulsifiers (e.g., triethanolamine, sodium petroleum sulphonates, salts of fatty acids and non-ionic surfactants).
- Alkanolamines.
- Biocides (e.g., triazine compounds, oxazolidine compounds).
- Preservatives.
- Stabilizers.
- Dispersants.
- Defoamer.
- Colourants.
- Dyes.
- Odourants.
- Fragrances.

Does the composition of MWFs change with storage or use?

Yes.

When stored, nitrosamines can form while the fluid is stored for long periods of time. Nitrosamines form slowly in the water-based MWFs and may be the result of interaction of nitrites in the fluid, lining of the cans used for storage, or from nitrogen oxides in air. Recycling MWFs can increase the problem if more reactants are added. The formation of nitrosamines in the metalworking fluids is a concern since many nitrosamines are classified as carcinogens.

When MWFs are used, a primary concern is the presence of contaminants that encourage the growth of bacteria and fungi in water-based MWFs. The bacteria can degrade the emulsions and change the properties of the MWFs. While biocides are added to reduce the amount of microbial growth, the biocide products themselves have hazardous properties.

Other sources of contamination include "tramp" oil - oil used for lubrication of the machines, such as hydraulic oil, gear box oil, and other lubricants. Tramp oils that leak into the metalworking fluids can contribute to microbial growth in many ways, including by being a source of nutrients for bacteria, and by creating various conditions for anaerobic microbial growth.

MWFs are also contaminated by small particles of the metal or alloy objects (e.g., fines, chips, swarfs) that come off the parts while they are being machined. Common metals used include steel or alloys containing nickel, cobalt and chromium.

In addition, while the extent of the problem is not clear, there is the potential for straight oils to be heated during use (usually at the site where the cutting tool works on the metal workpiece), and the temperature may increase high enough to cause the formation of polynuclear hydrocarbons (or polyaromatic hydrocarbons, PAHs).

MWFs may also be contaminated by water, cleaning products used for routine housekeeping, or other products at the work site. Improper recycling of materials or the addition of unspecified fluids (such as old lubricating oils) to the MWF will also change the composition of fluid.

How do MWFs enter the body?

MWFs can enter the body when:

- The mist, aerosols, or vapour is inhaled. Exposure will depend on:
    - What kind of machining being done.
    - How the fluid is applied (e.g., manually with an oil can; flooded through a hose or pipe, or atomized (aerosolized) and the mist directed where the tool contacts the workpiece).
    - How, or if, the machine is enclosed and ventilated. Higher exposures happen when:
        - The operator works close to the metalworking machine.
        - The operations involve high-speed tools or deep cuts.
        - The machines do not have an enclosed process.
        - The ventilation is poor.

- It comes into contact with the skin. The risk of absorption through the skin is high especially if there are cuts, rashes, cracks, or other breaks in the skin. Hands and arms are most at risk if adequate precautions are not taken. Fluids can splash onto the skin during machining, and can also occur when they are prepared or drained, when work pieces are handled, when tools are being changed and set, and during maintenance or cleaning operations. Rags or clothes soaked with MWF that are in constant contact with the skin are also a concern (including when rags are placed in the pockets of clothing).
- Ingested if you eat, drink or smoke at the workstation or without washing your hands first.

What are health concerns about working with MWFs?

MWFs have been associated with several health concerns. Contact dermatitis is the most common skin condition reported. Symptoms include burning, itching, and blistery skin. Inhalation of the mists may cause asthma and lung irritation (hypersensitivity pneumonitis), chronic bronchitis, and impaired lung function.

There is also evidence that some MWFs are associated with an increased risk of certain cancers such as larynx, rectum, pancreas, skin, scrotum, and bladder. Since the time between exposure and the development of the disease is often more than 20 years, most of the cancer cases associated with the use of MWFs are due to the exposure to MWFs used in the mid 1970s or earlier. In the past few decades, substantial changes to the composition of MWFs and reductions in the contaminants have occurred. As a result, the risk of cancer from more recent exposures is not as clear.

Overall, the type and severity of the health problem depend on:

- What MWF is used.

- Degree and type of contamination to the MWF.
- The level (how much), duration (how long), and frequency (how often) of exposure.

The three major areas of concern (skin, respiratory and cancer) are described in more detail below.

Skin

All types of MWFs can cause skin irritation. If you had severe eczema as a child, there is a high risk that you will suffer dermatitis when exposed to MWFs. Exposure occurs when hands are dipped into the fluid, or when a person handles the parts, tools and equipment covered in fluid. Splashing is a concern if guarding is absent or inadequate. Clothing contaminated with MWF, poor housekeeping, and poor personal hygiene also contributes to skin exposure.

