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Thermal performance of buildings — Determination of air change in buildings — Tracer gas dilution method

Performances thermiques des bâtiments — Détermination du renouvellement d'air dans les bâtiments — Méthode de dilution de gaz traceurs

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights other than those identified above. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12569 was prepared by Technical Committee ISO/TC 163, *Thermal insulation*, Subcommittee SC 1, *Test and measurement methods*.

Annexes A to G of this International Standard are for information only.

Introduction

Air change often accounts for a significant portion of the heating or air-conditioning load of a building. It also affects the moisture and contaminant levels in the building. Moisture-laden air passing through cracks in the building envelope under the influence of air pressure differences and through structural elements under the influence of vapour pressure differences can condense and cause material degradation. Air flow and air change rates depend on the size and distribution of air leakage sites, pressure differences induced by wind and temperature, mechanical system operation, and occupant behaviour. An appropriate level of ventilation is also required in all buildings for hygiene reasons.

This International Standard presents three test methods that use the measurement of tracer gas concentrations to determine air change in a building or other enclosure that can be characterized as a single zone. The measurement of tracer gas concentration, and sometimes the volume rate of flow at which the tracer gas is injected into the zone, allows calculation of the volume rate of air flow leaving the zone. The volume rate of incoming air flow can be inferred from this. The three test methods presented are:

a) tracer gas decay (5.4), which tracks the decay rate of tracer gas concentration after an initial injection of tracer gas,

b) constant injection (5.5), which tracks the tracer gas concentration resulting from a known, constant injection rate of tracer gas, and

c) constant concentration (5.6), which tracks the amount of tracer gas required to maintain it at a constant concentration at a constant level.

Each test method employs specific tracer gas injection and sampling strategies. Other techniques exist, but are beyond the scope of these test methods.

Because air change depends on such variable conditions as building operation, wind speed, and indoor-outdoor temperatures, this International Standard does not provide information about building airtightness directly. ISO 9972 should be used to measure airtightness.

Thermal performance of buildings — Determination of air change in buildings — Tracer gas dilution method

1 Scope

This International Standard describes the use of tracer gas dilution for determining the air change in a single zone as induced by weather conditions or mechanical ventilation. The procedures for tracer gas dilution include concentration decay, constant injection and constant concentration. Tracer gas concentration is determined by a gas analyser. Air change rate is directly calculated from the rate of change of tracer gas concentration by the tracer gas decay method. Air flow rate is calculated directly from the tracer gas flow rate by the constant injection or constant concentration method.

These test methods are restricted to any single tracer gas. The associated data analysis assumes that the tracer gas concentration can be characterized within the zone with a single value.

NOTE The constant concentration test method given in 5.6 is usually used for multiple zones and allows the measurement of the air flow rate from the outside to each zone, if the residential zones are kept at the same concentration.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 7345, *Thermal insulation — Physical quantities and definitions.*

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 7345 and the following apply.

3.1
air flow rate

$\dot{V}$

total volume of air passing through the zone to and from the outdoors per unit of time

NOTE It is expressed in cubic metres per second or per hour (m^3/s, m^3/h).

3.2
air change rate

n

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

NOTE It is expressed in reciprocal seconds or reciprocal hours (1/s, 1/h).

3.3
building envelope
boundary or barrier separating the interior volume of a building from the outside environment

3.4
single zone
space or set of spaces wherein the concentration of a tracer gas can be maintained uniformly throughout and that only exchanges air with the outside

3.5
tracer gas
gas that can be mixed with air and measured in very small concentrations in order to study air change

NOTE The tracer gas is not used to study air movement. Rather it is used to assess air transfer, exchange or infiltration. Types of tracer gas, measuring apparatus, limits of measurement, allowable concentration and specific gravity of the tracer gases are given in annex F. A gas at a temperature extremely different from that of the room should not be used for the tracer gas dilution method.

4 Apparatus

The apparatus includes means for distributing the tracer gas, means for obtaining air specimens, a gas analyser to measure tracer gas concentration in the air specimens, and other measurement devices, as follows.

4.1 Tracer gas concentration standard

Use a source of air with a known concentration of tracer gas.

Use the tracer gas within safe limits for concentration. Avoid conditions where the amount of tracer gas that may be absorbed onto surfaces and into subordinate enclosures is significant, compared with the amount of tracer gas in the zone. Avoid conditions where the added amount of tracer gas is small, compared to the atmospheric background level of that gas. The use of radioactive tracer gases should be avoided.

