SINTEF Building and Infrastructure

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Project report 66 2010

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# ABSTRACT

The airtightness of 17 wood-frame detached houses was predicted by collecting basic data on geometry, materials and sealing methods, and then aggregating component leakages from laboratory data. The predicted airtightness ($n_{50}$), for the early wind-tight stage of construction, varied from 0.27 to 1.0 ach, while the measured values varied from 0.37 to 2.6 ach. The predicted values were very weakly correlated to measured values.

# SAMMENDRAG

Data om geometri, materialer og tettemetoder ble samlet inn for 17 småhusboliger i tre. Lufttettheten i vindtettfase ble predikert på basis av laboratoriedata. De predikerte lekkasjetallene varierte fra 0,27 til 1,0, men målte verdier varierte fra 0,37 til 2,6. Det var svært liten korrelasjon mellom predikerte og målte verdier.

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# 1 Introduction

The airtightness is the most important factor influencing the infiltration. For energy-efficient houses in cold climates, a prerequisite is to minimize infiltration rates and recover heat from exhaust air with mechanical ventilation. Uncontrolled infiltration contributes much to the heat loss, so it is highly desirable for builders to be able to predict the airtightness prior to construction. In recent years, more emphasis has been put on the airtightness of the wind-barrier on the outside of the thermal insulation, as this often is more accessible for repair during construction. It has therefore become customary for builders to measure the airtightness just after the wind-barrier has been fitted, henceforth referred to as 'early wind-tight' airtightness, $n_{50w}$.

With only a wind-barrier fitted, leakage airflow paths are less complex than when also the thermal insulation and vapour barrier have been fitted. This has lead to attempts to describe and measure factors influencing the airtightness of buildings before the insulation or vapour-barrier is installed [1] [2, 3].

## 1.1 Objective of the work

The objective of the work described in this report was to test a method that has been suggested for estimating the value of $n_{50w}$ prior to construction. This has been done using specific information from 17 houses (sealing methods, materials used etc.), and laboratory measurements (component leakage data). The report puts emphasis on describing the method and its use, so that it can be further developed. To evaluate the success of the estimation method, the estimated airtightness was compared to the measured airtightness for all the 17 houses.

## 1.2 Earlier work

Several attempts to estimate the airtightness of buildings have been reported in the literature. The authors find it relevant to divide the estimation methods into three different classes:

1. Rough estimation methods:
   - These methods are rather quick to use, and uses a minimum of input data for the estimation.
   - Examples can be found in: [4], [5]

2. Multiple regression methods:
   - Based on airtightness measurements of a collection of houses, multiple regression is used together with chosen predictors (e.g. lengths of joints, areas etc.) to see if any relation can be found between the predictors and the response (airtightness). The model developed is valid for the current collection of houses under investigation.
   - Examples can be found in: [6], [7]

3. Component leakage methods:
   - Uses component leakage data (analogous to U-values, thermal bridges)
   - Uses specific information of the buildings – lengths of joints, areas etc.
   - Examples are found in: [4],[5, 8],[9, 10]

# 2 Hypothesis, model and assumptions

The basis of the work (a component leakage method) is that the total air leakage of a house is the sum of all the leakages on the building envelope, and that it is possible, in principle, to define all the components contributing to air leakage prior to construction.

The overall goal of this work is to test out a current suggestion that it is possible to identify those components, assign specific leakage rates to individual components from laboratory measurements, and from this reliably predict the airtightness. The intention therefore is *not* to *adjust* a model to predict the airtightness of wood-frame houses.

It is assumed that the wind-tightening layer of the house can be described as a surface. Air leakages can then be divided into three groups: (i) leakage through surface layers, (ii) in joints, and (iii) individual point leakages. The model can thus be formulated as in Eqn (1). Eqn formulates the total air leakage as the sum of the leakages in the surfaces, $q_S$ [(m³/h)/m²], the linear leakages in joints, $q_L$ [(m³/h)/m], and the leakages associated with all the penetrations, $Q_p$ [m³/h pcs]. It is further assumed that these specific leakages can be estimated from laboratory measurements.

$$n_{50w} \cdot V = \sum_{i=1}^{n_L} q_L L_L + \sum_{j=1}^{n_S} q_S A_S + \sum_{k=1}^{n_P} Q_p \qquad (1)$$

Since the airtightness is to be estimated *prior* to construction, one cannot know for certain the position and size of all the air leakages. One must therefore make assumptions about the airtightness of all the building components on the building envelope. The airtightness of components can be measured in the laboratory – so-called component leakage data.

Different categories were used for the linear leakages, the surface leakages and the penetrations. Based on a literature review [11], and a judgement of which leakages were the most common, a suggestion for which air leakages that were to be used was formulated. A formulation of a general model was therefore established and used for *all* the houses (all houses are estimated in Appendix 3).

Estimation of all the houses is given in Appendix 3 where also the different air leakage categories are listed. As is apparent from the appendix, the airtightness of all the houses was estimated using the same component leakage categories (the same model). It is clear that since the objective of this work is to test the presented model, the authors do not claim that this is the full model.

# 3 Data collection

For the modelling, laboratory data were collected from recent work considered relevant for the small-house building industry in Norway at present date. Information on construction and dimensions of 17 houses was collected as described below.

## 3.1 Gathering component leakage data

Much component leakage data has been published from different references, but as these represent very different materials, conditions and levels of craftsmanship[4], it is hard to identify what data are relevant for a specific construction project[12]. As described in e.g. [13] the detailing of component leakages is often very limited.

A literature survey was carried out to establish a relevant and up-to-date overview of available component leakage data applicable for wood-frame houses. This resulted in the component leakages assembled in Appendix 2. The data in Appendix 2 have a clear emphasis on recent years), and are mostly measured in Norway.