Irritant or allergic contact dermatitis is reported to occur from exposure to soluble, semisynthetic, and synthetic MWFs. Dermatitis can be caused by:

- Bacteria and their by-products.
- Chemicals added to control bacteria (biocides).
- Chemicals added to control rust and corrosion.
- Contact with metal contaminants such as nickel, cobalt and chromium, which are known sensitising agents.

Skin conditions associated with straight oils include:

- Folliculitis (inflammation of hair roots or follicles). Caused by prolonged and regular contact with straight oils.
- Oil acne (red bumps with yellow pustules/ blisters filled with pus). Caused by skin contact with oil soaked clothing. Can develop on various body parts: face, forearms, thighs, legs, etc.
- Irritation. The small metal particles (fines and swarfs), generated while parts are machined, can damage the skin and make existing irritations worse.

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Skin conditions can become disabling if not treated or if the worker continues to work with condition.

Respiratory

An increase in the number of work-related asthma, bronchitis, irritation of the respiratory tract and breathing difficulties has been reported among those exposed to MWFs. Exposure to mist, aerosol, and vapour can lead to the development of respiratory conditions or can aggravate the existing ones.

It is not clear whether respiratory problems are caused by specific fluid components, contaminants, products of microbial growth or degradation, or a combination of these factors. For example, metalworking fluid-induced asthma is reported more consistently with synthetic MWFs, but MWF-induced asthma can also occur with soluble and straight fluids.

Again, the severity of exposure depends on proximity to the machine, and if the operations involve high tool speeds and deep cuts, if the machine is enclosed, or if ventilation equipment is working properly. High pressure or excessive fluid application, contamination of fluid (with tramp oil), improper fluid selection, and poor maintenance will also result in higher exposures.

Bacteria contamination can cause irritation of respiratory tracts or flu-like symptoms, aggravate asthma, and irritate the eyes, nose and throat (causing a sore throat, red watery itchy eyes, runny nose, nose bleeds, coughing wheezing, or shortness of breath). For example, hypersensitivity pneumonitis (HP) is an allergic type reaction in the lungs that may be caused by exposure to microbial products. HP is marked by chills, fever, shortness of breath and a deep cough - similar to a cold that will not go away. If left untreated, it can lead to irreversible lung damage.

Cancer

Cancers often associated with exposure to metalworking fluids include rectum, pancreas, larynx, skin, scrotum, esophagus, and bladder. The National Institute for Occupational Safety and Health (NIOSH) in the USA reports that studies were not highly consistent regarding the specific types of cancer associated with MWFs. This uncertainty is likely due to the wide variation in the types of MWFs and contaminants and the lack of detailed exposure information.

Also, because the latency period (the time between first exposure and the discovery of disease) for cancer is often 20 years or more, it is likely that the diseases studied recently are associated with older formulations of MWFs (from the mid 1970s and earlier). For example, fluids used before 1985 may have contained nitrites, mildly refined petroleum oils and other chemicals which were removed because of health concerns. Cancer risks have likely been reduced, but there is not enough data yet to prove this theory.

Areas of concern for risk of cancer currently include:

- Unrefined mineral oils and contact with exposed skin (including oil soaked clothing and especially oily rags kept in pockets, which caused cancer of scrotum).

- Nitrites or nitrates and amines that cause the formation of nitrosamines when MWFs are heated or under pressure. Certain nitrosamines, such as N-nitrosodiethanolamines (NDELA), are known to be cancer causing agents.
- Some biocides release formaldehyde, a suspected carcinogen. Formaldehyde can also speed up the formation of nitrosamines.
- Chlorinated paraffins are carcinogens (often used when extreme pressure is required). They also form dioxin, another carcinogen.

How do you find out about the composition of a MWF?

The supplier/manufacturers of the fluid can provide you with the Safety Data Sheet (SDS) which will provide information about the ingredients and health and safety hazards.

It is important to monitor the MWF for contamination, and to have good work practices that help keep the fluids as free from contamination as possible.

How can you work safely with MWFs?

MWFs, in general, may contain any number and concentration of hazardous components. The risk of exposure to these chemicals varies with the manufacturing process, as well as changes such as refining, recycling, degradation, or using reclaimed chemicals, and potential reactions between components.

Since there are so many varieties of MWFs, it is best to work with them safely and keep exposures as low as possible, no matter which type is being used. Steps include:

- Obtain Safety Data Sheets (SDSs) from the supplier so you know exactly what type of MWF you are working with and what precautions to take.
- Obtain technical bulletins that may provide additional health and safety information.
- Apply exposure control measures.

