



Designation: **E2148–16 E2148 – 21**

An American National Standard

Standard Guide for Using Documents Related to Metalworking or Metal Removal Fluid Health and Safety¹

This standard is issued under the fixed designation E2148; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope-Scope*

1.1 This guide covers information on how to use documents related to health and safety of metalworking and metal removal fluids. As such, this guide will provide the user with sufficient background information to effectively use the documents listed in Section 2. Documents referenced in this guide are grouped as applicable to producers, to users or to all.

1.2 *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 requirements/limitations prior to use.*

1.3 *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](#)
- [D3519 Test Method for Foam in Aqueous Media \(Blender Test\) \(Withdrawn 2013\)³](#)
- [D3601 Test Method for Foam In Aqueous Media \(Bottle Test\) \(Withdrawn 2013\)³](#)
- [D7049 Test Method for Metalworking Fluid Aerosol in Workplace Atmospheres](#)
- [E1302 Guide for Acute Animal Toxicity Testing of Water-Miscible Metalworking Fluids](#)
- [E1497 Practice for Selection and Safe Use of Water-Miscible and Straight Oil Metal Removal Fluids](#)
- [E1542 Terminology Relating to Occupational Health and Safety](#)
- [E1687 Test Method for Determining Carcinogenic Potential of Virgin Base Oils in Metalworking Fluids](#)
- [E1972 Practice for Minimizing Effects of Aerosols in the Wet Metal Removal Environment \(Withdrawn 2017\)³](#)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](#)
- [E2169 Practice for Selecting Antimicrobial Pesticides for Use in Water-Miscible Metalworking Fluids](#)
- [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](#)

¹ This guide 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.

Current edition approved Oct. 1, 2016 Nov. 1, 2021. Published October 2016 November 2021. Originally approved in 2001. Last previous edition approved in 2014 as E2148 – 11b-E2148 – 16. DOI: 10.1520/E2148-16.10.1520/E2148-21.

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.

³ The last approved version of this historical standard is referenced on www.astm.org.

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

[E2694 Test Method for Measurement of Adenosine Triphosphate in Water-Miscible Metalworking Fluids](#)

[E2889 Practice for Control of Respiratory Hazards in the Metal Removal Fluid Environment](#)

[E3265 Guide for Evaluating Water-Miscible Metalworking Fluid Foaming Tendency](#)

2.2 *Other Documents:*

~~Management of the Metal Removal Fluid Environment: A Guide to Safe and Efficient Use of Metal Removal Fluids~~³ [Management of the Metal Removal Fluid Environment: A Guide to Safe and Efficient Use of Metal Removal Fluids](#)⁴

~~Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids~~⁴ [Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids](#)⁵

~~Metalworking Fluids: Safety and Health Best Practices Manual~~⁵ [Metalworking Fluids: Safety and Health Best Practices Manual](#)⁶

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *endotoxin, n*—pyrogenic high molar mass lipopolysaccharide (LPS) complex associated with the cell wall of gram-negative bacteria.

3.2.1.1 *Discussion—*

Though endotoxins are pyrogens, not all pyrogens are endotoxins. Endotoxins are specifically detected through a Limulus Amoebocyte Lysate (LAL) test.

3.2.2 *metal removal fluids, n*—the subset of metalworking fluids that are used for wet machining or grinding to produce the finished part.

3.2.2.1 *Discussion—*

Metal removal fluids addressed by this ~~practice~~guide include straight or neat ~~oils~~oils 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.

3.2.3 *mutagenicity index, n*—the slope of the dose response curve for mutagenicity in the modified Ames test described in Test Method [E1687](#).

4. Significance and Use

4.1 Application of this guide will provide users with information on how to use the various documents listed in Section 2 related to health and safety of metalworking and metal removal fluids.

4.2 Users of the documents listed in Section 2 may fall into several categories, such as producers of metalworking or metal removal fluids, suppliers of raw materials to those producers, users of metalworking or metal removal fluids, and other interested ~~parties~~parties such as ~~non-governmental~~non-governmental organizations.

4.3 While all parties may wish to be generally familiar with all the documents listed in Section 2, producers and users may each want to focus on certain documents which are directly applicable to them:

4.4 *Documents Applicable to Producers:*

4.4.1 [E1687 Test Method for Determining Carcinogenic Potential of Virgin Base Oils in Metalworking Fluids](#):

⁴ Available from Organization Resources Counselors, Inc., 1910 Sunderland Place, NW, Washington DC 20036 or at <http://www.orc-dc.com>

⁵ 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.

⁶ 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

4.4.1.1 Test Method **E1687** covers a microbiological test procedure based upon the *Salmonella* mutagenesis assay of Ames et. al.⁷ (see also Maron et al.).⁸ It can be used as a screening technique to detect the presence of potential dermal carcinogens in virgin base oils used in the formulation of metalworking oils. Persons who use this test should be ~~well-versed~~ well versed in the conduct of the Ames test and conversant with the physical and chemical properties of petroleum products.

