INTERNATIONAL STANDARD

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Thermal insulation — Determination of building airtightness — Fan pressurization method

Isolation thermique — Détermination de l'étanchéité à l'air des bâtiments — Méthode de pressurisation par ventilateur

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Contents

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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.

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.

International Standard ISO 9972 was prepared by Technical Committee ISO/TC 163, *Thermal insulation*, Subcommittee SC 1, *Test and measurement methods*.

Annexes A, B and C of this International Standard are for information only.

Introduction

The fan pressurization method produces a result that characterizes the airtightness of the building envelope or parts thereof. It can be used:

a) to compare the relative airtightness of several similar buildings or building components;

b) to identify the leakage sources and rates of leakage from different components of the same building envelope;

c) to determine the air leakage reduction for individual retrofit measures applied incrementally to an existing building or building component.

This method does not measure the air infiltration rate of a building. The results of the fan pressurization test can be used to estimate the air infiltration by means of calculation. If a direct measurement of the air infiltration is desired, other methods must be used. It is better to use the fan pressurization method for diagnostic purposes and measure the absolute infiltration rate with the tracer dilution method.

Thermal insulation — Determination of building airtightness — Fan pressurization method

1 Scope

This International Standard specifies the use of mechanical pressurization or depressurization of a building or building component. It describes techniques for measuring the resulting air flow rates at given indoor-outdoor static pressure differences. From the relationship between the air flow rates and pressure differences, the air leakage characteristics of a building envelope can be evaluated.

This International Standard is applicable to small temperature differentials and low-wind pressure conditions. For tests conducted in the field, it must be recognized that field conditions may be less than ideal. Nevertheless, strong winds and large indoor-outdoor temperature differentials should be avoided. The proper use of this International Standard requires a knowledge of the principles of air flow and pressure measurements.

This International Standard is intended for the measurement of the airtightness of building envelopes of single-zone buildings. For the purpose of this International Standard, many multi-zone buildings can be treated as single-zone buildings by opening interior doors or by inducing equal pressures in adjacent zones.

This International Standard is intended for the measurement of the airtightness of buildings and building components in the field. It does not address laboratory evaluation of air leakage through individual components. The results of the field measurements are not intended to characterize the air leakage of an isolated component but of the component and its junction with the building envelope under given conditions of installation. Therefore, the results from field tests of component airtightness may not be in agreement with the results from laboratory tests.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6781:1983, *Thermal insulation — Qualitative detection of thermal irregularities in building envelopes — Infrared method.*

ISO 7345:1987, *Thermal insulation — Physical quantities and definitions.*

3 Definitions, symbols and units

For the purposes of this International Standard, the following definitions and those given in ISO 7345 apply. Symbols and units are given in table 1.

3.1 air leakage rate: Air flow rate across the building envelope or component.

NOTE 1 This movement includes flow through joints, cracks, and porous surfaces, or a combination thereof, induced by the air-moving equipment (4.2.1).

3.2 building envelope: Boundary or barrier separating the interior volume of a building from the outside environment.

NOTE 2 The interior volume is the deliberately conditioned space within a building, generally not including the attic space, basement space, and attached structures, unless such spaces are connected to the heating and air conditioning system, such as a crawl space plenum.

Table 1 — Symbols and units

Symbol	Quantity	Unit
$\dot{V}$	Measured air flow rate	m^3/s
$\dot{V}_0$	Air leakage rate	m^3/s
q	Tracer gas injection rate	m^3/s
C	Air leakage coefficient	$m^3/(s \cdot Pa^n)$
ρ	Air density	kg/m^3
ϕ	Relative humidity	%
θ	Celsius temperature	°C
n	Air flow exponent	–
p	Pressure	Pa
p_{bar}	Uncorrected barometric pressure	Pa
p_v	Partial water vapour pressure	Pa
p_{vs}	Saturation water vapour pressure	Pa
Δp	Induced pressure difference	Pa
Δp_m	Measured pressure difference	Pa
Δp_0	Zero-flow pressure difference	Pa
Δp_{ref}	Reference pressure	Pa
η	Dynamic air viscosity	Pa·s
A	Area	m^2

4 Apparatus

4.1 General

The following description of apparatus is general in nature. Any arrangement of equipment using the same principles and capable of performing the test procedure within the allowable tolerances is permitted. Examples of equipment configurations commonly used are given in annex A.