SINTEF Building and Infrastructure publish technical approvals for many manufacturers of building materials. This gave information of the airtightness of e.g. wind-barriers *with* a typical amount of joints. This was used for estimating the area-specific leakages, $q_S$ in the surfaces [(m³/h)/m²].

Practically all of the component leakages used are single measured values – i.e. they are not 25, 50 or 75 percentiles as is reported in the AIVC leakage database [4]. If more component leakages had been available, it could have been considered to use this– and take the craftsmanship explicitly into account. However, this was not possible since the number of component leakage measurements were limited.

The average value of over- and underpressure was always used for the component leakages when estimating the airtightness of the wood-frame house when wind-tightened, $n_{50we}$. (where suffix 'e' stands for estimated).

## 3.2 Blower-door measurements of wood-frame houses

Different wood-frame house contractors were contacted and asked whether they were interested in a free-of-charge pressure test at the early wind-tight stage of construction, $n_{50wm}$ (where suffix 'm' stands for measured). Airtightness was measured according to NS-EN 13829. Airtightness was reported as $V_{50wm}$ [m$^3$/h] and $n_{50wm}$ [h$^{-1}$], both as an average of over- and underpressure at 50 Pa.

## 3.3 Data collection – registration of relevant quantities

Before visiting each house, relevant quantities for possible leakage areas, joints and penetrations were calculated on the basis of blueprints. On site, these quantities were *verified* as to whether modifications of the catalogue houses had been done. Since the actual sealing techniques were not known a priori, these had to be collected when the house was inspected and measured. On site, the craftsmen were asked which sealing techniques were used, and for instance, how the joints around the windows were sealed, and what material was used for the wind-barrier. For each of the houses a sheet of 10 pages with 56 questions was answered in cooperation with the craftsmen.

The quantities and volumes were taken from [14] and were hardly modified at all. An overall concept of the calculation of the quantities was that quantities *outside* that enclosed by the wind-barrier were not of interest. The houses were built either in 2008, 2009 or 2010.

# 4 Modelling

It is clear that a perfect match between the component leakage data in the assembled database and what was *actually* built, was not always possible. For instance for one house it was stated that the window perimeters were sealed with backer rod and mastic, but this sealing technique was not available in the assembled database. Specific assumptions had to be made to deal with these mismatches, such as that backer rod with mastic was as tight as PU foam. Since the purpose of this work is to test a model, and *not* use the measurement data to *adjust* a model, all these mismatch assumptions had to be established *prior* to the comparison with the measured value. (This issue is also discussed in e.g. [8]). All these assumptions are listed in detail in Appendix 1.

Many of the sealing descriptions of various joints indicated that multiple sealing methods had been used. Since most of the measurement results applicable for Norwegian wood-frame houses were of single sealing materials, the following simplification was done: For cases where more sealing materials were used, it was generally assumed that the airtightness was determined by the most airtight layer. For instance, the airtightness of a double wind-barrier; gypsum board *with* a rolled wind-barrier was assumed to be as airtight as a rolled wind-barrier only. This assumption was also utilized for joints, e.g. window perimeter joints. If a joint was sealed with PU foam and mineral wool, and the combination of both was not given, the airtightness of PU foam was used.

Another general simplification is that when linear leakages of *joints* [(m³/h)/m] were evaluated, it was assumed that it was more important that the *type* of joint was correct rather than the materials used. For instance the leakage between two asphalt boards or two gypsum boards was considered to be similar if they were fastened in a similar manner.

# 5 Calculation method

The airtightness was calculated according Eqn (1). This calculation procedure is conceptually similar to that presented in e.g. [8]. A number of different air leakage categories were used for the linear leakages, the surface leakages and the penetration air leakages. The calculation procedure should be apparent from Appendix 3 where the airtightness of all the houses is estimated.

# 6 Results – comparison of measurements and calculations

The estimated air flow at 50 Pa, $V_{50we}$, varied from 105 to 560 m³/h corresponding to air change rates $n_{50we}$ between 0,27 $h^{-1}$ and 1,0 $h^{-1}$.

Figure 1 shows the relation between the estimated and the measured airtightness. As can be seen from the figures, the measured air leakages were generally higher than the estimated values, and correlation between observed and estimated values was virtually non-existing.