4.4.1.2 Producers of metalworking fluids and metal removal fluids should assure themselves that virgin base oils used in the formulation of neat metalworking and metal removal oils and soluble and semi-synthetic metal removal fluids have an acceptable mutagenicity index or mutagenic potency index.

4.4.2 **E1302** *Guide for Acute Animal Toxicity Testing of Water-Miscible Metal Removal Fluids:*

4.4.2.1 Guide **E1302** defines acute animal toxicity tests and sets forth references for procedures to assess the acute toxicity of water-miscible metal removal fluids as manufactured.

4.4.2.2 Application of Guide **E1302** will provide information on the acute toxicity of water-miscible metal removal fluids and will assist the user in evaluating the potential health hazards of the fluid and developing appropriate work practices.

4.4.3 **E3265** *Guide for Evaluating Water-Miscible Metalworking Fluid Foaming Tendency:*

4.4.3.1 Guide **E3265** provides an overview of foaming tendency evaluation protocols and their appropriate use.

4.4.3.2 Test Methods **D3519** and **D3601** were withdrawn in 2013. Although each method had some utility, neither method reliably predicted in-use foaming tendency. Since Test Methods **D3519** and **D3601** were first adopted several more predictive test protocols have been developed. However, it is also common knowledge that no single protocol is universally suitable for predicting water-miscible metalworking fluid (MWF) foaming tendency.

4.4.3.3 There are no generally recognized reference standard fluids (either MWF or foam control additive). Instead, it is important to include a relevant reference sample in all testing.

4.4.3.4 Guide **E3265** summarizes foam forming theory then provides a summary of commonly used foaming test protocols, including blender, shake, air sparge, and recirculation tests.

4.4.3.5 For each protocol, Guide **E3265** explains the testing concept, apparatus needed, a summary of the test process, reporting, protocol variations, most appropriate applications and advantages, and least appropriate applications and limitations.

4.5 *Documents Applicable to Users:*

4.5.1 **E1497** *Practice for Selection and Safe Use of Water-Miscible and Straight Oil Metal Removal Fluids:*

4.5.1.1 Practice **E1497** sets forth guidelines for the safe use of metal removal fluids, additives, and biocides. This includes product selection, storage, dispensing, and maintenance.

4.5.1.2 Water-miscible metal removal fluids are typically used at high dilution and dilution rates vary widely. Additionally, there is potential for exposure to undiluted metal removal fluid as manufactured, as well as metal removal fluid additives and biocides.

4.5.1.3 Straight oils generally consist of a severely solvent-refined or hydro-treated petroleum oil, a synthetic oil, or other oils of animal or vegetable origin. Straight oils are not intended to be diluted with water prior to use. Additives are often included in straight oil formulations.

4.5.2 **E1972** *Practice for Minimizing Effects of Aerosols in the Wet Metal Removal Environment:*

4.5.2.1 Practice **E1972** sets forth guidelines for minimizing effects of aerosols in the wet metal removal environment.

⁷ Ames, B. N., et al., *Mutation Research*, Vol 31, 1975, pp. 347–363.

⁸ Maron, D., et al., *Mutation Research*, Vol 113, 1983, pp. 173–215.

4.5.2.2 Practice **E1972** incorporates all practical means and mechanisms to minimize aerosol generation and to control effects of aerosols in the wet metal removal environment.

4.5.3 **D7049** *Test Method for Metal Removal Fluid Aerosol in Workplace Atmospheres:*

4.5.3.1 Test Method **D7049** covers a procedure for the determination of both total collected particulate matter and extractable mass metal removal fluid aerosol concentrations in a range from 0.05 mg/m³ to 5 mg/m³ in workplace atmospheres.

4.5.3.2 Test Method **D7049** describes a standardized means of collecting worker exposure information that can be compared to existing exposure databases, using a test method that is also more specific to metal removal fluids.

4.5.4 **E2144** *Practice for Personal Sampling and Analysis of Endotoxin in Metalworking Fluid Aerosols in Workplace Atmospheres:*

4.5.4.1 Practice **E2144** covers quantitative methods for the personal sampling and determination of bacterial endotoxin concentrations in polydisperse metal removal fluid aerosols in workplace atmospheres. Users should have fundamental knowledge of microbiological techniques and endotoxin testing.

4.5.4.2 Endotoxins in metal removal fluid aerosols present potential respiratory hazards to workers who inhale them.

4.5.4.3 Users of Practice **E2144** may obtain personal exposure data of endotoxin in metal removal fluid aerosols, either on a short-term or full-shift basis in workplace atmospheres.

4.5.4.4 Practice **E2144** gives an estimate of the endotoxin concentration of the sampled atmosphere.

4.5.4.5 Practice **E2144** seeks to minimize interlaboratory variation, but does not ensure uniformity of results.

4.5.4.6 It is anticipated that Practice **E2144** will facilitate interlaboratory comparisons of airborne endotoxin data from metalworking fluid atmospheres, particularly metal removal fluid atmospheres, by providing a basis for endotoxin sampling, extraction, and analytical methods.

