



Standard Practice for Control of Respiratory Hazards in the Metal Removal Fluid Environment¹

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1. ~~Scope~~ Scope*

- 1.1 This practice sets forth guidelines to control respiratory hazards in the metal removal environment.
- 1.2 This practice does not include prevention of dermatitis, which is the subject of Practice [E2693](#), but it does adopt a similar systems management approach with many control elements in common.
- 1.3 This practice focuses on employee exposure via inhalation of metal removal fluids and associated airborne agents.
- 1.4 Metal removal fluids used for wet machining operations (such as cutting, drilling, milling, or grinding) that remove metal to produce the finished part are a subset of metalworking fluids. This practice does not apply to other operations (such as stamping, rolling, forging, or casting) that use metalworking fluids other than metal removal fluids. These other types of metalworking fluid operations are not included in this document because of limited information on health effects, including epidemiology studies, and on control technologies. Nonetheless, some of the exposure control approaches and guidance contained in this document may be useful for managing respiratory hazards associated with other types of metalworking fluids.
- 1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*
- 1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

- [D1356 Terminology Relating to Sampling and Analysis of Atmospheres](#)
- [D2881 Classification for Metalworking Fluids and Related Materials](#)
- [D7049 Test Method for Metalworking Fluid Aerosol in Workplace Atmospheres](#)
- [E1302 Guide for Acute Animal Toxicity Testing of Water-Miscible Metalworking Fluids](#)
- [E1370 Guide for Air Sampling Strategies for Worker and Workplace Protection](#)
- [E1497 Practice for Selection and Safe Use of Water-Miscible and Straight Oil Metal Removal Fluids](#)

¹ This practice is under the jurisdiction of ASTM Committee [E34](#) on Occupational Health and Safety and is the direct responsibility of Subcommittee [E34.50](#) on Health and Safety Standards for Metal Working Fluids.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

- [E1542 Terminology Relating to Occupational Health and Safety](#)
- [E1972 Practice for Minimizing Effects of Aerosols in the Wet Metal Removal Environment \(Withdrawn 2017\)³](#)
- [E2144 Practice for Personal Sampling and Analysis of Endotoxin in Metalworking Fluid Aerosols in Workplace Atmospheres](#)
- [E2148 Guide for Using Documents Related to Metalworking or Metal Removal Fluid Health and Safety](#)
- [E2169 Practice for Selecting Antimicrobial Pesticides for Use in Water-Miscible Metalworking Fluids](#)
- [E2275 Practice for Evaluating Water-Miscible Metalworking Fluid Bioresistance and Antimicrobial Pesticide Performance](#)
- [E2523 Terminology for Metalworking Fluids and Operations](#)
- [E2563 Practice for Enumeration of Non-Tuberculosis *Mycobacteria* in Aqueous Metalworking Fluids by Plate Count Method](#)
- [E2564 Practice for Enumeration of *Mycobacteria* in Metalworking Fluids by Direct Microscopic Counting \(DMC\) Method](#)
- [E2657 Practice for Determination of Endotoxin Concentrations in Water-Miscible Metalworking Fluids](#)
- [E2693 Practice for Prevention of Dermatitis in the Wet Metal Removal Fluid Environment](#)
- [E2694 Test Method for Measurement of Adenosine Triphosphate in Water-Miscible Metalworking Fluids](#)
- [E3265 Guide for Evaluating Water-Miscible Metalworking Fluid Foaming Tendency](#)

2.2 *OSHA (U.S. Occupational Safety and Health Administration) Standards:*³

- [29 CFR 1910.132 Personal Protective Equipment](#)
- [29 CFR 1910.134 Use of Respiratory Protection in the Workplace](#)
- [29 CFR 1010.1020 Access to Employee Exposure and Medical Records](#)
- [29 CFR 1910.1048 Formaldehyde](#)
- [29 CFR 1910.1200 Hazard Communication](#)

2.3 *EPA (U.S. Environmental Protection Agency) Standards:*⁴

- [40 CFR 156 Labeling Requirements for Pesticides and Devices](#)

