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An American National Standard

Standard Practice for Control of Respiratory Hazards in the Metal Removal Fluid Environment[1]

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1. 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 and health practices and determine the applicability of regulatory limitations prior to use.*

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 Metal Removal 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
E1542 Terminology Relating to Occupational Health and Safety
E1972 Practice for Minimizing Effects of Aerosols in the Wet Metal Removal Environment
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 Test Method 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

[1] This test method 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.

2.2 *OSHA (US 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 (US 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, Mist Control Considerations for the Design, Installation and Use of Machine Tools Using Metalworking Fluids[5]

Metal Working Fluid Optimization Guide, National Center for Manufacturing Sciences[6]

Metal Removal Fluids, A Guide To Their Management and Control, Organization Resources Counselors, Inc.[7]

Industrial Ventilation: A Manual of Recommended Practice[8]

Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids[9]

Metalworking Fluids: Safety and Health Best Practices Manual[10]

Method 0500: Particulates Not Otherwise Regulated, Total[11]

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, the 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 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 Method D7049.

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 (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 inlet of a standard 37-mm filter cassette when operated at 2.0 L/min, as described in Method D7049.

3.2.5.1 *Discussion*—As defined in 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*—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.

[3] Code of Federal Regulations available from United States Government Printing Office, Washington, DC 20402.

[4] Code of Federal Regulations available from United States Government Printing Office, Washington, DC 20402.

[5] Available from Association for Manufacturing Technology, 7901 Westpark Drive, McLean VA 22102.

[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℠). Contact Independent Lubricant Manufacturers Association, 651 S. Washington Street, Alexandria, VA 22314, for a list of members of the MWFPSG℠.

[8] Available from American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240-1634.

[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.

[10] Available from US Occupational Health and Safety Administration, 200 Constitution Avenue NW, Washington, DC 20210 or at http://www.osha.gov/SLTC/metalworkingfluids/metalworkingfluids_manual.html

[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

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 E2693 Practice for Prevention of Dermatitis in the Wet Metal Removal Fluid Environment.

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 sacks (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/M^3 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 MWF were known to be much higher in the 1970s–80s than those today. The composition of MRF has also changed dramatically over the years. The fluids in use prior 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

[12] Gauther, S.L., Metal Working Fluids: Oil Mist and Beyond, *Applied Occupational & Environmental Hygiene*, Volume 18: 818-824, 2003.

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 fungal) 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)

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 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; complex communities of diverse species, which function in ways that resemble multi-cellular 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 machine/work piece 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.

6.3.2 *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, 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 tank side 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.

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, A Guide To Their Management and Control. Consult with your metal removal fluid suppliers.

8. Product Selection

8.1 Fluids vary in their misting characteristics. Select fluids with an understanding of their misting characteristics, bearing in mind available engineering control measures. Some fluids mist less, other factors being equal. Misting characteristics may change significantly with contamination. Some fluids retain entrained air, causing a significant increase in mist generation, possibly in areas away from the metal removal fluid operation. Polymeric additives may be useful in reducing aerosol from straight or neat oils and some water-miscible metal removal fluids. Components or contaminants may be more concentrated in the aerosol phase relative to their concentrations in the bulk fluid.

8.2 Practice E1497 and Metal Removal Fluids, A Guide to Their Management and Control describe product selection criteria. While specifically directed towards water-miscible metalworking fluids, the same principles generally apply to selection of neat or straight metal removal fluids.

8.3 Select fluids with an understanding of their acute and chronic toxicity characteristics. Guide E1302 references procedures to assess the acute toxicity of water-miscible metalworking fluids as manufactured. Review the material safety data sheet, required by 29 CFR 1910.1200, for health and safety information for the metal removal fluids being considered for the operation.

8.4 Select fluids that minimize components that can be irritating or can produce noxious odors.

8.5 Select fluids that are appropriate for the machining process, are cost-effective, can be safely disposed when they are no longer economically feasible to re-use, have supplier support, and are used with a fluid management program.