4.2 Equipment

4.2.1 Air-moving equipment

A device that is capable of inducing a specific range of positive and negative pressure differences across the building envelope or component. The air-moving equipment shall provide constant air flow at each pressure difference for the period required to obtain readings of air flow rate. In large buildings, the heating, ventilating and air conditioning (HVAC) systems can be used.

4.2.2 Pressure-measuring device

An instrument capable of measuring pressure differences with an accuracy of ± 5 % of reading in the range of 10 Pa to 60 Pa.

4.2.3 Air flow measuring system

A device to measure air flow within ± 5 % of the reading.

4.2.4 Temperature-measuring device

An instrument to measure temperature to an accuracy of ± 1 K.

4.3 Optional equipment

4.3.1 Wind-measuring device

4.3.2 Barometer

4.3.3 Humidity-measuring device

5 Procedure

5.1 Measurement of the building envelope

5.1.1 General

The entire building must be configured to respond to pressurization as a single zone for the whole building airtightness test. The accuracy of this procedure is largely dependent on the instrumentation and apparatus used and on the ambient conditions under which the data are recorded. It is more precise to record data at higher pressure differences than at lower differences. Therefore, special care should be exercised when measurements are taken at low pressure differences.

5.1.2 Steps of the procedure

All interconnecting doors in the conditioned space shall be opened (except for cupboards and closets, which should be closed) so that a uniform pressure is maintained within the conditioned space to within a range of less than 10 % of the measured inside-outside pressure difference. This condition shall be verified by selected differential pressure measurements throughout the structure at the highest pressure contemplated.

NOTE 3 Good practice would require measuring pressures induced in adjoining spaces such as the attic and basement or adjacent apartments, since airflow into or out of these spaces may be induced by the test method.

The building should be prepared in accordance with the purpose of the test. Thus the opening, closing or sealing of specific openings such as vent dampers and fireplace openings should be based on whether or not it is the intention of the test to include these openings in the definition of the tightness of the building envelope.

NOTE 4 Good practice requires periodic calibration of the measurement system used in this test method, especially if unskilled operators perform the test.

HVAC balancing dampers and registers should not be adjusted. Fireplaces and other operable dampers should be closed unless they are used to pass air to pressurize or depressurize the building.

Make general observations of the condition of the building. Take notes on the windows, doors, opaque walls, roof and floor.

Measure the outdoor temperature at the beginning and end of the test. Record the wind speed.

Measure and record the indoor temperature at the beginning and end of the test so that their average values can be estimated. If the product of the indoor-outdoor air temperature difference, in kelvins, multiplied by the building height, in metres, gives a result greater than 200 m·K, do not perform the test, as the pressure difference induced by the stack effect is too large to allow accurate interpretation of the results.

Connect the air-moving equipment (4.2.1) to the building envelope (3.2) using a window, door, or vent opening. Ensure that the joints between the equipment and the building are sealed to eliminate any leakage.

In an airtight building, it is possible that the greatest amount of leakage occurs at the door, window or vent used to pass air during the test. Take care in such cases with the selection of the position of the air-moving equipment and/or the interpretation of the test results.

Temporarily cover the opening used by the air-moving equipment for moving air into or out of the building.

Zero the pressure-measuring device (4.2.2) by connecting the sample port to the reference port. Record the zero reading and adjust the device to indicate zero. At the end of the test, recheck the zero of the pressure-measuring device.

Install the pressure-measuring device across the building envelope at any convenient representative location. It is good practice to use more than one location across the building envelope for pressure measurement, for example, one across each facade. In checking for zero pressure, protected exterior areas should not be used and the exterior pressure tap should be placed in an exposed location near the building facade. At the beginning and end of the test, measure the zero-flow pressure difference across the building envelope induced by natural conditions with the air-moving equipment off and air intakes and exhausts covered.

It is important that, for tall buildings or large temperature differences, the pressure difference is measured close to the neutral plane of the building.