2.4 *Other Documents:*

- [ANSI Technical Report B11 TR 2-1997,2-1997 Mist Control Considerations for the Design, Installation and Use of Machine Tools Using Metalworking Fluids⁵](#)
- ~~[Metal Working Fluid Optimization Guide, National Center for Manufacturing Sciences National Center for Manufacturing Sciences Metal Working Fluid Optimization Guide⁶](#)~~
- ~~[Metal Removal Fluids, ACGIH A Guide To Their Management and Control, Organization Resources Counselors, Inc. Industrial Ventilation: A Manual of Recommended Practice for Design⁷](#)~~
- ~~[Industrial Ventilation, ACGIH Industrial Ventilation: A Manual of Recommended Practice for Operation and Maintenance⁸](#)~~
- ~~[Criteria for a Recommended Standard, NIOSH Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids⁹](#)~~
- ~~[Metalworking Fluids, OSHA Metalworking Fluids: Safety and Health Best Practices Manual¹⁰](#)~~
- ~~[NIOSH Method 0500:5524 Particulates Not Otherwise Regulated, Total Metalworking Fluids \(MWF\) All Categories¹¹](#)~~

<https://standards.iteh.ai/catalog/standards/sist/4c4db4fa2-a5cc-4002-ab8b-5532c07be919/astm-e2889-23>

3. Terminology

3.1 For definitions and terms relating to this guide, refer to Terminologies [D1356](#), [E1542](#), and [E2523](#).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *dilution ventilation, n*—referring to the supply and exhaust of air with respect to an area, room, or ~~building~~; building; the

³ Code of Federal Regulations—Available from United States Government Printing Office, Washington, DC 20402:20402 or at eCFR, 29 CFR Part 1910, <https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1910?toc=1>.

⁴ Code of Federal Regulations—Available from United States Government Printing Office, Washington, DC 20402:20402 or at eCFR, 40 CFR Part 156, <https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-156>.

⁵ Available from Association for Manufacturing Technology, 7901 Westpark Drive, McLean VA 22102:American National Standards Institute (ANSI); see B11 Standards, Inc. (www.ansi.org).

⁶ Available from National Center for Manufacturing Sciences, Report 0274RE95, 3025 Boardwalk, Ann Arbor, MI 48018.

⁷ Available from Organization Resources Counselors, 1910 Sunderland Place, NW., Washington, DC 20036 or from members of the Metal Working Fluid Product Stewardship Group (MWFPSG/ACGIH at <https://portal.acgih.org/s/store#/store/browse/detail/a158a0000CgqcfAAB.SM>). Contact Independent Lubricant Manufacturers Association, 651 S. Washington Street, Alexandria, VA 22314, for a list of members of the MWFPSGSM.

⁸ Available from American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240-1634:ACGIH at <https://portal.acgih.org/s/store#/store/browse/detail/a154W0000BOaw1QAD>.

⁹ Available from U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati, OH 45226:Health (NIOSH) at <https://www.cdc.gov/niosh/docs/98-102/>.

¹⁰ Available from U.S. Occupational Health and Safety Administration, 200 Constitution Avenue NW, Washington, DC 20210 or at http://www.osha.gov/SLFC/metalworkingfluids/metalworkingfluids_manual.html:Administration (OSHA) at <https://www.osha.gov/metalworking-fluids/manual>.

¹¹ Available from U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati, OH 45226 or at <http://www.cdc.gov/niosh/docs/2003-154/pdfs/0500.pdf>:Health (NIOSH) at <https://www.cdc.gov/niosh/docs/2003-154/pdfs/5524.pdf>.

dilution of contaminated air with uncontaminated air for the purpose of controlling potential health hazards, fire and explosion conditions, odors, and nuisance-type contaminants, ~~from~~ contaminants. From Industrial Ventilation: A Manual of Recommended Practice.

3.2.2 *extractable mass, n*—the material removed by liquid extraction of the sampling filter using a mixed-polarity solvent mixture as described in Test Method [D7049](#); or NIOSH Method 5524.

3.2.2.1 *Discussion*—

This mass is an approximation of the metal removal fluid portion of the workplace aerosol.

3.2.3 *metal removal fluid (MRF), n*—any fluid in the subclass of metalworking fluids used to cut or otherwise take away material or piece of stock. **E2148**

3.2.3.1 *Discussion*—

Metal removal fluids include straight or neat oils (Classification [D2881](#)); not intended for further dilution with water, and water-miscible soluble oils, semisynthetics, and synthetics, which are intended to be diluted with water before use. Metal removal fluids become contaminated during use in the workplace with a variety of workplace substances including, but not limited to: abrasive particles, tramp oils, cleaners, dirt, metal fines and shavings, dissolved metal and hard water salts, bacteria, fungi, microbiological decay products, and waste. These contaminants can cause changes in the lubricity and cooling ability of the metal removal fluid as well as have the potential to adversely affect the health and welfare of employees in contact with the contaminated metal removal fluid. **E2148**

3.2.4 *metal removal fluid aerosol, n*—aerosol generated by operation of the machine tool itself as well as from circulation and filtration systems associated with wet metal removal operations and may include airborne contaminants of microbial origin.