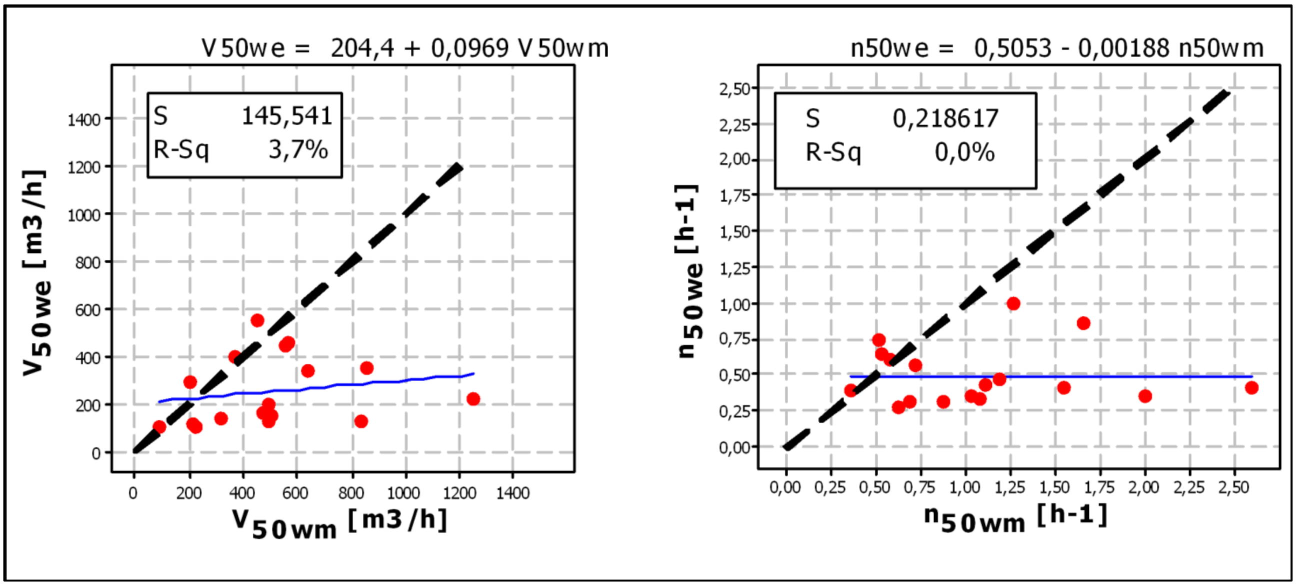


**Figure 1 Estimated vs. measured airtightness in [m³/h] in the left, and in [h$^{-1}$] in the right. Black dashed line: Ideal relationship where estimated = measured. Blue line: linear regression.**

# 7 Discussion

## 7.1 Measured vs. estimated airtightness

From

Figure 1 it is apparent that a few of the estimated values correspond very well with the measured values (close to the black dashed line). There are also some other values that are not too far from the dashed line both in the left and the right. There are, however, too few data to speculate in what the values lying close to the dashed line have in common. From the figures on the right hand side ($n_{50w}$), it is evident that the estimation model predicts almost all values in the interval 0.25 $h^{-1}$ to 0.75 $h^{-1}$. This fits rather well for the measured values in this range, but not outside the range.

The regression line shows a practically absent relation between the estimated and the measured airtightness. The $R^2$ is also practically zero. Apart from the lowest air leakage the airtightness is underestimated. Because of the lack of correlation between the estimated and measured airtightness, there is no reason to proceed to any statistical subtleties.

## 7.2 Sources of error in the component model

Since the suggested estimation method did not show any reliable results, it is appropriate to discuss possible sources of error in the model.

### 7.2.1 Individual variation

Many of the component leakages depend heavily on manual operations performed by different craftsmen, and are prone to large variation. It seems reasonable that joints and penetrations that rely on caulking etc. may vary considerably with the experience and effort of the craftsman as well as on the properties of the materials that are actually used.

### 7.2.2 Material variation

Variation in properties of building materials may be a source of error. In general it may be hypothesized that more complex components may be more variable than e.g. simple sheet materials, as more variables in the building process can affect the property.

### 7.2.3 Not all leakages are included in the component model

No known leakages have been consciously omitted from the model, but this does not guarantee that the model is complete.

### 7.2.4 Mismatch between as-built and laboratory measurement/component leakage data

Laboratory data were not available for all materials and air tightening methods, and in some cases data from comparable solutions was selected. This introduces considerable uncertainty.

### 7.2.5 Different performance in the field and in the laboratory

All the component leakages are gathered in the laboratory, and even though the laboratory studies were designed to represent actual building practices as closely as possible, it is possible that differences in working conditions between laboratory and field can lead to errors. Many building materials change dimension or form with heat and moisture differences, and the climatic conditions on a building site is normally much more variable than in a laboratory.

There will be some air leakages that cannot be accounted for by the estimation model – although the craftsmen are thorough. For as airtight houses as these, it is clear that the relative importance of these leakages are higher than for leakier houses.

### 7.2.6 Quantities calculated

Quantities are calculated from blueprints, and may not exactly match the physical dimensions. This source of error is considered to be of relatively little importance.

## 8 Conclusions

The attempt to predict airtightness from the chosen component leakages was unsuccessful; measured and predicted air leakage were almost uncorrelated. It is noted that both the predicted and achieved values were rather low.

The fact that the component estimation method turned out not to give very reliable results, does not mean that such a method by definition will not work in general. Rather it means that, with the information available at this time, and the assumptions used, it was not possible to show a relation between the estimated and the measured airtightness. The fact that the measured and estimated airtightness did not correlate should not be taken as an invitation not to be conscious when choosing between different wind-barrier products.

## 9 Acknowledgements

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# A Appendix A: Description and explanation of the model assumptions and simplifications

In order to make the estimation model as re-examinable as possible, all the assumptions are explained here. Refer to Appendix 2 for specific the measurement values.

## A.1 Leakages assumed to be zero

Some materials and solutions were assumed to be airtight. Since this might not be correct in all cases, it was decided to visualize this assumption by showing the component leakages in the calculation table. The following air leakages related to the concrete were assumed to be completely airtight:

- The vertical joint concrete wall/concrete wall [($m^3$/h)/m]
- Leakages in concrete walls [($m^3$/h)/$m^2$]
- Leakages in concrete floors [($m^3$/h)/$m^2$]
- The horizontal joint concrete floor/ concrete or LECA foundation wall [($m^3$/h)/m]
  - Due to lack of component leakage data, this leakage was set to zero. It would be relevant to have measurements for this component.

## A.2 Leakages in surfaces [($m^3$/h)/$m^2$]

For the surface leakages, the technical approvals made by SINTEF Building and Infrastructure were used as a basis. Here the airtightness is measured *including* joints. Deviations from this are explained in each of the calculation sheets for the different houses.

If it was stated that joints were glued or something similar, this was not taken into account – just as the general assumption previously explained.

1. Wood-frame walls
   a. Description
      i. A leakage will occur in the joints of the walls and in the wind-barrier material itself. This is taken into account jointly when using the technical approvals measured including joint leakages.
   b. Quantity determination
      i. The total area of the wood-frame walls was calculated.
   c. Component leakage used
      i. Depending on the materials used, the technical approvals given by SINTEF Building and Infrastructure for the current materials were used. The leakage *including* joints was used.
   d. Assumptions
      i. When a double wind-barrier was used, the airtightness was considered to be determined by the tightest layer.

