AIC Translation No.4

"Tightness and its testing in single and terraced housing"

Translated from the original Swedish:
"Täthetsprovning av småhus och radhus"
P.O. Nylund
Paper to 1st AIC Conference "Instrumentation
and measuring techniques", Windsor, UK,
6-8 October, 1980.

Special reprint from Byggmästaren 5, 1979.
Tyrens Teknisk Meddelande 1979:5

TYRENS

TECHNICAL MEMORANDUM

1979:5

TIGHTNESS AND ITS TESTING IN SINGLE AND TERRACED HOUSES

PER OLOF NYLUND

Special Reprint From "Byggmästaren 5, 1979"

TIGHTNESS AND ITS TESTING IN SINGLE AND TERRACED HOUSES

The comments in the Swedish Building Regulations give recommended values for tightness in buildings. The values refer to results achieved during tightness testing in accordance with pressure test method SP 1977:1.

The following air change rates are given:

small detached houses and linked houses, 3.0 changes/h
other dwelling houses with a maximum of two floors, 2.0 changes/h
dwelling houses with three or more floors, 1.0 changes/h

These values, or perviousness factors, relate to an air change rate at a pressure difference of 50 Pa between internal and external air pressure. The values can be regarded as standards which, indirectly, can form the basis for calculating the ventilation and air leakage through the structure.

The corresponding energy losses comprise the energy consumed to heat the incoming cold air to room temperature which is later lost with the outgoing air. It is therefore important that the standard obtained during pressure testing refers to the air which goes from the inside to the outside or from the outside to the inside as a result of positive air pressure and negative air pressure testing respectively.

First a recapitulation of tightness testing of small detached houses.

TESTING SMALL DETACHED HOUSES

Figure 1 gives a schematic illustration of how positive pressure testing is carried out in a detached house. This is done by using a test fan, connected in series with a flowmeter, which supplies air at positive pressure to the building through an opening, normally in sheet material, which temporarily replaces the door during pressure testing. All the air which passes through, past the fan and through the flowmeter, also passes out through the structure. While the flow is being measured the pressure is also registered on a manometer which is affected on one side by the internal air pressure and on the other side by the external air pressure via a tube which is passed through the panel in the door. By varying the speed of the fan and measuring the flow at different pressures, a leakage curve is obtained which indicates the relationship between the pressure difference and the flow. Then by reversing the fan and evacuating the building a leakage curve which relates to negative pressure testing of the building is obtained in the same way. The values for the leakages, both in and out respectively, at a pressure difference of 50 Pa are noted as is the mean value, the latter being the value to be compared with the standard requirement. (If the external temperature differs significantly from room temperature during testing, a correction is made on the basis of the difference in density.)

TESTING TERRACED HOUSES

Figure 2 illustrates testing in three adjacent terraced house flats A, B and C. Let us assume that we are carrying out a positive pressure test on the middle flat (B). Part of the air pumped in leaks out directly through the external envelope, i.e. walls and roof. A further amount leaks out through the party walls and out into the open if there are gaps inside the party walls. These two types of leakages have been designated with a 1 in the diagram. More air leaks through the party walls and into the adjacent flats - flow routes, number 2 in the diagram. The leakage measured during testing is therefore comprised of leakage type 1 in the diagram, which must be counted in the result for the building's tightness and leakage of type 2, which must not be counted.

The requirement for tightness in terraced houses has therefore been recently modified in relation to the figure of 2.0 changes/h given in the introduction. The following is an extract from Planverkets 38.aktuellt 4-1978 (Newsletter No. 38, 4-1978 published by the National Swedish Board of Physical Planning and Building):

> It should be observed that in the result obtained from testing air leakage, in accordance with test method SP 1977:1, the result also comprises the proportion of air leakage which can be related to parts of buildings adjacent to areas with the same temperature unless particular correction for the values obtained is carried out. This leakage cannot normally be considered to constitute any real energy loss. In terraced houses this can apply to the party walls.

in cases where party walls have a construction which is somewhat pervious, for example certain types of framework walls, and correction for leakage through these is not carried out, it can be considered acceptable for the time being that the air leakage can amount to 3.0 changes/h in flats in the group "Other dwelling houses with a maximum of 2 floors".