In situations where there are significant variations in pressure across the different facades of the building and at the top and bottom of the building (for example, due to wind), an average pressure difference across the four facades should be measured.

Record the zero-flow pressure reading. If the absolute value of the zero-flow pressure reading is greater than 3 Pa, do not perform the test. Analyse induced flows only for an induced pressure difference 10 times the zero-flow pressure difference.

If the wind speed is greater than 3 m/s, it is unlikely that an acceptable zero pressure reading can be obtained.

Uncover and turn on the air-moving equipment.

When the building is depressurized, air leakage sites can be located using infrared thermography in accordance with ISO 6781.

Under no circumstances should the air-moving equipment be allowed to create unsafe, hazardous or uncomfortable conditions for the building, its contents or its occupants.

The range of the induced pressure difference shall be from 10 times the zero-flow pressure to 60 Pa, depending on the capacity of the air-handling equipment. Increments of no more than 10 Pa shall be used for the full range of induced pressure differences.

Since the capacity of the air-handling equipment and the tightness of the building affect leakage measurements, the upper limit of 60 Pa may not be achievable. In such cases, a partial range encompassing at least five approximately equally spaced data points shall be substituted.

At each pressure difference, measure the air flow rate and the pressure difference across the envelope. After the fan and instrumentation have stabilized, the average over an interval equal to, or greater than, 10 s, should be used if fluctuations are observed.

It is advisable to check that the condition of the building envelope has not changed after each pressure reading, for example that sealed openings have not become unsealed or that doors, windows or dampers have not been forced open by the induced pressure.

For each test, collect data for both pressurization and depressurization.

Repeat the zero-flow pressure difference measurement. If this reading differs from the last zero-flow pressure difference reading by more than 1 Pa, repeat the test.

If the wind speed is to be a part of the measurement record, use a wind-measuring device or obtain readings from a nearby weather bureau.

To correct the air flow measurement for air density and viscosity (see annex B), read the temperature inside and outside the building before and after the test and either obtain readings of relative humidity and uncorrected barometric pressure from a nearby weather bureau or use a humidity-measuring device and barometer.

5.2 Building components

5.2.1 General

The component to be tested (for example a door, window, wall section, wall-to-wall joint or wall-to-floor joint) is covered with an airtight enclosure. This enclosure can be either a plastic sheet carefully taped to the component's edges or a specially built box. The air-moving equipment (4.2.1) including the air flow measuring system (4.2.3) and the pressure-measuring device (4.2.2), are connected to the airtight enclosure such that all the air delivered by the air-moving equipment passes through the component when the enclosure is pressurized or depressurized. The accuracy of this procedure is largely dependent on the instrumentation and apparatus used and on the ambient conditions under which the data are taken. It is more precise to take data at higher pressure differences than at lower differences. Therefore, special care should be exercised when measurements are taken at low pressure differences.

It is also possible to determine the leakage of a component without an airtight enclosure by performing the test once with the component sealed and once with the component not sealed. The flow at any pressure difference is equal to the difference between the flow with the component unsealed and the flow with the component sealed. In such cases, the flow difference shall be determined to within ± 5 %.

5.2.2 Steps of the procedure

Cover the component to be tested with the airtight enclosure and seal the edges of the enclosure to the boundary of the component being tested.

Note the limits of the tested area and the characteristics of the tested component.

Pressurize the enclosure and component to 100 Pa and check for possible leaks using accepted methods such as those using smoke, an ultrasonic meter or tracer gas. Eliminate the observed leaks.

When the enclosure is transparent in an infrared wavelength window of 2 µm to 5 µm or 8 µm to 12 µm and depressurized above 10 Pa with the indoor-outdoor temperature difference greater than 10 °C, an infrared thermographic system with a wavelength window in the appropriate range can be used to locate the air leakage sites of the component.

Turn off the air-moving equipment and temporarily cover the opening used to pressurize the enclosure.

Check the zero of the pressure-measuring device. Connect the sample port to the reference port and adjust the device so that it indicates zero.

