INTERNATIONAL

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Standard Practice for Setting and Verifying the Flow Rate of Personal Sampling Pumps[1]

This standard is issued under the fixed designation D5337; 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

1.1 This practice describes the setting and verification of flow rate for sampling pumps commonly used for monitoring personal airborne exposures in the workplace.

1.2 This practice includes procedures for using working standard flow meters that are traceable to national or international standards, as well as those that are not. Traceable standards are preferred.

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

D4532 Test Method for Respirable Dust in Workplace Atmospheres Using Cyclone Samplers

2.2 *ISO Standards:*[3]

ISO/IEC 17011 Conformity assessment – Requirements for accreditation bodies accrediting conformity assessment bodies

ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories

ISO 13137 Workplace atmospheres – Pumps for personal sampling of chemical and biological agents – Requirements and test methods

2.3 *NIOSH and OSHA Documents:*

HSM-99-71-31 Personal Sampling Pump for Charcoal Tubes; Final Report[4]

NIOSH Manual of Analytical Methods (NMAM) 0600, 5th ed.[5]

OSHA Analytical Methods Manual[6]

OSHA Technical Manual (OTM)[7]

3. Terminology

3.1 *Definitions of Terms Specific to This Practice* (otherwise, refer to Terminology D1356)*:*

3.1.1 *traceability, n*—property of a measurement result whereby the result can be related to a reference through a

[1] This practice 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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from the U.S. Department of Commerce, National Technical Information Service, Port Royal Road, Springfield, VA 22161.

[5] Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH), Cincinnati, Ohio (1994); Available from NIOSH Publications, 4676 Columbia Parkway, Cincinnati, Ohio 45226; www.cdc.gov/niosh/nmam/default.html.

[6] Occupational Safety and Health Administration, Salt Lake Technical Center, Salt Lake City, Utah (1985); Available from OSHA Analytical Laboratory, 8660 S. Sandy Parkway, Sandy, UT 84070; www.osha.gov/dts/sltc/methods.

[7] Occupational Safety and Health Administration, Washington DC; Available from OSHA website; www.osha.gov/otm/section-2-health-hazards/chapter1#appendix_II_6.

documented unbroken chain of calibrations, each contributing to the measurement uncertainty.[8]

4. Summary of Practice

4.1 A flow meter is used for setting and verifying the flow rate of personal sampling pumps. The practice is applicable to systems using air sampling devices.

4.2 The verification of flow rates using equipment demonstrated to be traceable to national or international standards is required, and the traceability of all measurement results involved in the determination of flow rate should be established on a routine (generally annual) basis. Correction of measurement results is allowed, for example, for rotameters and mass flow meters, where the results from sensors in the field measurement of the parameters used in the corrections are also traceable. Organizations which perform traceable calibration of equipment should be accredited under ISO/IEC 17025 by an organization certified to do so under ISO/IEC 17011.

4.3 In older documents flow meters with traceable calibrations have been referred to as "primary standards," and those without as "secondary standards." However, primary standard and secondary standard have different definitions in metrology, and so those terms should not be applied here. In metrology, both types of flow meters used in this practice are referred to as "working standards," with or without traceability of calibration.

5. Significance and Use

5.1 Most occupational exposure assessment methods require the use of personal sampling pumps to collect air samples at typical sampling flow rates, with sampling volumes specified by (a) particular procedure(s). The precision and bias of these methods are directly affected by the precision and bias of the pumps used in the measurement of the air volume(s) sampled.

6. Apparatus

6.1 *Sampling train,* including a sampling pump, tubing, sampling substrate, and sampler (Test Method D4532), with either bubble burette (6.2) or electronic flow meter (6.3) and other accessories as required (6.4).

6.2 *Bubble burettes,* 1 L (for high flow) and 100 mL or 10 mL (for low flow).

6.2.1 *Bubble trap,* to trap bubbles before reaching a sampler.

6.2.2 *Beaker,* 250 mL to place soap solution.

6.2.3 *Bottle,* 1 L for the use of cyclone sampler in the case that an adapter to set a flow rate is not available.

6.2.4 *Stop-watch.*

6.3 *Electronic flow meter.*

6.4 *Other Accessories*—Pulsation dampener, tube holder with variable manifold.

NOTE 1—There are several electronic flow meters developed based on different measurement principles, such as near-frictionless piston flow meter (for example, automated bubble meter, dry piston), thermal mass flow meter, and orifice flow meter. Any flow meter with traceability of calibration can be used.

NOTE 2—Some flow meters recommend a pulsation dampener between a sampling pump and the flow meter. Refer to the manufacturer's instructions.