4.2 Tracer gas injection and distribution apparatus

Choose an apparatus from one or more of the following, as appropriate to the test method.

4.2.1 Graduated syringe, or other container of known volume with a means for controlled release of its content.

4.2.2 Compressed tracer gas supply, with a critical orifice, a critical orifice metering valve, an electronic mass flow controller, or other tracer gas flow rate measurement and control device.

4.3 Tracer gas distribution devices

Choose an apparatus from one or more of the following, as appropriate to the test method.

4.3.1 Fans that permit good mixing within the zone of manually-injected tracer gases.

These fans are required so as not to give any influence on the air change rate.

4.3.2 Tubing networks that dispense tracer gas via manifold or switches.

All parts of the tubing network shall be clearly labelled "Tracer Gas Only" and keyed to the location that receives the tracer gas.

NOTE Leaks in tubing networks can release tracer gas at unwanted locations and in uncontrolled unwanted concentrations.

4.4 Tracer gas sampling apparatus

4.4.1 Materials for sampling apparatus

Materials used in tracer gas sampling systems shall be nonabsorbent, non-reactive, and non-diffusive to the tracer gas in use. Depending on the tracer gas, desirable materials may include glass, copper, and stainless steel. Metal foil may be appropriate for flexible containers. Other acceptable materials may include polypropylene, polyethylene, and polyamide. Materials that absorb tracer gas may cause major inaccuracies in the measurement.

NOTE Inappropriate materials may release substances that interfere with the tracer gas analyser. Depending on the tracer gas, materials to avoid include soft plastics.

4.4.2 Manual samplers, including syringes, flexible bottles, or air specimen bags with a capacity of at least three times the minimum specimen size of the gas analyser used.

Each shall have a label that may be keyed to a record of the time and location that it was used.

Manual samplers shall have an airtight seal to assure that the specimen is not diluted or contaminated. Avoid reusing sample containers without first confirming that they are not contaminated with tracer gas.

4.4.3 Sampling network for *in-situ* analysis

Label all parts "Sampling only".

The sampling network may include:

a) tubing that is keyed to the location sampled;

b) manifold that connects to individual legs of the network and receives air with mutual equal air flow rates, combines them and leads to the gas analyser;

c) selection switch that permits sampling of individual legs of the network going to the gas analyser;

d) pump that delivers air specimens through the network to the gas analyser at a rate that minimizes delays between the time air specimens leave the zone and the time they reach the gas analyser;

e) sampling device for laboratory analysis, including, for example, syringes or bag samplers or direct to the gas analyser that may be programmed to draw air specimens at defined time intervals.

NOTE Separate automatic samplers may be placed at different locations throughout the zone to be evaluated.

4.5 Gas analyser

The gas analyser shall be suitable for the tracer gas used and the concentrations applied to conform to the test procedure within the zone studied. It should be properly calibrated and have a measurement uncertainty of less than ± 5 % at the concentrations employed in the tracer gas study.

4.6 Data acquisition and control system

NOTE This equipment is optional for all but the constant concentration technique.

4.6.1 Data acquisition device, with appropriate interfaces to provide indoor and outdoor temperatures, wind speed, wind direction, and tracer gas concentration data to a computer or other machine-readable data storage unit.

4.6.2 Process controller, i.e. a computer that uses current tracer gas concentration information to control metering and switching equipment to deliver tracer gas to the appropriate parts of the network.

NOTE When a feedback process controls the gas concentrations based on gas concentration measurements, an algorithm that minimizes deviation from the target concentration is required. A digital optimal adaptive proportional control algorithm has been used effectively for constant concentration measurements.

4.7 Portable meteorological station (optional), i.e. a device that records wind speed and direction and outdoor temperature.

4.8 Temperature measurement sensor (optional), i.e. thermometer or recorder for the output of thermocouples, thermistors and resistance thermal devices.

4.9 Timing device (optional), i.e. device to provide a common standard for all events relating to the measurement procedure, including gas injection times, sampling times, and meteorological driving forces.

The time difference between events shall be determined within a 1 % uncertainty by the timing device.

5 Procedure

5.1 General

Choose the tracer gas decay method (5.4) to determine air change rate, n. To determine the air flow rate, V, choose either the constant injection (5.5) or the constant concentration (5.6) method. If the zone configuration makes maintaining a uniform concentration difficult for the decay (5.4) or constant injection (5.5) methods, then choose the constant concentration (5.6) method with automated networks for tracer gas injection and for air sampling.