What are some exposure control measures?

Substitution

- Choose MWFs with the least toxic materials, whenever possible.

Engineering controls

Design and operation

Fine mists are created when the MWF stream breaks up during use and becomes airborne, especially when the fluid is moved at a high speed or velocity. The small mist droplets are easily suspended in air and are hard to contain or collect. To minimize the amount of mist produced it is important to choose fluid delivery systems which release minimum amount of mist.

Ways to reduce the amount of mist include the following:

- Low pressure delivery of MWF.
- Addition of mist suppressants.
- Lower MWF flow rate.
- Covered fluid reservoirs and return system to prevent contamination.
- Proper machine maintenance (e.g., no leaks causing contamination).
- Interrupt (stop) the flow of MWF when a part is not being machined instead of the fluid running continuously (e.g., feeding the machine with MWF only when parts are being machined).
- Do not use compressed air to blow clean parts covered in MWF as the air pressure will cause the fluid to become airborne.

Effective ventilation

- Exhaust ventilation prevents accumulation and recirculation of contaminants
- Local exhaust (near the source) is the most effective
- Enclosed operations are easier to ventilate

Isolation

- Install complete enclosures or splash guards, depending on the operation, to keep the metalworking fluids contained and away from the operator.

Proper use of biocides

- Use biocides according to supplier or manufacturer's directions. Overuse of biocides can cause biocide-resistant strains to develop or another strain to overtake other strains.

- Biocides themselves can cause either allergic or contact dermatitis.

Administrative controls

Good work practices include the following:

Proper maintenance of equipment

- Reduce the amount of contaminants into the MWFs, such as hydraulic oils and other "tramp" oils, by keeping equipment in good working order.
- Make sure that all systems (ventilation, guarding, etc.) are maintained properly.

Appropriate level of personal hygiene

- Stress the importance of personal hygiene. To maintain clean skin, be sure to wash with gentle soaps, use clean water and towels and wear clean work clothes (those that are not soaked in fluids).
- To prevent unintentional ingestion, do not eat, drink or smoke in the work area, and always wash your hands before eating, drinking or smoking. Observe good hygiene - wash your hands before and after you go to the bathroom.
- Barrier creams developed for specific hazards may offer a level of protection, but they should not be substituted for good personal hygiene and chemical protective gloves. The effectiveness of barrier creams has not been well documented. Some barrier creams can actually make some skin conditions worse so they should only be applied to normal, healthy skin (that is, no cuts, rashes, scratches, etc.).

Good housekeeping

- Maintain good housekeeping. Keep floors, equipment and the general work environment clean. Use appropriate cleaning agents, work practices, and protective clothing. All workers should be trained in how to clean MWFs properly.
- Spills should be cleaned immediately. Wastes, including floor wash water, should not be dumped or swept into the MWF sumps or coolant return trenches. Solvent soaked rags should be deposited in airtight metal containers.
- All machines should be cleaned and MWF changed periodically. When changing the MWF, thoroughly clean the entire system to remove bacterial deposits.

Personal Protective Equipment (PPE)

Engineering controls are preferred before using PPE, but in certain situations, PPE may be required. Employees should be trained to know when PPE are necessary, what PPE to wear, how to wear and remove it properly, the limitations of the PPE, and its proper care and maintenance.

PPE that may be required when working with metalworking machines and metalworking fluids include those that provide protection from:

- Chemicals in the MWFs, cleaning fluids, etc.
- Flying metal particles (fines and swarfs).
- Sharp edged parts.
- High temperatures / hot parts that could produce burns.
- Falling objects.
- Machine noise.

For example, gloves, protective sleeves, aprons, eye protection (goggles and/or face shields with safety goggles), chemical-resistant clothing, and caps may be needed. **However**, in some situations, gloves may not be appropriate as they can get tangled in moving parts or workpieces. A thorough hazard assessment of the task must be done.

Respiratory protection that is classified as "resistant to oil" (class R) or oil proof (class P) should be selected where appropriate. Depending on the level of airborne contaminants, an air-purifying, half mask respirator (with HEPA filter) including disposable (P- or R-series) (for oil mists less than 50 mg/m^3), or any powered, air-purifying respirator equipped with hood or helmet and HEPA filter (for oil mists less than 125 mg/m^3).

Remember that there may be other hazards associated with the MWF. For example, straight oil systems may also require fire protection. Read your SDS and technical bulletins so that you know and understand the hazards of the products that you are using, how to work safely with them, and what to do in case of spills or any emergency situations.

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