In reality the modification means that the requirement of 2.0 changes/h is retained for terraced houses with party walls of stone material and is increased to 3.0 changes/h when the walls are of wood. The values relate to results from pressure testing without the elimination of, or correction for, leakage through party walls.

There are, however, ways of approaching the problem of obtaining a relevant figure during pressure testing, i.e. a perviousness factor which does not include leakage through party walls.

ELIMINATION OF LEAKAGE BETWEEN PARTY WALLS

One method of eliminating leakage routes (2) is to provide the flats on either side with fans which maintain the same pressure as the air in the flat being tested. This method is, however, very complicated. Even if we can assume that we have access to three fans and replace the doors in all three flats with sheet material, it would be necessary to synchronise all three fans so that the pressures in the flats were identical for a series of in/out pressure difference measurements carried out at the given flow rate supplied to the middle flat.

This measurement procedure is hardly acceptable for practical pressure testing purposes.

Instead of eliminating the leakage between the party walls, it is possible to make an appropriate correction.

CORRECTION FOR LEAKAGE BETWEEN PARTY WALLS

The principle is quite simple. It has been verified through scale tests in the laboratory, tested in practice and is at present being standardized in Sweden.

Let us assume that we are carrying out a positive pressure test on middle flat (B) using the same procedure as for a detached house. We obtain a leakage curve at varying pressure drops and take particular note of the leakage value at a positive pressure of 50 Pa. The fan is then switched off and the pressure allowed to drop to equilibrium with the external air pressure. One of the two people engaged in pressure testing goes into the adjacent flat (A) which has been prepared in the same way as the measurement flat, i.e. by taping-up or closing the ventilation ducts. In flat A, a manometer is used to measure the magnitude of the resulting pressure difference when the pressure in the measurement flat (B) is raised from zero (or equilibrium pressure equal to the outside air pressure) to an excess pressure of 50 Pa. What needs to be done in flat A is to zero the manometer, when the fan is switched off in measurement flat B, and then to read off the pressure increase obtained in A when the pressure in measurement flat B amounts to 50 Pa. Communication by telephone or walkie-talkie is necessary between the two flats for this task. The same procedure is repeated, this time by registering the pressure increase in flat C, when the pressure is increased from 0 to 50 Pa in measurement flat B.

In order to simplify the description of the correction method we shall assume that the three flats are equally airtight. In this case no more measurement or registration than that previously discussed is necessary.

There is nothing to prevent the use of the same correction method even if the tightness in the flats differs. It is however necessary to repeat the procedure discussed first with flat A as the measurement flat, and then with flat C as the measurement flat. In both cases the rise in pressure in the adjacent flats is recorded when the pressure is increased from 0 to 50 Pa in the measurement flats.

It is assumed that diagram 3 shows the leakage curve $Q_{measured}$ which was registered during pressure testing of flat B. From the curve we can obtain a value for the total measured leakage at 50 Pa positive pressure. This leakage is designated $Q_{50,\ measured}$. We assume that we have measured the pressure increase P_A when we measured the pressure change in the adjacent flat. From the measured leakage curve we can obtain the necessary correction term Q_{pA}.

The corrected value for the leakage can be derived and expressed as follows:

$$Q_{50,\ corrected} = Q_{50,\ measured} - Q_{pA} - Q_{pB} + \text{remainder.}$$

The remainder can be calculated from the measurement values obtained.

In all probability it will be possible to carry out sample tightness tests in detached houses by selecting a flat at random and merely registering the pressure changes in adjacent flats. However, the relationship must be studied in more detail by systematic field investigations before the method can be accepted as a complement to the pressure testing methods for measuring tightness in terraced flats drawn up by the National Swedish Institute for Materials Testing.