3.2.4.1 *Discussion*—

Metal removal aerosol does not include background aerosol in the workplace atmosphere, which may include suspended insoluble particulates.

3.2.5 *total particulate matter, n*—the mass of material sampled through the ~~4-mm~~ 4 mm inlet of a standard ~~37-mm~~ 37 mm filter cassette when operated at 2.0 L/min, as described in Test Method [D7049](#).

3.2.5.1 *Discussion*—

As defined in Test Method [D7049](#), total particulate matter is not a measure of the inhalable or thoracic particulate mass.

3.3 *Acronyms:*

3.3.1 *GHS, n*—globally harmonized system

3.3.1.1 *Discussion*— <http://www.astm.org/standards/sist/4cdb4fa2-a5cc-4002-ab8b-5532c07be9f9/astm-e2889-23>

GHS is an acronym for the Globally Harmonized System of Classification and Labeling of Chemicals.

4. Significance and Use

- 4.1 Exposure to aerosols in the industrial metal removal environment has been associated with adverse respiratory effects.
- 4.2 Use of this practice will mitigate occupational exposure and effects of exposure to aerosols in the metal removal environment.
- 4.3 Through implementation of this practice, users should be able to reduce instances and severity of respiratory irritation and disease through the effective use of a metal removal fluid management program, appropriate product selection, appropriate machine tool design, proper air handling mechanisms, and control of microorganisms.

5. Respiratory Health Hazards Associated with Metal Removal Fluids

5.1 *General:*

5.1.1 Metal removal fluids (MRF) can cause adverse health effects through skin contact with contaminated materials, spray, or mist and through inhalation from breathing MWF mist or aerosol.

5.1.2 Skin and airborne exposures to MRF have been implicated in health problems including irritation of the skin, lungs, eyes, nose, and throat. Conditions such as dermatitis, acne, asthma, hypersensitivity pneumonitis, irritation of the upper respiratory tract, and a variety of cancers have been associated with exposure to MRF (NIOSH 1998a). The severity of health problems is dependent on a variety of factors such as the kind of fluid, the degree and type of contamination, and the level and duration of the exposure.

5.2 Skin Disorders:

5.2.1 Skin contact occurs when the worker dips his/her hands into the fluid or handles parts, tools, and equipment covered with fluid without the use of personal protective equipment, such as gloves and aprons. Skin contact may also result from fluid splashing onto the employee from the machine if guarding is absent or inadequate. For further information, refer to Practice E2693.

5.3 Respiratory Diseases:

5.3.1 Inhalation of MRF mist or aerosol may cause irritation of the lungs, throat, and nose. In general, respiratory irritation involves some type of chemical interaction between the MRF and the human respiratory system. Irritation may affect one or more the following areas: nose, throat (pharynx, larynx), the various conducting airways or tubes of the lungs (trachea, bronchi, bronchioles), and the lung air sacs (alveoli) where the air passes from the lungs into the body. Exposure to MRF mist or aerosol may also aggravate the effects of existing lung disease.

5.3.2 Some of the symptoms reported include sore throat; red, watery, itchy eyes; runny nose; nosebleeds; cough; wheezing; increased phlegm production; shortness of breath; and other cold-like symptoms. These symptoms may indicate a variety of respiratory conditions, including acute airway irritation, asthma (reversible airway obstruction), chronic bronchitis, chronically impaired lung function, and hypersensitivity pneumonitis (HP). When symptoms of respiratory irritation occur, in many cases it is unclear whether the disease was caused by specific fluid components, contamination of the in-use fluid, products of microbial growth or degradation, or a combination of factors.

5.3.3 Exposure to MRF has been associated with asthma. In asthma, airways of the lung become inflamed, causing a reduction of the flow of air into and out of the lungs. During an asthmatic attack, the airways become swollen, go into spasms and fill with mucous, reducing airflow and producing shortness of breath and a wheezing sound. A variety of components, additives, and contaminants of MRF can induce new onset asthma, aggravate pre-existing asthma, and irritate the airways of non-asthmatic employees.

5.3.4 Chronic bronchitis is a condition involving inflammation of the main airways of the lungs that occurs over a long period of time. Chronic bronchitis is characterized by a chronic cough and by coughing up phlegm. The phlegm can interfere with air passage into and out of the lungs. This condition may also cause accelerated decline in lung function, which can ultimately result in heart and lung function damage.

