Metalworking fluids

Metalworking fluids (MWFs) are used in cutting, machining, and grinding metal parts to cool and lubricate tools, wash away chips, prolong tool life, and prevent corrosion. In small operations, fluids typically flow by gravity to individual sumps where they are filtered and pumped back to the tool. Larger operations may use a central system that circulates fluid to machines and returns it through trenches to a central reservoir.

The application of MWFs can create airborne mist. When fluid contacts rapidly spinning or heated tools, the droplets can be atomized, cooled, and inhaled by workers if not controlled.

MWFs are generally divided into two categories:

- Straight oils (neat oils, petroleum-based)
- Water-based MWFs include soluble oils, semi-synthetics, and synthetics (no petroleum oil).

Water-based fluids often contain emulsified oil and numerous additives such as ethanolamines, esters, biocides, corrosion inhibitors, emulsifiers, and anti-foaming agents. Many ingredients can irritate unprotected skin. Operators may be exposed during machine setup, part loading/unloading, reservoir filling, tool changeouts, and maintenance, not just when machining is happening.

Hazardous ingredients

Some MWF components may present health hazards:

- **Ethanolamines (mono-, di-, triethanolamine):**
  Skin irritants that may cause dermatitis or asthma;,nitrosamines, which are recognized carcinogens, may form in the presence of nitrites.
- **Formaldehyde-releasing biocides:**
  Such as 1,3,5-tris(2-dydroxyethyl)-s-triazine. When interacting with biological materials, they may release formaldehyde (human carcinogen).
- **IPBC (3-iodo-2-propynyl butylcarbamate):**
  A fungicide that can be harmful if inhaled and can cause skin sensitization.
- **Boric acid:**
  Used as a rust inhibitor or biocide; classified in the EU as Reproductive Toxicity Category 1B (may damage fertility and the unborn child).
- **Isothiazolinones:**
  Strong sensitizers that can cause occupational allergy or asthma, even at low concentrations.
- **Morpholines:**
  Corrosion inhibitors/biocides, potential skin sensitizers.

MWF contamination

MWFs can become contaminated with:

- Tramp oils (e.g., hydraulic oils)
- Fine metal particulates
- Biological growth (bacteria, fungi)

Though direct infection is unlikely, exposure to microbes or endotoxins can trigger respiratory or skin symptoms.

Biocides help maintain low microbial levels but may not eliminate contamination in systems with slime or biofilm buildup; those typically require thorough cleaning and recharge.

What are the health hazards?

Exposure to MWF aerosol and skin contact can lead to:

- Hypersensitivity pneumonitis (HP)
- Occupational asthma
- Chronic bronchitis or impaired lung function
- Irritant and allergic dermatitis

Increased risk of some cancers has been linked to older straight-oil formulations and higher past exposures. While modern fluids and controls reduce risk, respiratory and skin illness remain the primary concerns.

Measuring exposure

An industrial hygienist can measure metalworking fluid aerosol in air and compare it to:

- **NIOSH Recommended Exposure Limit (REL):**
- 0.4 mg/m^3 thoracic particulate or 0.5 mg/m3 total particulate, as a 10-hour TWA (non-regulatory).

The REL aims to prevent respiratory diseases. NIOSH NMAM Method 5524 is recommended for sampling MWF aerosol.

Exposure prevention

Substitution

Check the safety data sheet (SDS). If the product is a sensitizer or reproductive/ carcinogenic hazard, consider selecting a less hazardous fluid.

Engineering controls

- Install splash guards or machine enclosures.
- Use local exhaust ventilation (LEV) or mist collectors designed for the specific MWF type.
- Verify LEV performance and maintain it regularly.
- Do not use compressed air to blow off parts or clothing, as this greatly increases aerosolization.

Administrative controls

- Maintain correct fluid concentration, pH, and tramp oil removal.
- Replace fluids that show:
  - Foul odor
  - Slimy buildup
  - Major appearance shifts (color change, low pH)
- Follow structured sump cleaning procedures; never add new fluid to a dirty reservoir.

Personal protective equipment (PPE)

- Minimize skin exposure; select task-appropriate gloves when safe to use around rotating equipment.
- Maintenance personnel handling concentrated additives may require additional PPE.

Personal hygiene

- Wash exposed skin with mild soap and water.
- Avoid abrasive or solvent-based hand cleaners.
- Promptly change contaminated clothing.

Resources

1. NIOSH – Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids (DHHS 98-102) (bit.ly/45CmFKw)
2. OSHA – Metalworking Fluids: Best Practices Manual (bit.ly/4rhAHtf)
3. NIOSH NMAM 5524 – Sampling and analysis of metalworking fluid aerosol (bit.ly/3NMqmai)