The most significant disadvantage of the method described is that it includes the measurement of small pressure differences - between the measurement flat and adjacent flats - and it may be necessary to limit the method to occasions when the prevailing wind is slight or non-existent.

EXAMPLES OF THE MAGNITUDE OF LEAKAGE THROUGH PARTY WALLS

As an example of the magnitude of leakage, the results from pressure testing of terraced houses administered by AB Folkhems in Sollentuna are given.

In the middle flat a change rate of 2.0 changes/h at 50 Pa was measured. The corrected value was 1.5 changes/h. In an end-of-terrace flat, the corresponding values were 1.8 and 1.5 changes/h respectively.

SIMPLIFIED PROCEDURES FOR REGISTERING INTERNAL/EXTERNAL PRESSURE DIFFERENCES

In the introduction it was noted that the registration of the difference between external and internal air pressure is carried out with manometers which, on one side, are connected to the internal air pressure and the other via a tube which is inserted through a temporary panel in the external envelope and which is in contact with the external air pressure.

When it is necessary to register the pressure change in adjacent flats it is obviously inconvenient to have to place an extra panel in the door opening purely to introduce a tube connected to a manometer. There is an easy way of avoiding this complication by passing a tube through the water trap of a sink or toilet to achieve contact with the external air pressure through the ventilation opening. (This is assuming that the ventilated pipe is not fitted with a non-return valve.)

Using the method discussed for registering pressure in the building in relation to a ventilation pressure reference, it is possible to eliminate sheets in the external doors completely, even in the measure ment flat. This is assuming that we connect the fan, with which we extract or supply air to one of the house's ventilation ducts. This is particularly simple when testing during a production stage. In this way there is the minor advantage of having external doors with their inherent perviousness as part of the house's total tightness.

PERVIOUSNESS FACTORS FOR SINGLE AND TERRACED HOUSES

In the introduction it was noted that the standard - perviousness factor obtained from relevant tightness tests in accordance with the pressure test method - can form a basis for calculating ventilation and air leakage. The perviousness factor is <u>one</u> of the parameters which, in a quite complicated interaction, is decisive for ventilation and natural ventilation and thus the associated energy losses. (Natural ventilation means the air leakage in and out through the building structure, i.e. the air change which does not go through the ventilation system.)

Even if the interaction between the structure's perviousness, the effects of wind and temperature, and the ventilation system is complicated, it is still possible to consider in principle that

> the amount of natural ventilation in a push-pull system is linearly dependent on the perviousness factor
>
> the total ventilation for a supply air system is linearly dependent on the perviousness factor
>
> the natural ventilation for an exhaust air system increases in proportion to the perviousness factor, but not linearly.

In the long term it is necessary to relate the tightness requirements for detached houses to the type of ventilation system. In order to do this, it is necessary to expand the basis of knowledge from practical and theoretical development work.

At the moment it is important that there should be a balance between the requirements for both detached houses and terraced houses on the basis of current knowledge. The way in which perviousness factors for the two categories relate to each other so that "justice is done" depends on the criteria we have. For example:

On the basis of production conditions.

On the basis of specific energy consumption.

On the basis of ventilation requirements.

The basis for this argument is that the air change rate of 3.0 for small detached houses can be considered reasonable at the moment.

PERVIOUSNESS IN TERRACED HOUSES - PRODUCTION CONDITIONS

Terraced houses with framework walls between flats provide roughly the same, or somewhat better, conditions as for detached houses with the same design technology in relation to achieving tightness, measured without correction for leakage between party walls.

Terraced houses with party walls of stone material provide somewhat better conditions and should mean a lower value for the perviousness factor.

Using this argument we arrive at values which agree quite well with those recommended by the National Swedish Board of Physical Planning and Building and the newsletter referred to above.