8.6 As the concentration of metal removal fluid in the machining system sump or reservoir increases, the level of chemicals in the metal removal fluid aerosol increases and the net exposure is greater. Maintaining proper metal removal fluid concentration while in use enhances machining performance and minimizes exposure potential.

9. Methods for Metal Removal Fluid Mist Minimization

9.1 *Minimizing Insoluble Particulate Matter:*

9.1.1 The difference between total particulate matter and extractable mass, as measured by Method D7049, is an estimate of the insoluble particulate matter in the machining environment. Minimize insoluble particulate matter such as may be generated by dry machining, welding operations, and so forth.

9.1.2 Estimate the background level of insoluble particulate by evaluating exposures in the workplace away from metal removal fluid operations.

9.1.3 Keep the metal removal fluid clean. Minimize accumulation of grinding swarf from cast iron grinding operations or aluminum and silicon from aluminum machining operations through proper design, selection, and maintenance of metal removal fluid filtration systems.

9.2 *Minimizing Extractable Mass Concentration:*

9.2.1 Minimize extractable mass concentration. The amount and average particle size of aerosol generated is dependent on the amount of energy imparted to the fluid. Energy may be imparted to the fluid through high pressure spray application, high speed tools, parts or machines, and any other activity that causes the bulk fluid to generate a mist of liquid droplets. The transfer of energy from the machine to the fluid can be reduced by several means. Combined means may also be required.

9.2.2 In addition to product selection, proper maintenance of metal removal fluid sump concentration, and the design, selection, and maintenance characteristics noted earlier in this section, excessive generation of metal removal fluid aerosol can be affected by parameters, such as compressed air blowoffs and higher than optimum fluid flow rates, pressures, and tool feeds and speeds.

9.2.3 Optimize machine tool feeds and speeds consistent with part finish, dimension, and productivity requirements. Excessively high speeds and feeds increase the amount of aerosol generated.

9.2.4 Minimize fluid flow rates consistent with desired part finish and dimension and movement of generated chips or swarf. If feasible, reduce or temporarily interrupt fluid flow when the metal removal operation is not occurring. Higher-than-required flow rates increase aerosol generation.

9.2.5 Reduce fluid pressure consistent with machine tool design and chip removal requirements. Use flooding instead of spray application, whenever possible.

9.2.6 Consider the geometry of fluid application. Minimize the number of directional changes the fluid must make before reaching the cutting zone.

9.2.7 Control sources of nonmetal removal fluid mists, such as from parts washers or mist lube systems.

10. Machine Tool Design & Maintenance—Engineering Control Methods

10.1 ANSI B-11 TR 2-1997 provides guidance concerning consideration for the design of metalworking fluid delivery systems, of machine tools, of machine enclosures for the control of airborne contaminants, of exhaust ductwork from machine tool enclosures, and of mist collectors, and guidelines for testing collection systems. Users of this practice should be well-versed in these considerations and implement them when practical where occupational exposures to metal removal fluids is expected to occur.

10.2 Design metal removal fluid delivery systems to minimize generation of metal removal fluid aerosols. For transfer line machines, as the earliest operation in the line is often the heaviest cut, early operations may contribute most to metal removal fluid aerosol generation.

10.3 Maintain metalworking fluid delivery system components, including pumps. Leaking seal packing, leaking mechanical seals, and leaking ports in delivery pumps entrain air in the metal removal fluid, significantly increasing aerosol generation.

10.4 Cover flumes and other sources of aerosol generation. Vent them to the metal removal fluid reservoir, if feasible, to minimize release of aerosol or to maintain negative pressure.

10.5 Select new machining and grinding equipment with enclosures and appropriate ventilation that minimizes generation of metal removal fluid aerosols in the workplace atmosphere.

10.6 Maintain existing equipment enclosures and guarding to minimize release of aerosol. Restore missing equipment and enclosures. If enclosures are not maintained or guarding is removed, larger particles may escape through openings in the enclosure.