2. Roof
   a. Description
      i. An air leakage was assigned to the area of the roof. The leakage will be in the material itself and in the joints.
   b. Quantity determination
      i. The area of the roof was calculated. The area outside the airtight outer layer was not a considered.
   c. Component leakage used
      i. The leakage from the technical approval including joints.
   d. Assumptions
      i. Asphalt roofs (used for flat roofs) were considered completely airtight.

3. Windows and doors
   a. Description
      i. The window will have an air leakage.

b. Quantity determination
   i. The total area of all windows and doors was calculated.
c. Component leakage used
   i. The maximum allowed leakage was used for all windows, since specific information for all windows was unavailable. This value was used both for windows and doors.
d. Assumptions
   i. It is assumed that there is a minor difference between windows and doors regarding airtightness.

4. Floors
   a. Description
      i. Floors may have air leakages through cracks
   b. Quantity determination
      i. Floor area inside envelope (BRA) was used. This is not strictly correct, but is of no significance since specific leakage is assumed zero.
   c. Component leakage used
      i. Zero specific air leakage is assumed.
   d. Assumptions
      i. All floors on ground were concrete floors, and considered airtight.

## A.3 Horizontal joints [($m^3$/h)/m]

2. Concrete floor/wood-frame wall
   a. Description
      i. Relevant for houses with slab on grade. The leakage between the concrete floor (slab on grade) and the wood-frame wall. Depends i.a. on the sealing method used.
   b. Quantity determination
      i. The total perimeter of the joint between the wood-frame wall and the concrete wall was used.
   c. Component leakages used
      i. Here the leakages as measured in [13] were used.
      ii. Since information about the planeness was not given for each of the houses, class PC (medium planeness – typical requirement) was assumed for all the houses. High load was used for 2 storeys
   d. Assumptions
      i. It is assumed that the measurements of concrete wall/wood-frame wall as measured by [13] are relevant in this context.

3. Intermediate floor
   a. Description
      i. The leakage associated with a wind-barrier not covering the height of two storeys.
      ii. In order to have intermediate floors there has to be more than two wood-frame storeys.
      iii. The intermediate floor also includes the storey separator on the gable walls.
   b. Some of the houses (1, 14) had a high knee wall. For these cases both intermediate floor and eaves occurred. (
   c. Quantity determination
      i. The perimeter of the side walls (and the gable walls) was calculated
   d. Component leakages used
      i. Bauwens measured the air leakage from intermediate floors. This was used as a basis.
   e. Assumptions
      i. It is assumed that there is a joint between the two storeys.
      ii. It is assumed that joints between walls parallel to or perpendicular to the floor beams have identical specific leakages.

4. Concrete wall/wood-frame wall
   a. Description
      i. The leakage in between the wood-frame wall and the basement wall. This leakage is relevant for houses with a basement. The leakage depends on the sealing method used and on the smoothness of the surface.
   b. Quantity determination
      i. The total perimeter of the side walls and the gable walls where a joint between the wood-frame wall and the basement wall existed. Houses with panel walls could have both the leakage concrete wall/wood-frame wall *and* concrete *floor*/wood-frame wall.
   c. Component leakage used

i. This leakage was considered to be a sum of concrete floor/wood-frame floor *and* the intermediate floor, i.e. combining [13] and [15].

d. Assumptions
   i. Information of planeness was not given. Therefore planeness PC was assumed.
   ii. Low load was used if one storey only was on top of the basement.
   iii. Although the walls were against the ground (not fully excavated basement), the joint was assumed to have the same properties as if it was against the outdoor and not against the ground.

## A.4 Vertical joints [($m^3$/h)/m]

1. Concrete wall/wood-frame wall
   a. Description
      i. For some cases, e.g. in panel walls one will have a vertical joint between a concrete wall and a wood-frame wall.
   b. Quantity determination
      i. The length of the vertical joints was calculated. This equalled the length of the number of corners multiplied by the height of the joints.
   c. Component leakage used
      i. The measurements by [13] were used as basis
      ii. Since the joint is vertical, a low load was always used.
   d. Assumptions
      i. Since information of the planeness was not given, class PC was assumed also here.

2. Wood-frame wall/wood-frame wall
   a. Description
      i. Depending on the type of wind-barrier used, leakages can occur in outer wood-frame corners.
   b. Quantity determination
      i. The total length of the outer corners having this joint was calculated.
   c. Component leakage used
      i. The measurements of the structural floor in [13] were used as a basis.
   d. Assumptions
      i. When using rolled wind-barriers, the craftsmen often roll the wind-barriers continuously around the corners and might only leave one corner with a joint. For more complex geometries more than one corner can have a joint. Instead of guessing which vertical corners that the vertical wind-barrier was rolled continuously around, a joint leakage was assigned to *each* of the corners. Therefore the number of joints in the corners would be the same if rolled wind-barriers or board wind-barriers were used.
      ii. Since no measurements existed for asphalt board wind-barriers, the same leakage as for the gypsum board was used.
      iii. If only a gypsum board was used on the wall, but a rolled wind-barrier was added at the corners, the rolled wind-barrier was used for the corners, and not only the board wind-barrier.

## A.5 Joints between roof and wall [($m^3$/h)/m]

For the cases where a double wind-barrier (rolled wind barrier on top of wind-barrier boards) or a rolled wind-barrier only was used on the wall, but not on the roof, or vice versa, it was assumed that the airtightness of the overlap joint was determined by the rolled wind-barrier and not the board wind-barrier.