PERVIOUSNESS IN TERRACED HOUSES - FROM AN ENERGY POINT OF VIEW

Another basis for achieving balance is that the specific energy consumption, i.e. the energy consumption per m^3 of building volume, should be the same for both house types. This provides the motivation for having the perviousness factor for terraced houses, after correction for leakage through party walls, equal to that of detached houses, i.e. 3.0 changes/h. This should also lead to a higher value for terraced houses than for detached houses if the tightness testing and perviousness factor is indicated without correction for leakage to adjacent flats.

PERVIOUSNESS IN TERRACED HOUSES - FROM A VENTILATION POINT OF VIEW

Natural ventilation is permissible in both detached houses and terraced houses. Such houses must not be too airtight.

If we make allowance for this and assume that the conditions for ventilation should be the same for both categories of houses, we arrive at the same result as was the case of the energy aspect. The perviousness factor for terraced houses, without correction for leakage to adjacent flats, should be set higher than for detached houses.

SUMMARY

The test method described for correcting for leakage through party walls in terraced houses could be developed relatively soon to a routine which is manageable for measurement technicians. Perviousness factors for terraced houses, after correction for side leakage through party walls, should be set to the same level as for small detached houses.

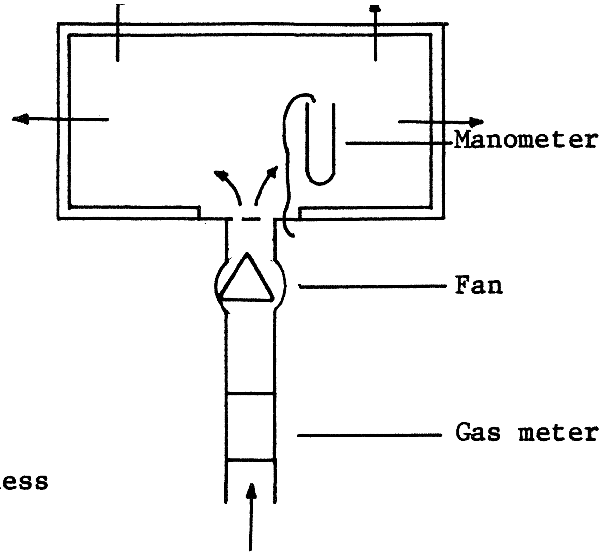

Figure 1. Tightness testing of small detached houses.