7. Procedure

7.1 Set and verify the flow rates of the personal sampling pumps before each sampling period and verify after each sampling period.

7.2 *Flow measurement devices with traceable calibration* (as noted in 4.3, these are not traceable working standards unless the apparatus used in the calibration has been demonstrated to be traceable to national and international standards according to the appropriate schedule):

7.2.1 *Bubble Meter Method (manual):*

7.2.1.1 Allow the pump to run 5 min before setting or verifying the flow rate, or both, to stabilize pump flow.

7.2.1.2 Connect the pump with the appropriate tubing and sampler. Sampling trains used for sampling with sorbent tubes, filter cassettes, and cyclones are shown in Figs. 1-3.

NOTE 3—In common practice in the United States, and specified in the OSHA Technical Manual, a separate sampler loaded with a sampling substrate that is not used for the sample collection is utilized for all pre- and post-sampling flow rate measurements. This has the advantage of preventing contamination of a sample during the flow rate verification procedure. However, it has the disadvantage of potentially not accounting for flow rate changes resulting from the build-up of sample. For this reason, it is common practice in other jurisdictions such as in Europe to use the actual sampler when setting and verifying flow rates.

7.2.1.3 Check all connections to ensure their integrity.

7.2.1.4 Wet the inside surface of the 1 L burette with the soap solution (use a 100 mL burette for low flow pumps).

7.2.1.5 Turn on the pump and momentarily submerge the opening of the burette into the soap solution to form a bubble.

7.2.1.6 With a stop-watch, time the travel of a single film from the zero mark to the burette volume mark. Note the time and repeat this procedure at least three times.

7.2.1.7 Calculate the flow rate using the formula:

$$\text{Flow Rate (L/min)} = \frac{\text{Volume (L)}}{\text{Time (min)}} \quad (1)$$

7.2.1.8 If using a pump equipped with a rotameter, record the position of center of the float that corresponds with the flow rate. The rotameter can then be used as an approximate indicator of flow rate during the sampling period.

7.2.2 *Electronic Flow Meters:*

7.2.2.1 Allow the pump to stabilize and connect to an appropriate sampling train (see Figs. 1-3). Record the flow rate shown in the flow meter's display.

7.2.2.2 An electronic-bubble flow meter has an electronic timer that measures the time taken for the bubble to move through a defined volume, producing a direct read-out of flow rate.

[8] Joint Committee for Guides in Metrology (2012) International vocabulary of metrology — Basic and general concepts and associated terms (VIM) (International Bureau of Weights and Measures (BIPM), Sèvres, France), 3rd Ed. BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP and OIML, JCGM 200:2012 (2017 version with minor corrections and informative annotations) Available at https://jcgm.bipm.org/vim/en/.