It was assumed that the linear leakage [$m^3$/hm] of joints between gypsum board/gypsum board and asphalt board/asphalt board wind-barriers was equal in magnitude. (For surface leakages [$m^3/hm^2$] this simplification was of course *not* used.)

1. Side wall/roof
   a. Description
      i. It is reason to assign a leakage to the joint between the wall and the roof – at the eaves
      ii. This also includes the joint between dormer walls and dormer roofs.
      iii. If the houses had an extension such as an entryway-addition or annex, side walls could also appear here.
      iv. If the eaves had penetrating roof beams, the leakage was assigned under “side walls/roof – penetrating beams”.
   b. Quantity determination

i. The length of the side walls where the eaves are located was calculated.

c. Component leakage used

i. The same component leakage as that used for the structural floor was used – i.e. from [13].

d. Assumptions

i. Alternative 1 was that loose eaves were mounted. For this case a horizontal joint was assumed where the wall meets the roof.

ii. Alternative 2 was that the rolled wind-barrier was mounted continuously around the eaves. For this case the same leakage and the same concept as for loose eaves was used.

iii. For the cold unvented lofts, it was assumed that the insulation at the eaves – if put in place was not an air flow resistance of importance.

2. Side wall/roof – penetrating roof beams

a. Description

i. When the wind-barrier is stopped against the roof (truss) beams and the wind-barrier is mounted in between the roof (truss) beams, it is reason to assign a leakage for the joint around each of the roof (truss) beams.

ii. The difference between this leakage and "side wall/roof" is that this is *only* used when the roof beams are penetrating, and not else.

b. Quantity determination

i. The total length of walls having penetrated roof beams was calculated. For rolled wind-barriers having penetrating roof beams at the side walls, the length equalled the length of the side walls.

ii. If a board wind-barrier was penetrated by the roof beams, the total perimeter of all the roof beams was calculated. This equalled the number of beams times the circumference of the beams. *Additionally* a leakage was assigned to the total length of the eaves, i.e. usually the length of the side walls. This was to account for the joint at the top sill.

c. Component leakage used

i. In [15] the leakage for *vapour* barriers penetrated by structural floor beams are measured per running metre structural floor. This was used for the *rolled* wind-barriers. A value for a sloppy mounted vapour barrier penetrated by roof (truss) beams was used. The sloppy mounted case was considered to be the default. This was considered to be the most correct since it is a very exacting job to seal this air leakage very properly – as described in [15]. The measurements in (Bauwens 2009) included the air leakage of the joint at the top sill in addition to the leakage around the floor beams.

ii. If a board wind-barrier was used, the values for a structural floor tightened with gypsum boards in [15] were used. This was considered to be the closest match since no measurement existed for board wind-barriers mounted in between the roof beams. For this case the total *perimeter* of all the penetrating roof truss beams was calculated. To also account for the joint at the top sill at the eaves, a joint was calculated here. This was measured per running metre.

iii. Although mastic or similar products were used together with this solution, this was not accounted for – as specified generally earlier.

d. Assumptions

i. It is assumed that for the linear leakages the difference between a vapour barrier and a rolled wind-barrier is of minor importance.

ii. It is assumed that the linear leakage from the structural floor tightened with a wind-barrier is representative for the leakage around the roof truss beams.

3. Joint between gable wall and roof

a. Description

i. A joint will occur where the gable wall meets the roof. On the gable walls there are no roof beams. Gable walls can also occur on dormer roofs.

b. Quantity determination

i. The length of the joint between gable wall and roof was calculated. For saddle roofs and lean-to roofs this joint was angled, and for flat roofs it was not.

c. Component leakage used

i. The leakage for structural floors measured in [15] was used. Refer to Appendix 2.

d. Assumptions

i. For flat roofs (none of these had penetrating roof beams) no distinguishing was made between gable walls and side walls.

4. Joint between lower-lying roof and higher lying wall

a. Description

i. Some buildings have roofs with different heights. This joint denotes the leakage connecting the lower-lying roof with the wall (leading to the higher-lying roof).

b. Quantity determination

i. This joint was often angled and was calculated as the total length of all such joints in the house.

c. Component leakage used

i. The component leakage for the structural floor as measured in [15] was used.

d. Assumptions

i. It is assumed that the component leakages in [15] are applicable.

5. <u>Joint between roof and roof – "roof valley"</u>

a. Description

i. For hoses having a saddle roof and a dormer, a joint will occur between the tightening material in the dormer roof and the saddle roof.

b. Quantity determination

i. The total length of all these roof valley joints of the house was calculated.

c. Component leakage used

i. The component leakage for the structural floor as measured in [15] was used.

d. Assumptions

i. It is assumed that the component leakages in [15] are applicable.

ii. If a wind-barrier was clamped and fastened in the roof-valley only (no rolled wind-barrier used elsewhere on the roof), it was treated as if the joint was covered with a wind-barrier entirely in this joint.

6. <u>Joint between the roof and the roof – at the ridge</u>

a. Description

i. Depending on the material used, a joint can occur at the ridge of the roof. Some of the materials used on the roof did not result in a joint at the ridge.

b. Quantity determination

i. The length of the ridge was calculated. The length outside the wind-barrier was not calculated – an overall concept for all the calculations.

c. Component leakage used

i. The component leakage for the structural floor as measured in [15] was used.

d. Assumptions

i. It is assumed that the component leakages in [15] are applicable.

ii. If it was stated that the wind-barrier was rolled continuously over the ridge, no joint leakage was assigned for the ridge.

## A.6 Joints around windows and doors (in masonry and wood-frame walls) [$(m^3/h)/m$]

a. Description

i. A leakage will occur around the window or door depending on what sealing method that has been used.

b. Quantity determination

i. The total length of all window and door joints was calculated.

c. Component leakage used

i. The measurement results from [16], [17] and [18] were used.

d. Assumptions

i. It is assumed that the airtightness of PU foam (measured) and backer rod with mastic are equal in airtightness performance.

ii. It is assumed that there is no difference between doors and windows regarding the airtightness.