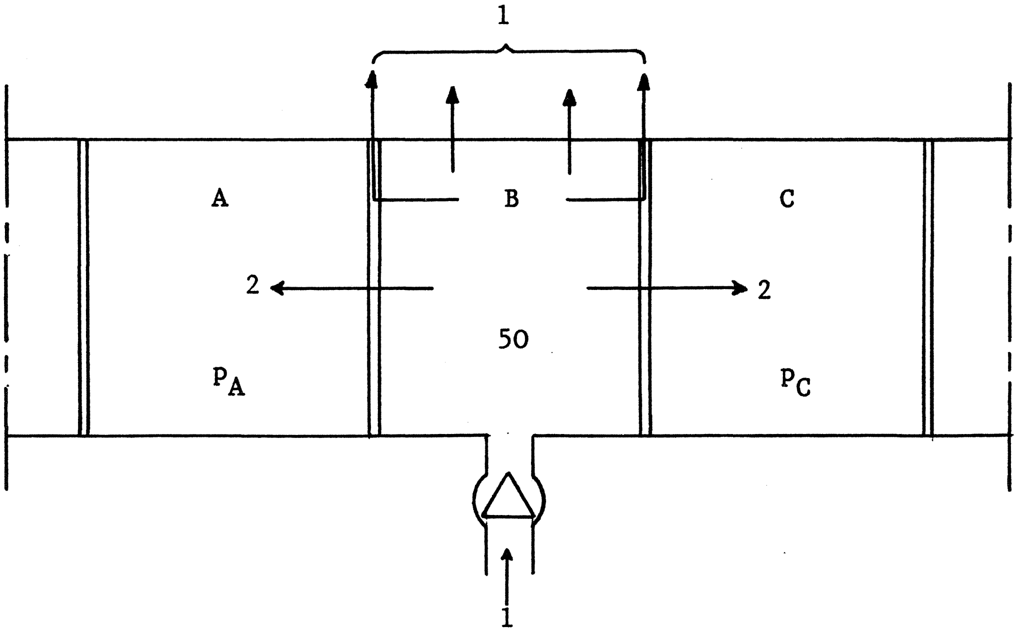

Figure 2. Tightness testing in terraced houses. Pressure measurement for correction with reference to leakage flows 2 in the figure.

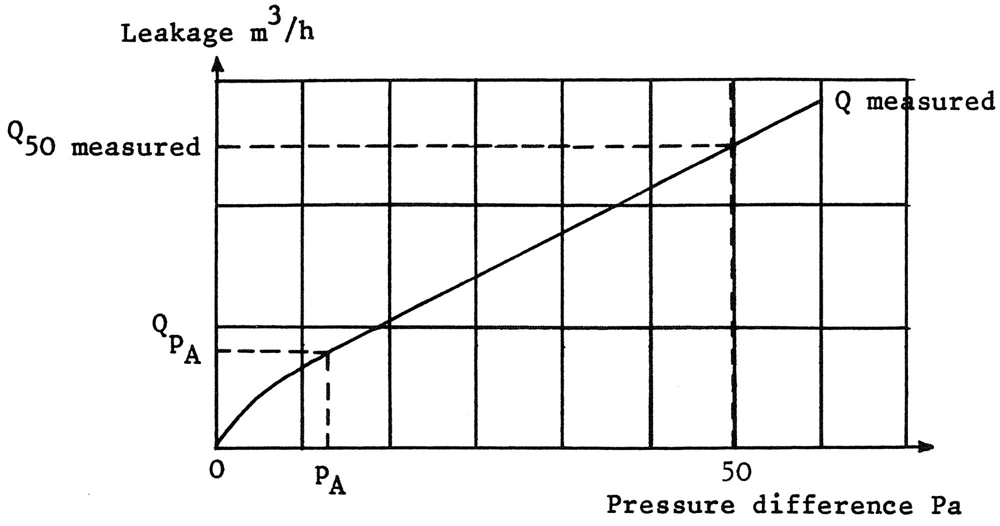

Fig. 3. Leakage curve and magnitude of correction term.

This terraced house area in Sollentuna has been tightness tested in accordance with the method described in the article.

SUMMARY

TIGHTNESS AND ITS TESTING IN SINGLE
AND TERRACED HOUSES

By Per Olof Nylund

The Swedish regulations give recommended tightness values for buildings of 3 changes per hour for single houses, 2 changes for other housing with not more than two stories and 1 change per hour for taller buildings. These values are measured at a pressure differential between outside and inside of 50 Pa.

Houses are tested by sealing ventilation ducts and the like and replacing the door with a panel having a reversible fan and a manometer connected to the outside by a hose through the panel. The house is tested for air flow through the fan at differing positive and negative pressure differentials.

For terrace houses the air leaks through walls facing the outside or cavities leading to the outside as well as through walls partitioning spaces with air at the same temperature. Because this leakage does not waste energy the authorities allow leakage of 3 changes per hour in terraced houses having party walls of a timber structure.

The leakage to or from terraced houses can be measured and allowed for if the houses adjoining the one being measured are sealed and the pressure differentials in them registered at the same time as in the house being tested. If the houses are very similar, correction can be made after testing one of them. If dissimilar all three must be measured as test houses.

The tube leading to the outer air from the manometer can be passed through an elbow bend from a wash basin or bath. The fan can be connected to a ventilation duct thus obviating replacing the front door with a special board and measuring the front door together with the rest of the house.

This method could be used generally. From energy and ventilation viewpoints it would seem that the air change factors for terraced houses ought to be the same as for single houses.