Designation: D3685/D3685M – 13 (Reapproved 2021)

Standard Test Methods for Sampling and Determination of Particulate Matter in Stack Gases[1]

This standard is issued under the fixed designation D3685/D3685M; 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 These test methods describe procedures to determine the mass emission rates of particulate matter and collected residue in gaseous streams by in-stack test methods (Test Method A) or out-of-stack test methods (Test Method B).

1.2 These test methods are suitable for measuring particulate matter and collected residue concentrations.

1.3 These test methods include a description of equipment and procedures to be used for obtaining samples from effluent ducts and stacks, a description of equipment and procedures for laboratory analysis, and a description of procedures for calculating results.

1.4 These test methods are applicable for sampling particulate matter and collected residue in wet (Test Method A or B) or dry (Test Method A) streams before and after particulate matter control equipment, and for determination of control device particulate matter collection efficiency.

1.5 These test methods are also applicable for determining compliance with regulations and statutes limiting particulate matter existing in stack gases when approved by federal or state agencies.

1.6 The particulate matter and collected residue samples collected by these test methods may be used for subsequent size and chemical analysis.

1.7 These test methods describe the instrumentation, equipment, and operational procedures, including site selection, necessary for sampling and determination of particulate mass emissions. These test methods also include procedures for collection and gravimetric determination of residues collected in an impinger-condenser train. The sampling and analysis of particulate matter may be performed independently or simultaneously with the determination of collected residue.

1.8 These test methods provide for the use of optional filter designs and filter material as necessary to accommodate the wide range of particulate matter loadings to which the test methods are applicable.

1.9 Stack temperatures limitation for Test Method A is approximately 400°C (752°F) and for Test Method B is 815°C (1500°F).

1.10 A known limitation of these test methods concerns the use of collected residue data. Since some collected residues can be formed in the sample train by chemical reaction in addition to condensation, these data should not be used without prior characterization (see 4.4.1).

1.10.1 A second limitation concerns the use of the test methods for sampling gas streams containing fluoride, or ammonia or calcium compounds in the presence of sulfur dioxide and other reactive species having the potential to react within the sample train.

1.10.2 A suspected but unverified limitation of these test methods concerns the possible vaporization and loss of collected particulate organic matter during a sampling run.

1.11 The values stated in either SI units or inch-pound units are to be regarded separately as standard within the text. The inch-pound units are shown in parentheses. The values stated in each system are not exact equivalents; therefore each system shall be used independently of the other. Combining values from the two systems may result in nonconformance to this standard.

1.12 *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.*

1.13 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

[1] This test method is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.03 on Ambient Atmospheres and Source Emissions.

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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]

D1071 Test Methods for Volumetric Measurement of Gaseous Fuel Samples

D1193 Specification for Reagent Water

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D2986 Practice for Evaluation of Air Assay Media by the Monodisperse DOP (Dioctyl Phthalate) Smoke Test (Withdrawn 2004)[3]

D3154 Test Method for Average Velocity in a Duct (Pitot Tube Method)

D3631 Test Methods for Measuring Surface Atmospheric Pressure

D3796 Practice for Calibration of Type S Pitot Tubes

D4536 Test Method for High-Volume Sampling for Solid Particulate Matter and Determination of Particulate Emissions (Withdrawn 2000)[3]

E1 Specification for ASTM Liquid-in-Glass Thermometers

E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

3. Terminology

3.1 *Definitions*—For definitions of terms used in these test methods, refer to Terminology D1356.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *collected residue, n—for the purpose of these test methods*, solid or liquid matter collected in the impingers employed in these test methods and remaining after solvent removal.

3.2.2 *particulate matter, n—for the purpose of these test methods*, all gas-borne matter (solid or liquid) collected in the front half of the sample train (probe, nozzle, and front half of filter).