## A.7 Penetrations, [$m^3/h$ apiece] or [$(m^3/h)/m$]

1. <u>Electrical penetrations, ventilation ducts, water/sewage and (LWAC element) chimneys</u>

a. Description

i. An air leakage was associated with the perimeter of penetrations – correspondingly to that for window and door perimeters.

ii. The number of penetrations installed when measuring $n_{50w}$ varied to a very large degree.

iii. LWAC element chimneys were seldom penetrating the roof when measuring $n_{50w}$.

b. Quantity determination

i. The amount of penetrations installed when measuring $n_{50w}$ was counted.

ii. For LWAC element chimneys also the total number of visible LWAC elements was calculated, i.e. not the ones in the structural floor or in the roof (one house with chimney only).

c. Component leakage used

i. Measurements in [19] were used for ventilation ducts and electrical penetrations. Here measurements of electrical penetrations and penetrations by ventilation ducts are given.

ii. One house had light spots at the eaves – this is component leakage was taken from [20] and is specified further under the current house.

iii. For LWAC element chimneys, measurement values were taken from [21] both for the perimeter leakage around the chimney *and* for that through the LWAC elements.

d. Assumptions

i. For electrical penetrations the measurements of electrical penetrations were used. No distinguishing was done for different sizes of electrical penetrations.

ii. For ventilation ducts *and* water and sewage, the value for ventilation ducts was used.

iii. In the cases where a wind-barrier was used as collar, the airtightness for collar was used (as measured in [19]).

iv. Generally if a penetration was casted in place in concrete, it was considered as tight as a collar specially designed for penetrations. If the penetration was carried through a precast opening or a drilled hole in the slab, the measurement values by [19] were used. For the LWAC element chimneys being installed when measuring $n_{50w}$, it was assumed that all LWAC *elements* (material leakage) experienced 50 Pa pressure difference. Since no measurement exis*ted f*or no coating of the LWAC elements, the least airtight coating existing in [21] was used for an element without any coating.

# B Appendix B: Component leakages used in the estimation

This appendix shows all the component leakages that were used in the estimation.