Install the pressure-measuring device across the enclosure. Cover the opening used to pressurize the component. Check the zero pressure by measuring the zero-flow pressure induced by natural conditions with the air-moving equipment off. If the absolute value of the zero-flow pressure difference is greater than 3 Pa, do not perform the test.

The test is carried out by varying the applied pressure in increments of no more than 10 Pa from a differential pressure of 10 times the zero-flow pressure to 60 Pa. At each pressure, record the pressure difference across the component in pascals and the air flow rate in cubic metres per second.

NOTE 5 Since laboratory pressure testing of building components is often done at higher pressure differences, it may be desirable to include such pressures in field pressurization tests if one wants to compare the results of the field testing with the laboratory results.

If possible, perform the test for both positive and negative pressures.

Record the indoor and outdoor air temperatures before and after the test.

Turn off the air-moving equipment and measure the zero-flow pressure difference. If this reading differs from the last zero-flow pressure difference by more than 1 Pa, repeat the test.

To correct the air flow measurement for air density and viscosity (see annex B), read the temperature inside and outside the building before and after the test and either obtain readings of relative humidity and uncorrected barometric pressure from a nearby weather bureau or use a humidity-measuring device and barometer.

6 Expression of results

Convert the readings of the air flow measuring system to obtain the air leakage rate, $\dot{V}_0$, at the temperature and pressure of the outside air for depressurization tests or of the inside air for pressurization tests.

Subtract the average zero-flow pressure difference Δp_0 from the measured pressure difference Δp_m to obtain the induced pressure difference Δp:

$$\Delta p = \Delta p_m - \Delta p_0$$

Plot the measured air leakage rate against the corresponding pressure differences on a log-log plot to complete the air leakage graph for both pressurization and depressurization (see figure 1).

To convert the air flow rate to air leakage rate for depressurization, use

$$\dot{V}_0 = \dot{V}\left(\frac{\rho_{in}}{\rho_{out}}\right) \quad \text{... (1)}$$

where

ρ_{in} is the indoor air density, in kilograms per cubic metre;

ρ_{out} is the outdoor air density, in kilograms per cubic metre.

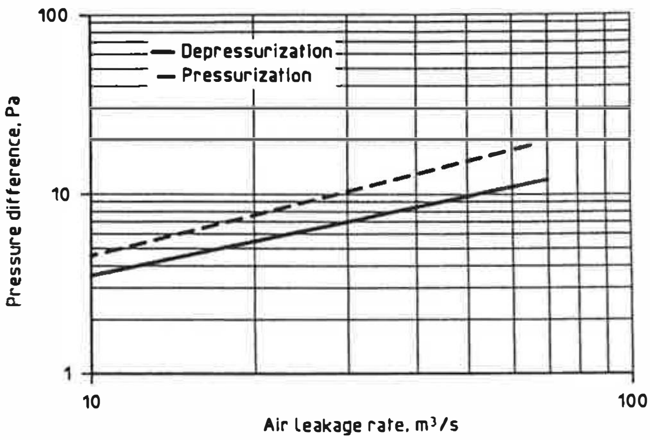

Figure 1 — Example of air leakage graph

To convert the air flow rate to air leakage rate for pressurization, use

$$\dot{V}_0 = \dot{V}\left(\frac{\rho_{out}}{\rho_{in}}\right) \quad \text{... (2)}$$

Calculate the derived quantities as follows.

The data shall be used to determine the air leakage coefficient C and air flow exponent n in the following equation:

$$\dot{V} = C\,(\Delta p)^n \quad \text{... (3)}$$

using a least squares technique, where $\dot{V}$ is the air flow rate in cubic metres per second; and dp is the differential pressure in pascals. In determining the fit of the above equation, the confidence intervals of the derived air leakage coefficient C and air flow exponent n should be calculated. C and n should be calculated separately for pressurization and depressurization.

There have been other forms of the equation between flow and pressure difference used for analysing the test data, for example, the equation

$$\Delta p = a\dot{V}^2 + b\dot{V}$$

where a and b are coefficients to be determined from the test data.