5.2 Preparation of the building envelope

The preparation of the building envelope depends on the purpose of the determination of the air flow rate, as follows.

a) When measuring only the air flow rate by infiltration into a building as the result of a corresponding weather situation (e.g. in cases of energetic considerations), all internal doors should be opened, all windows and external doors should be closed and the ventilation equipment (if any) shall be switched off.

b) When measuring only the air flow rate by infiltration into a room (e.g. for hygienic considerations), the internal doors and those to the adjoining rooms should be closed (possibly sealed off) and the ventilation equipment (if any) shall be switched off if there is no leakage interference from adjoining rooms. All windows and external doors should be closed and the ventilation equipment (if any) shall be switched off.

c) When assessing of the natural ventilation of a building (e.g. tilted windows), the corresponding boundary conditions shall be watched.

It should be emphasized that there is no general method of envelope preparation, because the purpose of air flow rate measurements can have different reasons. In the case where the internal doors are closed, the constant concentration method may be applied for air change measurement.

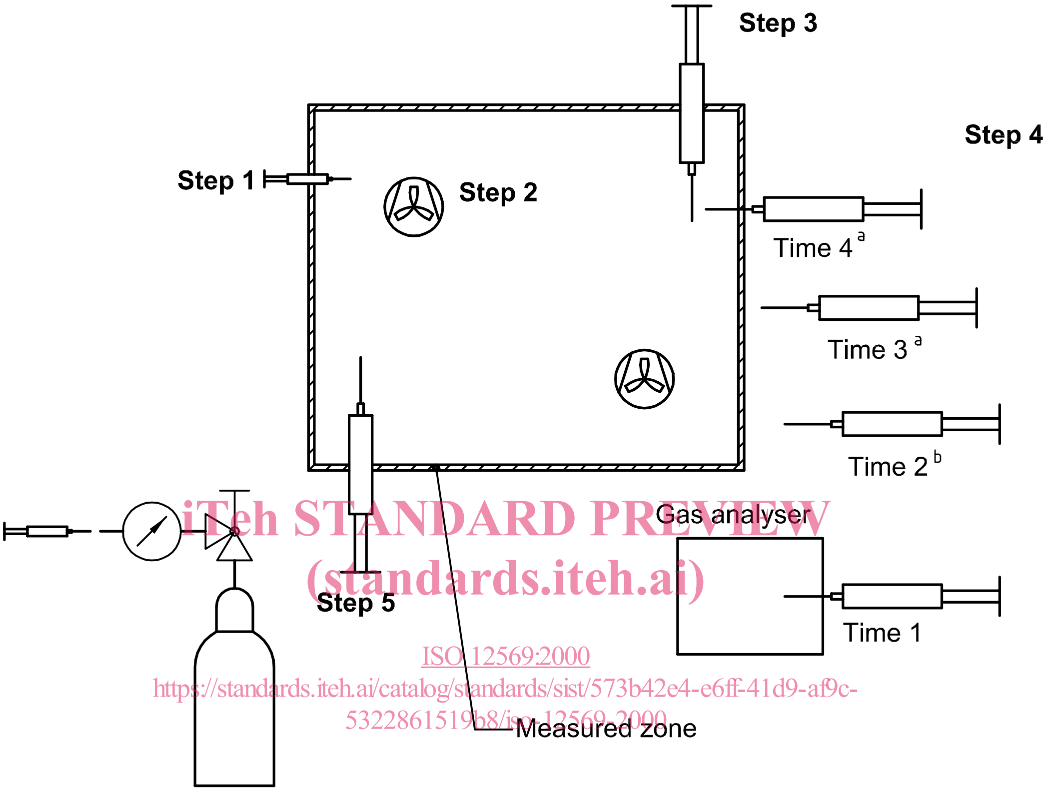
5.3 Ancillary measurements

Determine and record the indoor temperatures throughout the building zone. Obtain outdoor temperature, wind speed and wind direction from a nearby meteorological station or a portable meteorology station. Determine the status of building ventilation systems and envelope openings. Determine the volume of the zone, as required.

5.4 Tracer gas decay method

Introduce a small volume of tracer gas uniformly into the zone, sufficient to cause a concentration at the high end of the detection limits of the gas analyser. Mix the tracer gas in the zone, so that its concentration varies by less than 10 % from the mean value within the zone. Confirm a uniform initial concentration with simultaneous air specimens taken at least at two different places in the zone. Sample the air in the zone a minimum of two known times. As a recommended option, obtain additional air specimens at two different times to test the hypothesis that the air change rate was constant during the test. At the end of the sampling period, again confirm that the tracer gas concentration varies throughout the zone by less than 10 % with simultaneous air specimens. Analyse the tracer gas concentrations of the specimens. Figure 1 gives an overview of this test method.

