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Standard Test Method for Metalworking Fluid Aerosol in Workplace Atmospheres¹

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1. Scope

1.1 This test method covers a procedure for the determination of both total collected particulate matter and extractable mass metalworking fluid aerosol concentrations in the range of 0.07 to 5 mg/m³ in workplace atmospheres.

1.2 This test method 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.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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.*

1.5 *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](#)

[D3195 Practice for Rotameter Calibration](#)

[D4532 Test Method for Respirable Dust in Workplace Atmospheres Using Cyclone Samplers](#)

[D4840 Guide for Sample Chain-of-Custody Procedures](#)

[D5337 Practice for Flow Rate Adjustment of Personal Sampling Pumps](#)

¹ This test method is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.04 on Workplace Air Quality.

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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 *U.S. Government Regulations:*³

[29 CFR 1910.1000 Air Contaminants](#)

[29 CFR 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories](#)

3. Terminology

3.1 *Definitions*—For definitions of terms relating to this test method, refer to Terminology [D1356](#).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *extractable mass, n*—the amount of material removed by liquid extraction of the filter using a mixed-polarity solvent mixture.

3.2.1.1 *Discussion*—This mass is an approximation of the metal removal fluid portion of the workplace aerosol.

3.2.2 *filter set, n*—a group of filters from the same production lot that are weighed and assembled into the filter cassettes at one time.

3.2.2.1 *Discussion*—The filter set may be used for sampling on multiple days with the appropriate field blanks being submitted for each sampling day.

3.2.3 *metal removal fluids, n*—the subset of metalworking fluids that are used for wet machining or grinding to produce the finished part; such fluids are often characterized as straight, soluble, semisynthetic, and synthetic.

3.2.3.1 *Discussion*—Metalworking fluids addressed by this test method include straight or neat oils, not intended for further dilution with water, and water-miscible soluble oils, semi-synthetics, and synthetics, which are intended to be diluted with water before use. Metalworking 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 and may have the potential to adversely affect the health and welfare of employees exposed to the contaminated metal removal fluid.

³ Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, <http://www.osha.gov>.

4. Summary of Test Method

4.1 Workplace air is drawn into a 37-mm filter cassette containing a tared polytetrafluoroethylene (PTFE) filter for a measured period of time. The total particulate matter concentration is calculated from the mass gain of the filter and the volume of air sampled.

4.2 The filter is extracted with a ternary mixture of both nonpolar and polar solvents, a second mixture of methanol and water, dried, and reweighed. The extractable mass concentration is calculated from the loss of mass following extraction and the volume of air sampled.

4.3 As a cost-control procedure, the nonspecific total particulate matter concentration may be used in place of the extractable mass if the total particulate concentration is acceptable to the user of this test method.

5. Significance and Use

5.1 This test method covers the gravimetric measurement⁴ of metal removal fluid aerosol concentrations in workplace atmospheres.

5.2 This test method provides total particulate matter concentrations for comparison with historical exposure databases collected with the same technology.

5.3 This test method provides an extension to current non-standardized methods by adding an extractable mass concentration which reduces interferences from nonmetal removal fluid aerosols.

5.4 This test method does not address differences between metal removal fluid types, but it does include extraction with a broad spectrum of solvent polarity to adequately remove many of the current fluid formulations from insoluble background aerosol.⁵

5.5 This test method does not identify or quantify any specific putative toxins in the workplace that can be related to metal removal fluid aerosols or vapors.

5.6 This test method does not address the loss of semivolatile compounds from the filter during or after collection.

6. Interferences

6.1 The total particulate matter portion of this test method is not specific to metal removal fluid in the workplace and is subject to positive bias by other aerosol sources.

6.2 The extractable mass concentration measurement improves the specificity of this test method by eliminating insoluble background aerosol from the determination of the metal removal fluid aerosol concentration. This is an important consideration at low exposure limits.

6.3 Any metal removal fluid components that are insoluble in either extraction solvent mixture will not be measured in the extractable mass fraction.