Correct the air leakage coefficient C to standard conditions [(23 ± 1) °C and 1,013 × 10³ Pa] with equation (4).

$$C_0 = C\left(\frac{\eta}{\eta_0}\right)^{2n-1}\left(\frac{\rho}{\rho_0}\right)^{1-n} \quad \text{... (4)}$$

where

η is the dynamic viscosity of air, in pascal seconds;

ρ is the air density, in kilograms per cubic metre.

The unsubscripted quantities refer to the values under the conditions of the test, the subscripted quantities to the values under the standard reference conditions. Annex B contains the equations for the temperature, barometric pressure and relative humidity dependence of ρ and η.

The leakage area A_L, in square metres, can be calculated from the correct air leakage coefficient, C_0, the exponent, n, and a reference pressure, Δp_{ref}, from the following equation:

$$A_L = C_0 \left(\frac{\rho_0}{2}\right)^{0,5} (\Delta p_{ref})^{(n-0,5)} \qquad \ldots (5)$$

The conventional reference pressure is 4 Pa, but other values may be used if the value is included in the test report. The leakage area should be separately calculated for pressurization and depressurization. If the flow at a specified pressure difference (such as 50 Pa) is desired then it should be determined from equation (3) using the derived values C and n and the specified pressure difference. The error in the calculated flow should also be determined statistically from the data used to determine $\dot{V}$ from equation (3).

NOTE 6 The value of leakage area derived from equation (5) corresponds to a physical area if the air flow exponent n is 0,5.

7 Test report

The report shall contain at least the following information.

7.1 Purpose of test

7.2 Reference to this International Standard

7.3 Description of the test specimen

Location and estimated date of construction of the building.

a) For the building envelope tightness test:

   1) floor area and volume of conditioned space, and other required dimensions of the building;

   2) the status of all openings on the building envelope (latched, sealed, open, etc.);

   3) the type, configuration and capacities of the heating, ventilating and air conditioning system.

b) For the component test:

   description of the component, including area, materials, location in the building, and other required data, with appropriate diagrams.

7.4 Apparatus and procedure employed

a) Equipment and technique employed;

b) Calibration records for the air flow measuring system and the pressure-measuring device.

7.5 Test data

Record the following:

a) date of test;

b) times of beginning and end of test;

c) table of induced pressure differences and corresponding air flows;

d) inside and outside temperatures;

e) atmospheric pressure;

f) wind speed;

g) air leakage graph (see figure 1);

h) the air leakage coefficients, C and C_0, for both pressurization and depressurization tests determined by the method given in clause 6 along with their confidence limits;

i) other derived quantities such as leakage area and building airtightness at a given pressure should be reported, if required, and for any derived quantity, an estimate of the confidence interval shall be included in the data analysis.

NOTE 7 Annex C describes a recommended procedure for estimating the errors of derived quantities.

Annex A
(informative)

Description of equipment used to pressurize buildings

There are several ways to pressurize the building envelope. The four most common are described in A.1 to A.4.

A.1 Fan and duct system

A fan is installed in a duct which is connected to the building (see figure A.1). The size of the air duct and the capacity of the fan or blower shall be matched so that the linear flow velocity within the air duct falls within the range of measurement of the air flow meter.

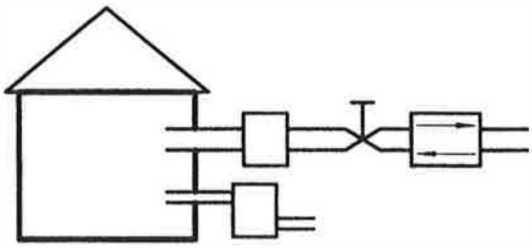

Figure A.1 — Schematic layout of equipment for whole building test

A.2 Blower door

A blower door assembly is an accepted device in many countries for performing envelope tightness measurements. The assembly includes a door mount for a fan or blower that is adjustable to fit common door openings. The fan or blower should possess a variable-speed motor to accommodate the range of required air flow rates. In order to conform to this International Standard, a blower door assembly must be calibrated to produce flow measurements to the accuracy specified in 4.2.3 for air flow measuring systems.

A.3 Component airtightness test apparatus

A component airtightness test apparatus incorporates an enclosure that is sized to fit the component to be tested (see figure A.2).