5.3.5 Hypersensitivity pneumonitis (HP) is a serious lung disease. Recent outbreaks of HP have been associated with exposure to aerosols of synthetic, semi-synthetic, and soluble oil MRF. In particular, contaminants and additives in MRF have been associated with outbreaks of HP (NIOSH 1998a). In the short term, HP is characterized by coughing, shortness of breath, and flu-like symptoms (fevers, chills, muscle aches, and fatigue). The chronic phase (following repeated exposures) is characterized by lung scarring associated with permanent lung disease.

5.3.6 Other factors, such as smoking, increase the possibility of respiratory diseases. Cigarette smoke may worsen the respiratory effects of MRF aerosols for all employees.

5.3.7 Respiratory effects have been observed among workers with exposures below 1.0 mg/m³ to diverse fluids,¹² with water-reduced fluids generally appearing more potent. Poorly controlled fluids have generally been more likely to be associated with adverse effects.

5.4 Cancer:

5.4.1 A number of studies have found an association between working with MRF and a variety of cancers, including cancer of the rectum, pancreas, larynx, skin, scrotum, and bladder (NIOSH 1998a). No authoritative review of studies of workers exposed to MRF has been conducted since 1999, although additional data have been published. Studies of MRF and cancer reflect the health experiences of workers exposed decades earlier. This is because the effects of cancers associated with MRF may not become evident until many years after the exposure. Airborne concentrations of MRF were known to be much higher in the 1970s and 80s than those today. The composition of MRF has also changed dramatically over the years. The fluids in use prior

¹² Gauthier, S. L., "Metal Working Fluids: Oil Mist and Beyond," *Applied Occupational & Environmental Hygiene*, Vol 18, 2003, pp. 818–824.

to 1985 may have contained nitrite, mildly refined petroleum oils, and other chemicals that were removed after 1985 for health concerns. Based on the substantial changes that have been made in the metalworking industry over the last decades, the cancer risks have likely been reduced, but there is not enough data to prove this.

6. Fluid Properties Associated with Adverse Health Effects

6.1 Aerosol Physical Properties:

6.1.1 Metal removal fluid aerosols consist of a broad range of particle sizes. Airborne particles shrink as water and other volatiles evaporate; particles farther from point of generation are smaller. The “inhalable” fraction includes very large particles excluded by the closed face filter used by NIOSH 0500 for “total particulate.” “Total” particulate includes particles larger than those in the “thoracic” fraction. Smaller particles are more easily captured by machine tool ventilation exhaust, but may pass through an air cleaner. Particles may be generated by evaporation and condensation from air cleaner filter media. Larger aerosol particles are more likely to be controlled by enclosures. Controlling metal removal fluid emissions on one machine will not affect background aerosol or other aerosol generated by other work stations; all machine tools need to be considered together. Air sampling using filter methods captures no measurable water. Oil evaporates when captured on a filter, while non-oil additives to water-soluble fluids do not.

6.2 Bioaerosols:

6.2.1 Bioaerosols include:

6.2.1.1 Whole microbes (archaeal, bacterial, and ~~funga~~funga): cells and viruses;

6.2.1.2 Microbial cell fragments: segments of cell wall material;

6.2.1.3 Biomolecules: predominantly carbohydrates, endotoxins, lipids, nucleic acids, and proteins;

6.2.1.4 Metabolites: innumerable microbial waste products (predominantly carbohydrates, organic acids, complex polymers (biofilm matrix), exotoxins, and microbial volatile organic ~~chemicals—MVOC~~chemicals—MVOC).

6.2.2 Factors affecting bioaerosol generation include:

6.2.2.1 Bioburden in recirculating, bulk MRF: the bioaerosol component of the total aerosol generated from MRF comes directly from the microbes and microbially produced molecules present in the bulk fluid. Except for MVOC, the introduction of which into the airspace is dictated by the physical-chemical properties of individual MVOC molecules, bioaerosol generation is proportional to bulk fluid bioburden.

6.2.2.2 Biofilm communities growing on MRF system surfaces are in dynamic equilibrium. Once they have formed, biofilms tend to slough off portions of the mass that are at the fluid-biofilm interface as new biofilm material is generated. The details of this equilibrium vary widely among systems.

(1) Biofilms that exist in high turbulent-flow conditions tend to be thinner than those growing in stagnant or slow laminar-flow environments.

(2) Biofilms growing in high turbulent-flow conditions tend to be more tenacious (more difficult to remove) than those growing in stagnant or low flow-rate environments.