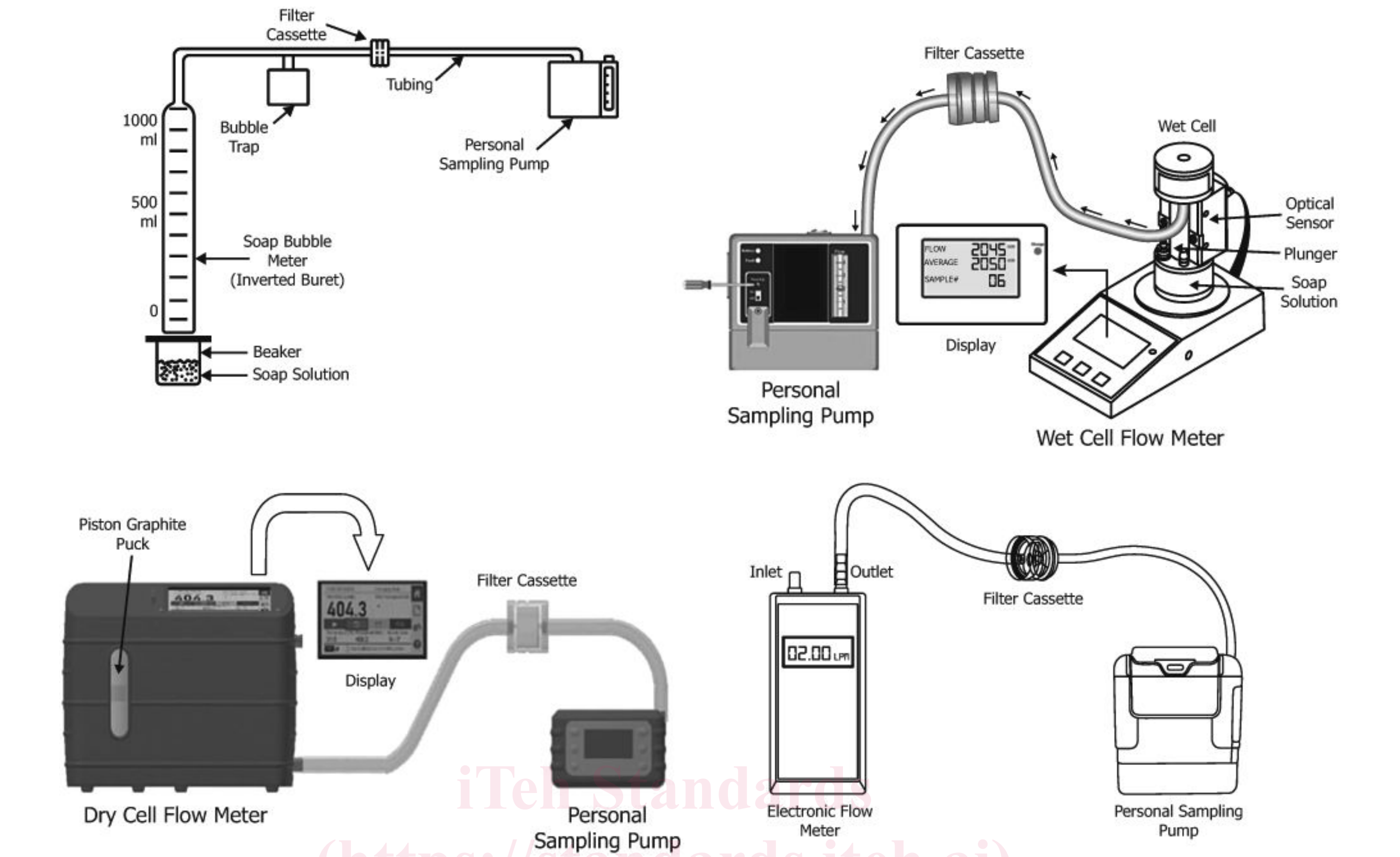

FIG. 1 Setting and Verifying Flow Rate for Personal Sampling Pump with Filter Cassette Using a Manual Bubble Burette (Top Left), Wet Cell Electronic Flow Meter (Top Right), Piston Dry Cell Flow Meter (Bottom Left), and Mass Flow Electronic Flow Meter (Bottom Right)

7.2.2.3 Dry cell or puck method utilizes a graphite puck travelling through a defined volume, producing a direct read-out of flow rate.

7.2.2.4 Orifice and thermal mass flow meter methods utilize sensors to convert temperature or pressure differentials, or both, into a volumetric flow rate. These sensors should also have a traceable calibration (4.2).

NOTE 4—For both electronic-bubble meter and dry cell methods, it is strongly recommended that users collect multiple samples (for example, ≥3 repeats) to obtain the average flow rate of the running pump. If the relative standard deviation of multiple flow rate measurements is less than 2.5 %, this can be taken as an indication of good stability of the pump.

NOTE 5—Some electronic flow meters offer flow rate measurement adjusted to standard reference conditions of temperature and pressure (STP), which produces a mass flow measurement. This measurement option is commonly signified by the use of STP as a descriptor. The STP option should not be used in the determination of concentration to be compared with occupational exposure limit values. Refer to the manufacturer's instructions.

NOTE 6—There are electronic flow meters offering options of interconnected communications between the pump and flow meter. This may be wired or via Bluetooth. Refer to the manufacturer's instructions.

NOTE 7—Personal sampling pumps should be designed to be self-adjusting to maintain the set flow rate independent of back pressure variation. Additionally, some accessories such as a tube holder with variable manifold (Fig. 2), can be operated in constant pressure mode, in which case the adjustment of flow rate is made to the accessory. Refer to the manufacturer's instructions for setting flow rate with accessories.

8. Post Flow Rate Comparisons

8.1 Pre- and post-sampling flow rates are expected to be within ±5 % of a nominal value, in which case the nominal value can be used, or within ±5 % of each other, when the average value can be used.

8.2 If the difference between the two measurements is greater than ±5 % then the sample must be flagged and the two separate results recorded, or the sample is discarded. The smaller value of flow rate can be used to determine an upper bound to the time-weighted average concentration, while the larger value provides a lower bound. The user of the data must decide how to deal with the results and must justify their choice as appropriate.

8.3 Samplers intended to select specific sizes of aerosols have nominal flow rates appropriate to this function. Flow rates outside of a 5 % range around this nominal value may affect the size-selection. Results, when measured flow rates are outside of this range, should not be used unless the magnitude of the effect is known.

9. Keywords

9.1 air monitoring; flow measurement devices; flow rate measurement; personal sampling pumps; traceable calibration