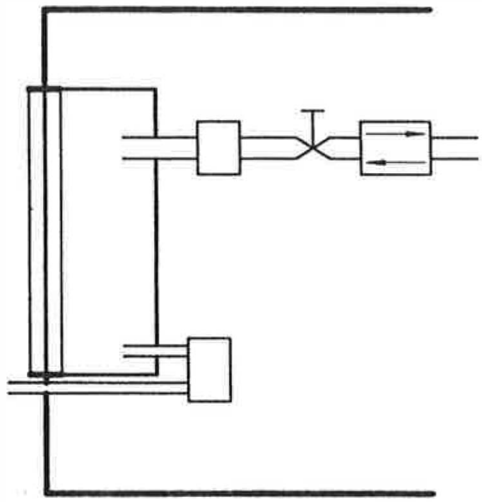

Figure A.2 — Schematic layout of equipment for component airtightness test using a pressurized enclosure

A.4 Building HVAC system fans

To determine the airtightness of large buildings, it is possible to use the building ventilation system fans for pressurization and depressurization of the building if the heating, ventilating and air conditioning (HVAC) system has fresh air intakes and exhausts. Since it is often difficult to satisfy accepted criteria for air flow rate measurements in ducts in an actual HVAC system, the air flow rate can be determined by using a constant injection of tracer into the air stream entering or leaving the building. The air flow rate is determined from

$$\dot{V} = \frac{q}{w_B} \qquad \text{. . . (A.1)}$$

where

$\dot{V}$ is the air flow rate, in cubic metres per second;

q is the tracer gas injection rate, in cubic metres per second;

w_B is the mass fraction of the tracer gas.

Annex B
(informative)

Dependence of air density and viscosity on temperature, dew point and barometric pressure

The air density, ρ, in kilograms per cubic metre, at a temperature θ, in degrees Celsius, barometric pressure, p_{bar}, in pascals, and the relative humidity, ϕ, in percent, can be obtained from the following equation:

$$\rho = \frac{p_{bar} - 0,378\,02\ p_v}{287,055(\theta + 273,15)} \qquad \text{. . . (B.1)}$$

where p_v is the partial vapour pressure of water in air given by

$$p_v = \phi \times p_{vs}$$

and p_{vs} is the saturation vapour pressure of water in air at a temperature θ obtained from the following equation:

$$p_{vs} = \exp\left[59,484\,085 - \frac{6\,790,498\,5}{\theta + 273,15} - 5,028\,02\ \ln(\theta + 273,15)\right] \qquad \text{. . . (B.2)}$$

The dynamic viscosity, η, in pascal seconds, at temperature, θ, in degrees Celsius, can be obtained from the following equation:

$$\eta = \frac{b(\theta + 273,15)^{0,5}}{1 + \frac{s}{\theta + 273,15}} \qquad \text{. . . (B.3)}$$

where

b is equal to $1,458 \times 10^{-6}$ Pa·s·K^{0,5};

s is equal to 110,4 K.

Annex C
(informative)

Recommended procedure for estimating errors in derived quantities

This International Standard contains several derived quantities which are often used to summarize the tightness of the building or component tested. It is important to report an estimate of the error in such quantities. The problem is more complicated than it appears. The following method is recommended: all derived quantities depend on the estimation of the air leakage coefficient C and air flow exponent n of equation (3). To determine C and n, make a log transformation of the variables $\dot{V}$ and Δp for each reading:

$$x_i = \ln(\Delta p_i)$$

$$y_i = \ln(\dot{V}_i) \text{ for } i = 1 \ldots N$$

where N is the total number of test readings. Equation (3) then transforms into

$$y = \ln(C) + nx \qquad \ldots \text{(C.1)}$$

Compute the following quantities

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad \ldots \text{(C.2)}$$

$$\bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i \qquad \ldots \text{(C.3)}$$

$$s_x^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2 \qquad \ldots \text{(C.4)}$$

$$s_y^2 = \frac{1}{N-1}\sum_{i=1}^{N}(y_i - \bar{y})^2 \qquad \ldots \text{(C.5)}$$

$$s_{xy} = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y}) \qquad \ldots \text{(C.6)}$$

Then the best estimate of n and $\ln(C)$ is given by:

$$n = \frac{s_{xy}}{s_x^2} \qquad \ldots \text{(C.7)}$$

$$\ln(C) = \bar{y} - n\bar{x} \qquad \ldots \text{(C.8)}$$

$$C = \exp(\bar{y} - n\bar{x}) \qquad \ldots \text{(C.9)}$$

An estimate of the confidence intervals of C and n can be determined as follows.

