SEMI E12-0303
STANDARD FOR STANDARD PRESSURE, TEMPERATURE, DENSITY, AND FLOW UNITS USED IN MASS FLOW METERS AND MASS FLOW CONTROLLERS

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1 Purpose

1.1 In the past, confusion has existed in the values of standard temperature and standard pressure when gas flow is expressed in 'standard' volumetric units. To eliminate this confusion, the Mass Flow Controllers Committee has established this Standard.

2 Scope

2.1 This Standard provides a common basis for communication between manufacturers and users.

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3 Referenced Standards and Documents

3.1 *ASTM Standards*[1]

ASTM E380-89a — Standard Practice for Use of the International System of Units (the Modernized Metric System)

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

4 Terminology

4.1 None.

5 Standard Temperature

5.1 Standard temperature is defined as 273.15 K (0.0°C).

6 Standard Pressure

6.1 Standard pressure is defined as 101,325 pascals (1 atm, 760 Torr).

7 Standard Density

7.1 The standard density is defined as Mw/22,413.6 grams per standard cubic centimeter (g/scc), where Mw is the molecular weight of the gas in grams per mole (g/mol), and 22,413.6 is the standard molar volume in cubic centimeters (scc/mol) (i.e., the volume of one mole of a perfect gas at standard temperature and standard pressure).

8 Standard Flow Rate

8.1 Standard flow rate is the volumetric flow rate of the gas at the standard density defined in ¶ 7.1.

9 Units

9.1 Units for standard flow rate may be expressed as standard cubic centimeters per minute (sccm), standard liters per minute (slm), standard cubic decimeters per minute (scdm), or as standard cubic meters per minute (scmm).

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$$1 \text{ sccm} = 1 \times 10^{-3} \times \text{slm}$$
$$= 1 \times 10^{-3} \times \text{scdm}$$
$$= 1 \times 10^{-6} \times \text{scmm}$$

NOTE 1: Units in this document have been editorially changed to sccm, slm, scdm, and scmm in line with international standards which require all units to be expressed in SI terms. While neither 'minute' nor 'liter' is a primary SI unit, each is acceptable under the system, and eliminating the use of these units in this Standard would seriously diminish its acceptability.

10 Background

10.1 In the absence of this Specification, there has been confusion in the definition of standard conditions. 'Standard' temperature in particular has been variously defined as 59°F, 68°F, 70°F, 20°C, 22°C, etc. to reflect 'normal' test conditions. The scientific community has generally accepted 0°C, as has the semiconductor industry, in its definition of sccm. Standard pressure has almost universally been accepted as one atmosphere, except for rounding errors in different units.

10.2 Further confusion has existed in the definition of standard density when extended to vapors. For perfect gases (most light gases are nearly perfect), the standard density can be defined as the density of the gas at standard temperature and pressure. Since one gram mole of a perfect gas occupies 22,414 cubic centimeters at standard pressure and standard temperature, it follows that a flow rate of 22,414 sccm of any perfect gas is one mole per minute.

10.3 By defining standard density as in ¶ 7.1, the correlation between sccm and moles/minute is retained, even for vapors. If standard density were defined as the actual density of the vapor at standard temperature and pressure, then the correlation with moles per minute would differ by the vapor's compressibility factor (Z). This is not an acceptable alternative because the compressibility of many vapors is not accurately known, and, in fact, does not exist for those materials that are liquid at standard temperature and pressure.

11 Implications for Calibration

11.1 Since the standard flow units are defined at a standard density, they represent units of mass flow rather than volumetric flow.

11.2 Gravimetric calibration readings in grams per minute (g/min) can be converted to standard cubic centimeters per minute (sccm) by dividing by the standard density (g/scc) as defined in ¶ 7.1.

11.3 Rate-of-rise (ROR) data will generally have negligible compressibility error when operated over a low absolute pressure range. If compressibility errors are significant, they will cause the rate of pressure rise to be reduced and become pressure-dependent as the pressure increases. In this case, the pressure range must be reduced, or correction made, for compressibility.

11.4 Volumetric flow data must be corrected from actual density of the real gas at the test conditions to the standard density. The actual density can be approximated for near-perfect gases by ratios of absolute pressure and temperature to the standard density. For vapors, the actual density at the test conditions must be known from other data.

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