(3) Biofilm communities are typically comprised of microbial ~~consortia~~consortia, complex communities of diverse ~~species~~species which function in ways that resemble multi-cellular ~~organisms~~organisms, excreting and secreting the full range of bioaerosol constituent molecules listed in 6.2.1.

(4) The factors described in 6.1 and 6.3 can affect the persistence and distribution of microbes and biomolecules in MRF. Consequently, these factors will also affect bioaerosol generation.

6.3 Chemicals:

6.3.1 Formulating Considerations:

6.3.1.1 Aerosols in the metal removal environment may differ significantly from the components of virgin metal removal fluid dilutions. In addition to avoiding the use of possible irritants in the original design, formulators must account for possible changes in chemistry, microbiology, levels of contamination, and alterations in physical misting when developing a metal removal fluid.

6.3.1.2 The pH of a metal removal fluid dilution impacts corrosion, materials compatibility, microbial resistance, and emulsion stability in addition to acting as a possible source of operator irritation. It is important that the pH of a working fluid avoid extremes, generally between 5 and 10. The fluid should also be buffered within the target range of the fluid such that small amounts of contaminants do not create wide shifts in pH.

6.3.1.3 Even at a stable and buffered pH, metal removal fluid formulations should limit or eliminate chemicals that pose irritation threats. These chemicals include volatile amines, aldehydes, ketones, alcohols, ethers, and multifunctional organics. Some of these materials may only be present as contaminant byproducts of primary components, or may only be generated within an in-use fluid through contact with machining components. An awareness of possible secondary reactions between the fluid and ~~piece-machine/workpiece~~ machine/workpiece substrates is key.

6.3.1.4 A recognized source of respiratory irritation in the metal removal fluid environment is microbiological contamination. A fluid formulated with materials that inhibit microbial growth and eradicate microbial contamination is necessary to mediate irritating worker mist contact. Unfortunately, many of the chemicals that are effective fluid preservatives can also contribute to irritating aerosols. Therefore, an effective formulation utilizes these preservatives within their well-defined inhibitory concentrations and within a product chemical matrix that does not magnify their irritation potential.

6.3.1.5 While mist is a physical phenomenon, metal removal fluid chemistry can play a role in enhancing or reducing mist generation in equivalent situations. Unfortunately, the dynamics of fluid chemistry and mist are not well understood. However, there exist effective chemical additives that increase droplet size and, as a result, reduce mist. These materials are generally unstable and must be added to a system continually over the life of a fluid system.

6.3.1.6 The tendency of a diluted, water-miscible metal removal fluid to foam can influence mist generation. See Guide E3265.

6.3.2 Contamination Considerations:

6.3.2.1 Diluted metal removal fluids quickly become contaminated in use. Some contaminants, such as alkaline materials, pH boosters, and similar materials, can increase the respiratory hazard.

6.3.2.2 Minimize tramp oil ~~contamination, contamination~~ such as leaking hydraulic fluids, way lubricants, and gear box lubricants. Of all potential contaminants, tramp oil has the most significant effect on increasing airborne concentrations of metal removal fluids.

6.3.3 Tankside Additive Considerations:

6.3.3.1 As supplied, antimicrobial pesticides and other additives for tankside addition can present greater health and safety risks than the metal removal fluid. Further, additives and antimicrobials are less likely to be handled automatically or with special delivery equipment than metal removal fluid concentrate, so greater care and attention are required to reduce risks of exposure.

6.3.3.2 Antimicrobial pesticides are designed to kill microorganisms and therefore have significant biological activity. To avoid potential for harm by mishandling or misapplication, antimicrobial pesticides must be handled with care. The user shall read, understand, and follow all appropriate instructions for handling, storage, and use of each antimicrobial pesticide as specified by the antimicrobial pesticide manufacturer on the ~~material safety data sheet.~~ Safety Data Sheet.

7. Metal Removal Fluid Management Practices

7.1 Management of metal removal processes is the most important step in minimizing exposure to metal removal fluid aerosols. As factors affecting aerosol generation are interdependent, a systems approach to metal removal process management will be the most effective approach.

7.2 Aerosolization of metal removal fluids may result in airborne exposure not only to the formulated components of the fluid, but also to contaminants introduced into the fluid systems while in use, including microbial contaminants.

7.3 Establish a metal removal fluid control program (see Section 12). Additional detailed guidance may be found in Practice E1497 and in Metal Removal ~~Fluids, Fluids~~: A Guide ~~To~~ Their Management and Control. Consult with your metal removal fluid suppliers.