SINTEF

| Category | Description | V50 [m3/h]/unit | Unit | Reference |
|---|---|---|---|---|
| Concrete floor /wood-frame w | Concrete floor/concrete wall (component leakage not available) | 0.00 | [m] | Assumption |
| | Sill membrane - Low Load | 0.48 | [m] | [13] |
| | Sill membrane - High Load | 0.45 | [m] | [13] |
| | *Tar paper - Low Load* | 1.68 | [m] | [13] |
| | *Tar paper - High Load* | 1.60 | [m] | [13] |
| | *SM+Mfoil / Low Load* | 0.10 | [m] | [13] |
| | *SM+Mfoil / High Load* | 0.06 | [m] | [13] |
| | *Mineral wool in PE foil - Low Load* | 0.20 | [m] | [13] |
| | *Mineral wool in PE foil - High Load* | 0.06 | [m] | [13] |
| | *Mineral wool in PE foill and Tar paper - Low Load* | 0.66 | [m] | [13] |
| | *Mineral wood in PE foil and Tar paper - High Load* | 0.93 | [m] | [13] |
| Structural Floor | Structural floor with Gypsum board wind-barrier | 1.66 | [m] | [15] |
| | *Structural floor with Rolled wind-barrier* | 0.22 | [m] | [15] |
| Concrete/wood-frame wall | Sill membrane - Low Load & Structural floor with Gypsum board wind-barrier | 2.15 | [m] | *[13],[15]* |
| | Sill membrane - High Load & Structural floor with Gypsum board wind-barrier | 2.11 | [m] | *[13],[15]* |
| | *Tar paper - Low Load & Structural floor with Gypsum board wind-barrier* | 3.34 | [m] | *[13],[15]* |
| | *Tar paper - High Load & Structural floor with Gypsum board wind-barrier* | 3.26 | [m] | *[13],[15]* |
| | *SM+Mfoil / Low Load & Structural floor with Gypsum board wind-barrier* | 1.76 | [m] | *[13],[15]* |
| | SM+Mfoil / High Load & Structural floor with Gypsum board wind-barrier | 1.73 | [m] | *[13],[15]* |
| | *Mineral wool in PE foil - Low Load & Structural floor with Gypsum board wind-barrier* | 1.86 | [m] | *[13],[15]* |
| | *Mineral wool in PE foil - High Load & Structural floor with Gypsum board wind-barrier* | 1.73 | [m] | *[13],[15]* |
| | *Mineral wool in PE foill and Tar paper - Low Load & Structural floor with Gypsum board wind-barrier* | 2.33 | [m] | *[13],[15]* |
| | *Mineral wood in PE foil and Tar paper - High Load & Structural floor with Gypsum board wind-barrier* | 2.59 | [m] | *[13],[15]* |
| | *Sill membrane - Low Load & Structural floor with Rolled wind-barrier* | 0.70 | [m] | *[13],[15]* |
| | Sill membrane - High Load & Structural floor with Rolled wind-barrier | 0.67 | [m] | *[13],[15]* |
| | *Tar paper - Low Load & Structural floor with Rolled wind-barrier* | 1.90 | [m] | *[13],[15]* |
| | *Tar paper - High Load & Structural floor with Rolled wind-barrier* | 1.81 | [m] | *[13],[15]* |
| | *SM+Mfoil / Low Load & Structural floor with Rolled wind-barrier* | 0.32 | [m] | *[13],[15]* |
| | *SM+Mfoil / High Load & Structural floor with Rolled wind-barrier* | 0.28 | [m] | *[13],[15]* |
| | *Mineral wool in PE foil - Low Load & Structural floor with Rolled wind-barrier* | 0.42 | [m] | *[13],[15]* |
| | *Mineral wool in PE foil - High Load & Structural floor with Rolled wind-barrier* | 0.28 | [m] | *[13],[15]* |
| | *Mineral wool in PE foill and Tar paper - Low Load & Structural floor with Rolled wind-barrier* | 0.88 | [m] | *[13],[15]* |
| | Mineral wood in PE foil and Tar paper - High Load & Structural floor with Rolled wind-barrier | 1.14 | [m] | *[13],[15]* |
| Vertical jonts joints | Assumed airtight | 0.00 | [m] | ***Assumption*** |
| | Vertical concrete/wood - Sill membrane - Low Load | 0.48 | [m] | ***Assumption*** |
| | Vertical concrete/wood - non specified / Low Load | 0.63 | [m] | ***Assumption*** |
| | Vertical wood/wood - Gypsum board wind-barrier | 1.66 | [m] | ***Assumption*** |
| | Vertical wood/wood - Rolled wind-barrier | 0.22 | [m] | ***Assumption*** |
| Junctions wall/roof | Eaves - gypsum board wind-barrier | 1.66 | [m] | *[15]* |
| | Eaves - rolled wind-barrier | 0.22 | [m] | *[15]* |
| | Gypsum board wind-barrier penetrated by roof beams | 1.66 | [m] | *[15]* |
| | Rolled wind-barrier penetrated by roof beams | 5.99 | [m] | *[15]* |
| | Gable wall/roof or roof/higher wall - Gypsum board | 1.66 | [m] | *[15]* |
| | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | [m] | *[15]* |
| | The roof is assumed completely airtight | 0.00 | [m] | ***Assumption*** |
| | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | [m] | *[15]* |
| Joint window and door | Window(or door)/wood-frame wall - TAPE | 0.00 | [m] | [16] |
| | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | [m] | [18] |
| | Window(or door)/wood-frame wall - Wind-Barrier-strips - - - or specially designed "fiber-strips for windows" | 0.31 | [m] | [16] |
| | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | [m] | *[17]* |
| Surfaces | Wall Surface - TYVEK [Tech Approv] - - - | 0.15 | [m²] | TG 2043 |
| | *Wall Surface - HUNTON asfalt [Tech Approv]* | 0.70 | [m²] | TG 2002 |
| | Wall Surface - Vempro | 0.10 | [m²] | TG 20017 |
| | Wall Surface - VAFLEX | 0.27 | [m²] | ***Producer*** |
| | Wall Surface - assumed airtight | 0.00 | [m²] | **Assumption** |
| | Roof Surface - Daltex [Tech Approv] | 0.50 | [m²] | TG 2375 |
| | Roof Surface - Hunton [Tech Approv] | 0.70 | [m²] | TG 2002 |
| | Roof Surface - Brettex [Tech Approv] | 0.80 | [m²] | TG2058 |
| | Roof Surface - "Glava Vindsperre" (old product "Glava Wind-barrier") | 1.35 | [m²] | SINTEF 08602 |
| | Roof Surface - Ventex | 0.10 | [m²] | TG 2318 |
| | Roof Surface - Divoroll [Tech Approv] | 0.45 | [m²] | TG 2401 |
| | Roof Surface - Tyvek Pro / Pro Super [Tech Approv] | 0.10 | [m²] | TG 2134 |
| | *Roof Surface - asphalt roof with seamed joints* | 0.00 | [m²] | **Assumption** |
| | Concrete floor - - - assumed airtight | 0.00 | [m²] | **Assumption** |
| | Airtight floor | 0.00 | [m²] | **Assumption** |
| | Window area - calculated from maximum value | 1.25 | [m²] | Product rules |
| | Door area - calculated from maximum value | 1.25 | [m²] | Product rules |

| Category | Description | V50 [m3/h]/unit | Unit | Reference |
| --- | --- | --- | --- | --- |
| Penetrations | Electrical 16 mm plumbing in 16 mm opening - - - or unsealed electrical plumbings | **0.93** | [pcs] | [19] |
| | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | **0.66** | [pcs] | [19] |
| | underpressure | **1.13** | [pcs] | [20] |
| | Ventilation 100 mm in 105 mm hole - - -generally mounted in wall without any sealing | **2.36** | [pcs] | [19] |
| | floor | **0.80** | [pcs] | [19] |
| | LWAC element - Normal/Board/One layer | **4.96** | [pcs] | [21] |
| | LWAC element - Normal/Brush/Two layers | | | [21] |
| | LWAC element - Hastily/Brush/One layer used for no layer | **47.82** | [pcs] | [21] |
| | Chiimney roof joint - with collar/flashing - high quality | **0.00** | [m] | [21] |
| | Chimney roof joint - backer rod at interior and exterior side, no mastic | **0.38** | [m] | [21] |
| | Chimney roof joint - with collar/flashing fastened with mastic - low quality | **3.62** | [m] | [21] |

# C Apppendix C: Estimation of all the 17 houses

The following pages show the airtightness estimation of all the 17 houses, $n_{50we}$. For all the houses also the measured airtightness is shown, $n_{50wm}$.