3.3 *Symbols:*

A = internal cross-sectional area of stack, m^2 (ft^2).
A_n = cross-sectional area of nozzle, m^2 (ft^2).
B_{wo} = proportion by volume of water vapor in the gas stream, dimensionless.
C_m = dry gas meter correction factor, dimensionless.
C_p = pitot tube coefficient, dimensionless.
$C'_{P.M.}$ = concentration of particulate matter in stack gas, on the dry basis, standard conditions, mg/m^3 ($gr/dsft^3$)
$C'_{P.M._{act}}$ = concentration of particulate matter in stack gas, at actual gas conditions, mg/m^3 (gr/aft^3).
C^2_{pm} = concentration of collected residue in stack gas, dry basis, standard conditions, mg/m^3 ($gr/dsft^3$).
$C^2_{pm_{act}}$ = concentration of collected residue in stack gas, at actual conditions, mg/m^3 (gr/aft^3).
$E_{P.M.}$ = emission rate for particulate matter, kg/h (lb/h).
E^2_{pm} = emission rate for collected residue, kg/h (lb/h).
I = percent of isokinetic sampling.
M_d = dry molecular weight of stack gas, g/g-mol (lb/lb-mole).
M_{H_2O} = molecular weight of water, 18.0 g/g-mol (18.0 lb/lb-mole).
M_s = molecular weight of stack gas, wet basis, g/g-mol (lb/lb-mole).
P_{bar} = barometric pressure at the sampling site, kPa (in. Hg).
$P.M.$ = total amount of particulate matter collected, mg.
pm = total amount of collected residue, mg.
P_s = absolute stack gas pressure, kPa (in. Hg).
P_{stat} = static stack gas pressure, kPa (in. Hg).
P_{std} = absolute pressure at standard conditions, 101.3 kPa (29.9 in. Hg).
$Q_{stp\text{-}d}$ = stack gas volumetric flow rate, dry basis, standard conditions, m^3/h ($dsft^3/h$).
R = ideal gas constant = 8.32×10^{-3} ($kPa \cdot m^3$)/($K \cdot g - mol$) for the SI system, and 21.8 ($in.\ Hg \cdot ft^3$)/($°R \cdot lb - mole$) for the U.S. customary system.
T_d = average temperature of the gas in the dry gas meter, obtained from the average of the initial and the final temperatures, K (°R) (see 10.2.2.6 and 10.2.2.9).
T_m = absolute average dry gas meter temperature, K (°R).
$(T_s)_{avg}$ = absolute average stack gas temperature, K (°R).
T_{std} = absolute temperature at standard conditions, 298 K (25°C) (537°R).
T_w = temperature of the gas in the wet test meter, K (°R) (see 10.2.2.6 and 10.2.2.9).
V_d = gas volume passing through the dry gas meter, K (°R) (see 10.2.2.6 and 10.2.2.9).
V_{lc} = total volume of liquid collected in impingers and desiccant, mL.
V_m = volume of gas sample through the dry gas meter, meter conditions, m^3 (dft^3).
$V_{m_{act}}$ = volume of gas sample through the dry gas meter, corrected to actual gas conditions, m^3 (or aft^3).
$V_{m_{std}}$ = volume of gas sample through the dry gas meter, corrected to dry standard conditions, m^3 (dft^3).
$(V_s)_{avg}$ = average stack gas velocity, m/s (ft/s).
$V_{m_{std}}$ = volume of water vapor in the gas sample, corrected to actual conditions, m^3 ($dsft^3$).
V_w = gas volume passing through the wet test meter, m^3 (aft^3) (see 10.2.2.6 and 10.2.2.9).
$V_{w_{std}}$ = volume of water vapor in the gas sample, corrected to dry standard conditions, m^3 ($dsft^3$).
Y = dry gas meter calibration factor.
Y_i = ratio of accuracy of wet test meter to dry gas meter (see 10.2.2.6 and 10.2.2.9).
θ = total sampling or calibration run time, min.
ρ_{H_2O} = density of water, 997 kg/m^3, at 298 K.

[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.