NOTE The use of more than two samples permits determination of whether the air change rate was constant during the period or allows the choice of a period when the air change rate was constant.



NOTE For each step, perform the corresponding action in Table 1. The gas storage vessel should be stored outside the building at all times during the test.

a Recommended

b Minimum

Figure 1 — Overview of the tracer gas decay method

Table 1 — Summary procedure for the tracer gas decay method

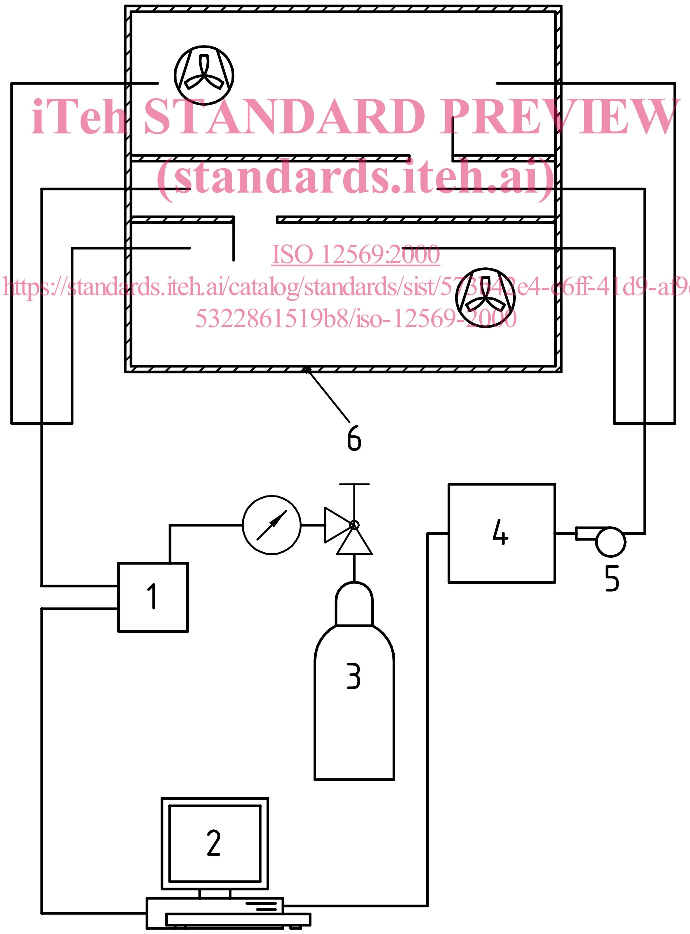
Step	Action
1	Measure and inject tracer gas.
2	Mix tracer gas uniformly.
3	Obtain spatial samples.
4	Obtain samples a minimum of two times.
5	Obtain spatial samples.

5.5 Constant injection method

Inject the tracer gas uniformly into the zone at a constant rate of flow, that is known within 2 % and is sufficient to cause a concentration within the detection limits of the gas analyser. Mix the tracer gas in the zone, so that its concentration varies by less than 10 % within the zone. Confirm a uniform concentration with simultaneous air samplings at diverse locations in the zone. Before the concentration measurement samples are taken, it is essential that the concentration of tracer gas in the zone has approached equilibrium for the prevailing weather conditions, not just an even distribution within the zone. Sample the air in the zone a minimum of two known times. As a recommended option, obtain additional air specimens at two different times to test the hypothesis that the air change rate was constant during the test. With the end of the sampling period, again confirm that the tracer gas concentration varies throughout the zone by less than 10 % by collecting simultaneously air specimens at the diverse locations with simultaneous air specimens. Analyse the tracer gas concentrations of the specimens. Determine that the concentration remains within ± 20 % of the average concentration during the measurement period. Determine the zone volume to within 15 % of the true value. Figure 2 gives an overview of this test method.

NOTE 1 The use of more than two samples permits determination of whether the air change rate was constant during the period or allows the choice of a period when the air change rate was constant.

NOTE 2 When the constant injection method is used for long-term measurements, the checks on how constant the concentration remains during the measurement period are irrelevant. For long-term tests the measurement period is broken down into short time periods (of say 30 min) and the results analysed for each of those short periods so that the trend over time of changing air change rate (or air flow rate) with weather or other parameters may be assessed.



Key

1 Gas
2 Data aquisition
3 Tracer gas
4 Gas analyser
5 Pump
6 Measured zone

Figure 2 — Overview of the constant injection method