10.7 Retrofitting existing equipment should be considered using ANSI B11 TR 2-1997 as a guide. Unless properly designed and constructed, retrofits may not significantly capture metal removal fluid aerosols.

10.8 Properly design and maintain exhaust ductwork from machine tool enclosures. ANSI B11 TR 2-1997 may be used as a guide. Inspect and clean ductwork regularly, and repair ductwork not in good working order.

10.9 Properly design and maintain mist collectors, ANSI B11 TR 2-1997 may be used as a guide. Other technologies may be appropriate. Poorly maintained mist collectors may increase metal removal fluid aerosol concentrations in workplace atmospheres. Check air cleaner filters and clean or replace as appropriate. Do not allow collected aerosol to drain back into the fluid system.

10.10 Measure exhaust airflow and compare to design specification. Make adjustments or repairs as appropriate.

10.11 Evaluate each workplace location in terms of the number of machine tools in a given area, the types of operations performed, existing ventilation patterns, ceiling height, and ultimate disposition of the collected mist.

10.12 Introduce a sufficient amount of make-up air into the plant ventilation system, particularly where machine enclosures are not present or local exhaust is ineffective. In colder weather, when doors and windows are shut, or in hotter weather in facilities with air conditioning, the amount of plant make-up air affects both the amount of insoluble particulate and extractable mass from metal removal fluid aerosol in workplace atmospheres. See Industrial Ventilation: A Manual of Recommended Practice for guidance on principles of ventilation.

11. Bioaerosol Control (Microbial Aerosols in the Metal Removal Environment)

11.1 Microorganisms can grow in all water-miscible metal removal fluid systems, producing offensive odors and potentially other adverse health effects as well as accelerating depletion of functional components of the metal removal fluid. Metal removal fluid aerosols may contain microbial contaminants, both viable and nonviable.

11.2 Monitor and control water-miscible metal removal fluid system microbiology on a routine basis. Methods E2657, E2563, E2564 and E2694 provide protocols for quantifying specific microbes and biomolecules likely to be found in metal removal fluids and metal removal fluid aerosols.

11.3 Practices E1497 and E2169 provide guidance regarding microbicides selection, storage, and use. Even if extractable mass and total particulate matter concentrations are low, uncontrolled fluid microbiology can potentially cause adverse respiratory health effects.

11.4 If unusual respiratory complaints are reported or if respiratory diseases are suspected, additional microbiological testing may be needed. Consult with your metal removal fluid or biocide supplier for their recommendations.

11.5 *Antimicrobial Pesticides and Control of Microorganisms in Metal Removal Fluids:*

11.5.1 Microorganisms can grow in all metal removal fluids, sometimes producing odors, irritation, and reducing product performance. Antimicrobial pesticides are often incorporated into water-miscible metal removal fluid formulations and are commonly added to machine sumps and to centralized water-miscible metal removal fluid systems to control microbial growth. Straight oils that become contaminated with water can also support the growth of bacteria.

11.5.2 Only antimicrobial pesticides that are registered for use in metalworking fluids by the applicable regulatory agency (the Environmental Protection Agency (EPA) in the United States) shall be used in metal removal fluids. Antimicrobial pesticide labels state approved uses.

11.5.3 Antimicrobial pesticides and combinations of antimicrobial pesticides should be evaluated for stability and efficacy in the specific fluid being used or under consideration prior to use. The use of ineffective antimicrobial pesticides may add to the toxicological burden of the metal removal fluid. See Practices E2275 and E2169.

11.5.4 Certain antimicrobial pesticides may release formaldehyde in use. Review fluid and antimicrobial pesticide MSDS information, and consult your antimicrobial pesticide and/or metal fluid supplier. See 29 CFR 1910.1048.

11.5.4.1 As discussed in Practice E2169, no individual antimicrobial pesticide is appropriate for all applications. Antimicrobial pesticides differ in their spectra of activities, speeds of kill, persistence in the treated fluid, and compatibilities with other MWF constituents. All antimicrobial pesticides