6.4 The total particulate and extractable mass concentrations measured with this test method are subject to a negative bias, to the extent that semivolatile compounds are lost from the filter during sampling.

6.4.1 Samples of workplace atmospheres in which metal removal fluids containing lower viscosity petroleum fractions or volatile alkanolamines are used may be particularly subject to this negative bias both during sampling and during storage preceding analysis.

6.5 Any insoluble materials that are lost from the filter during the extraction process will be reported as extractable mass, resulting in a positive bias.

7. Apparatus

7.1 The sampling unit consists of a sampling pump and filter cassette sampler, connected by tubing.

7.1.1 *Sampling Pump*, a constant-flow personal sampling pump capable of a flow rate of 2.0 L/min ($\pm 5\%$) through the filter cassette for a full work shift (8 h).

7.1.2 *Filter Cassette*, a closed-face (4-mm opening) two- or three-piece 37-mm filter cassette with filter-support pad and inlet and outlet plugs.

7.1.3 *Filter*, the filter shall be a 2- μ m PTFE membrane filter.

7.1.4 *Clips or harnesses*, to provide a suitable means of attaching the pump and filter cassette to the worker for breathing zone sampling.

7.1.5 *Tubing*, flexible, for connecting the sampling pump to the sampler.

7.2 *Field Blank*, a filter cassette prepared for sampling that has been taken to the workplace and handled in the same manner as the analytical filters, but which has not had any air drawn through it.

7.3 *Precision Flow Meter*, for calibration of sampler flow rates (for example, bubble flow meter, or dry seal flow meter).

7.4 *Rotameter*, calibrated in accordance with Practice **D3195** for field check of sampler flow rate.

7.5 *Weighing Room*, with temperature and humidity control to allow weighing under reproducible environmental conditions of $22 \pm 2^\circ\text{C}$ and $\pm 5\%$ relative humidity in a range of 30 to 55 %.

7.6 *Analytical Balance*, capable of weighing to ± 0.001 mg.

7.7 *Antistatic Strips*, of ^{210}Po , < 200 days old since packaging.

7.8 *Plane-Parallel Press*, for assembling of filter cassettes.⁶

7.9 *Chemical Desiccator*, with indicating CaSO_4 desiccant, for drying of filters.

7.10 *Filter Funnel*, for solvent extraction of 37-mm filters using a dichloromethane, methanol, and toluene mixed solvent.

⁴ "NIOSH Method 0500," in *NIOSH Manual of Analytical Methods*, 4th ed. National Institute for Occupational Safety and Health, Cincinnati, OH. Available from National Institute for Occupational Safety and Health, 4676 Columbia Pkwy., Cincinnati, OH 45226.

⁵ "NIOSH Method 5524," in *NIOSH Manual of Analytical Methods*, 5th ed., <http://www.cdc.gov/niosh/nmam>.

⁶ See Test Method **D4532**, where a plane-parallel press is described (to aid in the assembly of sampling cassettes).

NOTE 1—At least two choices of filtration funnels are available: a 37-mm aluminum funnel and 37-mm disposable polypropylene cassettes, modified for use with this test method, with polypropylene support pads.⁷

7.11 *Laboratory Extraction Blank*, a filter that has been subjected to the extraction procedure in the same manner as the analytical filters, but which has not had any air drawn through it.

8. Reagents

8.1 *Dichloromethane*, for solvent extraction of nonpolar compounds, analytical reagent grade with a maximum residue on evaporation of 5 ppm(v).

8.2 *Methanol*, for solvent extraction of polar compounds, analytical reagent grade with a maximum residue on evaporation of 5 ppm(v).

8.3 *Toluene*, for solvent extraction of nonpolar compounds, analytical reagent grade with a maximum residue on evaporation of 5 ppm(v).

8.4 *Water*, analytical reagent grade, distilled, deionized, and filtered.

