Designation: E741 – 23

Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution[1]

This standard is issued under the fixed designation E741; 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 test method covers techniques using tracer gas dilution for determining a single zone's air change with the outdoors, as induced by weather conditions and by mechanical ventilation. These techniques are: (*1*) concentration decay, (*2*) constant injection, and (*3*) constant concentration.

1.2 This test method is restricted to a single tracer gas.

1.3 The associated data analysis assumes that one can characterize the tracer gas concentration within the zone with a single value. The zone shall be a building, vehicle, test cell, or any conforming enclosure.

1.4 Use of this test method requires a knowledge of the principles of gas analysis and instrumentation. Correct use of the formulas presented here requires consistent use of units, especially those of time.

1.5 Determination of the contribution to air change by individual components of the zone enclosure is beyond the scope of this test method.

1.6 The results from this test method pertain only to those conditions of weather and zonal operation that prevailed during the measurement. The use of the results from this test to predict air change under other conditions is beyond the scope of this test method.

1.7 The text of this test method references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered requirements of this test method.

1.8 *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.*

1.9 *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]

D4480 Test Method for Measuring Surface Wind by Means of Wind Vanes and Rotating Anemometers (Withdrawn 1999)[3]

E260 Practice for Packed Column Gas Chromatography

E631 Terminology of Building Constructions

E779 Test Method for Determining Air Leakage Rate by Fan Pressurization

E1186 Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

2.2 *ASHRAE Documents:*[4]

ASHRAE Handbook of Fundamentals Chapter 23

ASHRAE Standard 62 Ventilation And Acceptable Indoor Air Quality

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of general terms related to building construction used in this test method, refer to Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air change flow, Q, n*—the total volume of air passing through the zone to and from the outdoors per unit time (m^3/s, m^3/h, ft^3/h).

[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.41 on Air Leakage and Ventilation Performance.

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

[4] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.

3.2.2 *air change rate, A, n*—the ratio of the total volume of air passing through the zone to and from the outdoors per unit of time to the volume of the zone (1/s, 1/h).[5]

3.2.3 *envelope, n*—the system of barriers between a conditioned building zone and the outdoors.

3.2.3.1 *Discussion*—This includes exterior doors, windows, roofs, walls, floors and ductwork. It excludes interior partitions, ducts, and so forth, that separate conditioned zones.

3.2.4 *single zone, n*—a space or set of spaces wherein the concentration of a tracer gas is maintained uniformly throughout and that only exchanges air with the outside.

3.2.4.1 *Discussion*—Multizone buildings are difficult to treat as single zones and meet the uniformity of tracer gas concentration required in this test method. Single zones within multizone buildings are difficult to isolate such that they exchange air only with the outside and not to other zones within the building via ventilation ducts, electrical conduits, elevator shafts, stairs, and other pathways.

3.2.5 *tracer gas, n*—a gas that is mixed with air and measured in very small concentrations in order to study air movement.

3.2.6 *tracer gas analyzer, n*—a device used to measure the concentration of tracer gas in an air sample.

3.2.7 *tracer gas concentration, C, n*—the ratio of the quantity of tracer gas in air to the quantity of that air (moles/mole or m^3/m^3).

3.3 *Symbols:*

3.3.1 *Variables:*

A = air change rate (1/s, 1/h).
C = concentration (dimensionless).
$CONF$ = confidence limit value (units of the variable measured).
d = desired precision (dimensionless).
ESE = estimated standard error.
i = location number.
k = constant.
n = number of data points.
N = number of sampling locations in the zone.
Q = flow (m^3/s, m^3/h, ft^3/h).
s = sample standard deviation (units of the variable estimated).
t = a specific time (s, h).
T = a period of time (s, h).
V = volume (m^3, ft^3).
α = probability (dimensionless).
ε = error (units of the variable estimated).
v = coefficient of variation (dimensionless).

3.3.2 *Superscripts:*

$'$ = value at the end of the test.
$-$ = mean value.

3.3.3 *Subscripts:*

A = pertaining to air change rate.
avg = average.
$bias$ = pertaining to bias.
C = pertaining to concentration.
est = estimated.
GA = pertaining to the gas analyzer.
i = pertaining to time or location.
inj = pertaining to the injection period.
$lower$ = lower limit.
$meas$ = pertaining to the measurement.
mix = pertaining to the mixing period.
$precis$ = pertaining to precision.
rep = pertaining to replicates.
$sample$ = pertaining to a discrete tracer gas or air sample.
$target$ = pertaining to the desired level of tracer gas.
$test$ = pertaining to the test period.
$tracer$ = pertaining to the tracer gas.
twt = weighted according to tracer gas flow.
$upper$ = upper limit.
vol = pertaining to the volume of the zone.
$zone$ = pertaining to the zone under study.
1 = first occurrence under discussion.
2 = last occurrence under discussion.

3.3.4 *Other Notations:*

Δt = time interval between periodic samples.
(t) = function of time.
(t, i) = function of time, t, and location, i.
$t(n, 1-\alpha)$ = t-distribution value for n degrees of freedom and a two-sided probability of α.

4. Summary of Test Method

4.1 This test method uses the measurement of tracer gas dilution to determine air change within a building or other enclosure that is characterized as a single zone. The measurement of the concentration, and sometimes the volume rate of the tracer gas that is injected into the zone, allows calculation of the volume rate of outgoing air from the zone. From this, one can infer the volume rate of incoming air. Three techniques are presented: (*1*) concentration decay, (*2*) constant injection, and (*3*) constant concentration. Each technique employs specific tracer gas injection and sampling strategies. Other techniques exist but are beyond the scope of this test method. Table 1 summarizes the three techniques.

4.2 *Choice of Technique*—In choosing a technique for measuring air change, consider the quantity to be measured, the comparative capabilities of the techniques, and the complexity of the required equipment.

4.2.1 *Air Change Quantity to Be Measured*—Choose between direct measurement of air change rate or air change flow. Conversions between rate and flow and vice versa are subject to the precision and bias of the measurement of the zone volume. To obtain air change rate directly, use the tracer gas decay technique. To obtain air change flow, use the constant injection or constant concentration techniques.

5. Significance and Use

5.1 *Effects of Air Change*—Air change often accounts for a significant portion of the heating or air-conditioning load of a

[5] A common way of expressing air change rate units is ACH = air changes per hour = 1/h.