4.5.5 **E2169** *Practice for Selecting Antimicrobial Pesticides for Use in Water-Miscible Metalworking Fluids:*

4.5.5.1 Practice **E2169** provides recommendations for selecting antimicrobial pesticides (microbiocides) for use in water-miscible metalworking fluids (MWF). It presents information regarding regulatory requirements, as well as technical factors including target microbes, efficacy, and chemical compatibility.

4.5.5.2 Practice **E2169** is not an encyclopedic compilation of all the concepts and terminology ~~uses~~used by chemists, microbiologists, toxicologists, formulators, plant engineers, and regulatory affairs specialists involved in antimicrobial pesticide selection and application. Instead, it provides a general understanding of the selection process and its supporting considerations.

4.5.6 **E2657** *Practice for Determination of Endotoxin Concentration in Water-Miscible Metalworking Fluids:*

4.5.6.1 Practice **E2657** covers quantitative methods for the sampling and determination of Gram-negative bacterial endotoxin concentrations in ~~water miscible~~water-miscible metalworking fluids (MWF).

4.5.6.2 Users of Practice **E2657** should be familiar with the handling of MWF.

4.5.6.3 Practice **E2657** gives an estimate of the endotoxin concentration of the sampled MWF.

- (1) ~~Used on-site,~~onsite, Practice **E2657** gives an indication of changes in Gram-negative bacterial contamination in the MWF.
- (2) Practice **E2657** does not replace Practice **E2144**.

4.5.6.4 Practice **E2657** seeks to minimize ~~inter-laboratory~~interlaboratory variation but does not ensure uniformity of results.

4.5.6.5 Practice **E2657** is intended to relate endotoxin concentration in MWF to health effects of inhaled endotoxin.

4.5.7 **E2563** *Test Method for Enumeration of Non-Tuberculosis Mycobacteria in Aqueous Metalworking Fluids by Plate Count Method:*

4.5.7.1 Test Method **E2563** covers the detection and enumeration of viable and culturable rapidly growing Mycobacteria (RGM), or non-tuberculosis *Mycobacteria* (NTM) in aqueous metalworking fluids (MWF) in the presence of high non-mycobacterial background population using standard microbiological culture methods.

4.5.7.2 NTM such as *Mycobacterium immunogenum* have been implicated as causative agents of the respiratory disease, *extrinsic allergic aveolitis* (also known as *hypersensitivity pneumonitis*; HP).

4.5.7.3 The measurement of viable and culturable mycobacterial densities combined with the total mycobacterial counts (including viable culturable (VC), ~~viable non-culturable (VNC) and non-viable~~ viable non-culturable (VNC), and non-viable (NV) counts) is usually the first step in establishing any possible relationship between *Mycobacteria* and occupational health concerns (for example, HP).

4.5.7.4 Test Method **E2563** can be employed in survey studies to characterize the ~~viable-culturable~~ viable culturable mycobacterial population densities of metal working fluid field samples.

4.5.7.5 Test Method **E2563** is also applicable for establishing the mycobacterial resistance of metalworking fluid formulations by determining mycobacterium survival by means of plate count technique.

4.5.7.6 Test Method **E2563** can be used to evaluate the relative efficacy of microbicides against *Mycobacteria* in metalworking fluids.

4.5.8 **E2564** *Test Method for Enumeration of Mycobacteria in Metalworking Fluids by Direct Microscopic Counting (DMC) Method:*

4.5.8.1 Test Method **E2564** describes a direct microscopic counting method (DMC) for the enumeration of the ~~acid-fast~~ acid-fast stained mycobacteria population in metalworking fluids. It can be used to detect levels of total mycobacteria population, including culturable as well as non-culturable (possibly dead or ~~moribund~~ moribund) bacterial cells. This test method is recommended for all water-based metalworking fluids.

4.5.8.2 As noted in 4.5.7.1, non-tuberculosis mycobacteria are common members of the indigenous MWF bacterial population that have been implicated as agents of HP.

4.5.8.3 Test Method **E2564** provides a quantitative assessment of the total numbers of acid-fast ~~baeilli~~ bacilli using ~~acidfast~~ acid-fast staining to selectively identify mycobacteria from other bacteria, followed by enumeration or direct microscopic counting of a known volume over a known area.

4.5.8.4 Although other microbes—particularly the Actinomycetes—also stain acid fast, they are differentiated from the mycobacteria because of their morphology and size. Non-mycobacteria, ~~acidfast~~ acid-fast microbes are ~~50-100~~ 50 to 100 times larger than mycobacteria.

4.5.8.5 Test Method **E2564** provides quantitative information on the total (culturable and non-culturable viable, and non-viable) mycobacteria populations. The results are expressed quantitatively as mycobacteria per mL of metalworking fluid sample.

4.5.8.6 The DMC method using the acid-fast staining technique is a semi-quantitative method with a relatively fast turnaround time.

4.5.8.7 The DMC method can also be employed in field survey studies to characterize the changes in total mycobacteria densities of metalworking fluid systems over a long period of time.

4.5.8.8 The sensitivity detection limit of the DMC method depends on the MF and the sample volume (direct or centrifuged, etc.) examined.

4.5.9 **E2694** *Test Method for Measurement of Adenosine Triphosphate in Water-Miscible Metalworking Fluids:*