8.5 *Extraction Solvent Mixtures:*

8.5.1 *Ternary Extraction Solvent*—Prepare an extraction solvent from equal volumes of dichloromethane, methanol, and toluene.

8.5.2 *Methanol/Water Solvent*—Prepare a second extraction solvent from equal volumes of methanol (8.2) and water (8.4).

9. Hazards

9.1 The dichloromethane used as a nonpolar extraction solvent could pose a carcinogenic hazard in the laboratory.

9.2 Perform all operations involving extraction in a chemical fume hood.

9.3 Follow good laboratory procedures for worker protection and waste disposal (see for example 29 CFR 1910.1000 and 29 CFR 1910.1450).

10. Sampling

10.1 *Preparation of Filter Cassettes:*

10.1.1 Desiccate the filters (7.1.3) over CaSO₄ (7.9) for no more than 2 h.

10.1.2 Equilibrate or condition the filters in the weighing room (7.5) for a minimum of 2 h.

10.1.3 Place each filter under a ²¹⁰Po antistatic strip (7.7). Place a second antistatic strip in the balance (7.6) weighing chamber, if possible.

10.1.4 Weigh the PTFE filters (7.1.3) and record the mass to the nearest 0.001 mg (*m*₁).

10.1.5 Place the tared filter and filter support (7.1.2) in the filter cassette and close fully using the plane-parallel press (7.8).

10.1.6 Place tape around the circumference of the cassette (7.1.2) and affix a unique number on cassette. Place the

identification number so it remains visible when the cassette is opened to access the filter.

10.2 Assemble the sampling apparatus as shown in Fig. 2 of Practice D5337.

10.2.1 Remove filter plugs, attach prepared filter cassette (7.1.2, 10.1), and turn on the sampling pump (7.1.1).

10.3 Check the sampling unit for proper operation, check for leaks, and adjust the flow rate to 2.0 L/min according to Practice D5337.

10.4 Install the sampling unit on the worker with the filter cassette (7.1.2) placed in the breathing zone (7.1.4). Place the filter cassette in a manner that prevents the entry of falling or splashing material, but which does not restrict the inlet.

10.5 Record the start time and make appropriate field notes to document the process and work practices being monitored.

10.6 Sample at 2.0 L/min for a full shift.

10.6.1 Sampling times shorter than a full shift are permitted under any of the following conditions:

10.6.1.1 The filter becomes overloaded.

NOTE 2—This may be identified by discoloration of the support pad where the fluid has broken through the filter.

10.6.1.2 Specific working operations of shorter duration are being evaluated.

NOTE 3—This raises the limit of detection (LOD) of this test method.

10.6.1.3 The sample pump stops at a known time before the end of the shift.

NOTE 4—This may also raise the LOD of this test method.

10.7 Measure the final flow rate, record the stop time, and remove the sampling equipment.

10.8 Replace the filter cassette plugs.

10.9 For each sampling day, submit at least three field blank (7.2) filter cassettes or 10 % of the total used, which ever is greater.

10.10 If field blanks (7.2) within a set of filters remain consistent between days, then the field blanks may be pooled for the set of filters to reduce the LOD and limit of quantitation (LOQ) of this test method.

10.11 Calculate the LOD and LOQ of this test method using individual day field blanks.

10.12 Prepare and analyze all field blanks (7.2) in the same manner as the analytical filters (7.1.3) used for workplace sampling.

10.13 Return the filter cassettes (7.1.2) to the laboratory via overnight delivery service in a container that minimizes sample damage in transit.

10.14 Refrigerate received samples at 4 ± 2°C immediately after receipt to preclude bacterial decomposition.

10.14.1 Store samples no longer than two weeks prior to analysis.

10.15 Analyze samples (12) as soon as possible after receipt.

⁷ Harper, M., "A Simplified Procedure for the Extraction of Metalworking Fluid Samples in Accordance with Provisional ASTM/NIOSH Methods," *American Industrial Hygiene Association Journal*, Vol 63, 2002, pp. 488–492.