The variance of n is given by the estimate

$$s_n = \frac{1}{s_x}\left(\frac{s_y^2 - n s_{xy}}{N-2}\right)^{1/2} \qquad \ldots \text{(C.10)}$$

and the estimate of the variance of $\ln(C)$ is given by

$$s_{\ln(C)} = s_n \left(\frac{\sum_{i=1}^{N} x_i^2}{N}\right)^{1/2} \qquad \ldots \text{(C.11)}$$

If $T(p_r,N)$ is the significance limit of the two-sided Student's distribution for a probability p_r on N events, then the confidence intervals at that probability for $\ln(C)$ and n are respectively:

$$I_{\ln(C)} = s_{\ln(C)}\, T(p_r, N-2) \qquad \ldots \text{(C.12)}$$

$$I_n = s_n\, T(p_r, N-2) \qquad \ldots \text{(C.13)}$$

The values of the two-sided Student's distribution are given in table C.1.

This means that with a probability p_r the air flow exponent n lies in the interval $(n - I_n, n + I_n)$ and the air leakage coefficient C lies in the interval

$$C \times \exp\left[-I_{\ln(C)}\right], C \times \exp\left[I_{\ln(C)}\right]$$

The estimate of the variance around the regression line [equation (C.1)] at the value x is

$$s_y(x) = s_n\left[\frac{N-1}{N}s_x^2 + (x - \bar{x})^2\right]^{1/2} \qquad \ldots \text{(C.14)}$$

and the confidence interval in the estimate of y using equation (C.1) at any x is

$$I_y(x) = s_y(x)\, T(p_r, N-2) \qquad \text{... (C.15)}$$

Therefore the air flow rate $\dot{V}$ predicted by equation (3) at any pressure difference Δp lies in the interval

$$\dot{V} \times \exp\left[-I_{y\ln(\Delta p)}\right], \dot{V} \times \exp\left[I_{y\ln(\Delta p)}\right]$$

with a probability p_r.

It is this interval that should be used to estimate the error in the leakage area or the air flow rate across the building envelope or building envelope component at a reference pressure (for example 50 Pa). For example the confidence interval of the estimate of the leakage area A_L using equation (5) is

$$A_L \times \exp\left[-I_{y\ln(\Delta p)}\right], A_L \times \exp\left[I_{y\ln(\Delta p)}\right]$$

with a probability p_r.

Table C.1 — Two-sided confidence limits $T(p_r, N)$ for a Student's distribution

N	p_r					
	0,8	0,9	0,95	0,99	0,995	0,999
1	3,0780	6,3138	12,7060	63,6570	127,3200	636,6190
2	1,8860	2,9200	4,3027	9,9248	14,0890	31,5980
3	1,6380	2,3534	3,1825	5,8409	7,4533	12,9240
4	1,6380	2,1318	2,7764	4,6041	5,5976	8,6100
5	1,5330	2,0150	2,5706	4,0321	4,7733	6,8690
6	1,4760	1,9430	2,4470	3,7070	4,3170	5,9590
7	1,4400	1,8946	2,3646	3,4995	4,0293	5,4080
8	1,4150	1,8595	2,3060	3,3550	3,8330	5,0410
9	1,3970	1,8331	2,2622	3,2498	3,6897	4,7810
10	1,3720	1,8125	2,2281	3,1693	3,5814	4,5870
∞	–	1,6450	1,9600	2,5760	2,8070	3,2910

In practice, the above error analysis can be carried out using standard statistical computer programs.

ICS 91.120.10

Descriptors: thermal insulation, buildings, tests, gas permeability tests, air.

Price based on 10 pages