## Estimated airtightness of House 1

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **60.03** |
| Concrete floor/concrete wall | 44.17 | - | - | Foundation wall | - | - | | | - |
| Concrete floor/wood-frame wall | - | - | - | - | | | | | - |
| Concrete wall/wood-frame wall | 44.17 | - | - | Mineral wool in PE foil and tar paper | Mineral wood in PE foil and Tar paper - High Load & Structural floor with Rolled wind-barrier | 1.14 | | | 50.46 |
| Intermediate floor | 44.17 | - | - | Double wind-barrier: Gypsum board and Glava Wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 9.57 |
| **Vertical joints** | | | | | | | | | **6.88** |
| Concrete/concrete | 19.20 | - | - | Foundation wall | Assumed airtight | - | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 31.76 | - | - | Double wind-barrier: Gypsum board and Glava Wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 6.88 |
| **Junctions wall/roof** | | | | | | | | | **18.20** |
| Side walls/roof | 23.90 | - | - | Roof wind-barrier pulled around the eaves and fastened at the top sill of the wall. Wall wind-barrier pulled around the eaves and fastened at the top of the eaves. | Eaves - rolled wind-barrier | 0.22 | | | 5.18 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | 28.30 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 6.13 |
| Roof against higher walls | 2.45 | - | - | The wind-barriers are fastened together with battens. | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 0.53 |
| Roof/roof (roof valley) | 11.66 | - | - | The wind-barrier is clamped | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 2.53 |
| Ridge of roof | 17.69 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 3.83 |
| **Joint window and door** | | | | | | | | | **4.23** |
| Window against wood | 85.20 | - | - | Wind-barrier over the joint, PU foam, insulation, silicone | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 2.64 |
| Window against masonry | 18.40 | - | - | Wind-barrier over the joint, PU foam, insulation, silicone | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.70 |
| Door against wood | 21.44 | - | - | PU foam, insulation, silicone, wind-barrier fastened with butyl-bands | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.66 |
| Door against masonry | 6.20 | - | - | PU foam, insulation, silicone, wind-barrier fastened with butyl-bands | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.23 |
| **Surfaces** | | | | | | | | | **296.60** |
| Concrete wall | - | 98.66 | - | | | | | | - |
| Wood-frame wall | - | 173.62 | - | Double wind-barrier: Gypsum board and Glava Wind-barrier | Roof Surface - "Glava Vindsperre" (old product "Glava Wind-barrier") | - | 1.35 | | 234.39 |
| Roof | - | 137.62 | - | Daltex supra wind-barrier | Roof Surface - Ventex | - | 0.10 | | 13.76 |
| Floor | - | 112.41 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 27.48 | - | - | Window area - calculated from maximum value | - | 1.25 | | 34.26 |
| Door | - | 11.38 | - | - | Window area - calculated from maximum value | - | 1.25 | | 14.19 |
| **Penetrations** | | | | | | | | | **12.24** |
| Electrical cables | - | - | 4.00 | The penetration is placed in position prior to casting. | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | - | - | 0.66 | 2.64 |
| Ventilation ducts | - | - | 3.00 | PU foam around penetrations in the basement, collars/flashings elsewhere. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 2.40 |
| Water & Sewage | - | - | 9.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 7.20 |
| Chimneys | - | - | - | - | | | | | - |

| | |
|---|---|
| **V50 total** | 398.18 |
| **Volume** | 643.60 |
| **n50w** | 0.62 |

## Estimated airtightness of House 2

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **60.38** |
| Concrete floor/concrete wall | - | - | - | - | | | | | - |
| Concrete floor/wood-frame wall | 46.78 | - | - | Tak | Sill membrane - High Load | 0.45 | | | 21.00 |
| Concrete wall/wood-frame wall | - | - | - | - | | | | | - |
| Intermediate floor | 23.69 | - | - | Tak møter utstikkvegg | Structural floor with Gypsum board wind-barrier | 1.66 | | | 39.38 |
| **Vertical joints** | | | | | | | | | **31.92** |
| Concrete/concrete | - | - | - | - | | | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 19.20 | - | - | Tak møter utstikkvegg | Vertical wood/wood - Gypsum board wind-barrier | 1.66 | | | 31.92 |
| **Junctions wall/roof** | | | | | | | | | **95.51** |
| Side walls/roof | 23.10 | - | - | Møne | Eaves - gypsum board wind-barrier | 1.66 | | | 38.40 |
| Side walls/roof - penetrating beams (total roof beam perimeter) | 26.45 | | | Møne | Gypsum board wind-barrier penetrated by roof beams | 1.66 | | | 43.97 |
| Gable wall/roof | 30.67 | - | - | Vindu | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 6.65 |
| Roof against higher walls | - | - | - | - | | | | | - |
| Roof/roof (roof valley) | 13.29 | - | - | Vinduskjøt mot mur | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 2.88 |
| Ridge of roof | 16.71 | - | - | Dør | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 3.62 |
| **Joint window and door** | | | | | | | | | **2.44** |
| Window against wood | 60.20 | - | - | Dørskjøt mot mur | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 1.86 |
| Window against masonry | - | - | - | Elkabler | | | | | - |
| Door against wood | 18.60 | - | - | Vann og avløp | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.58 |
| Door against masonry | - | - | - | Piper | | | | | - |
| **Surfaces** | | | | | | | | | **137.17** |
| Concrete wall | - | - | - | - | | | | | - |
| Wood-frame wall | - | 128.43 | - | Tak møter utstikkvegg | Wall Surface - HUNTON asfalt [Tech Approv] | - | 0.70 | | 89.90 |
| Roof | - | 178.27 | - | Tak/tak skrå | Roof Surface - Tyvek Pro / Pro Super [Tech Approv] | - | 0.10 | | 17.83 |
| Floor | - | 117.72 | - | Ringmur/etasjeskiller i tre | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 17.32 | - | Dørskjøt mot tre | Window area - calculated from maximum value | - | 1.25 | | 21.59 |
| Door | - | 6.30 | - | Ventilasjonsrør | Door area - calculated from maximum value | - | 1.25 | | 7.85 |
| **Penetrations** | | | | | | | | | **13.28** |
| Electrical cables | - | - | 8.00 | Utstikk mellombjelkelag | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | - | - | 0.66 | 5.28 |
| Ventilation ducts | - | - | - | - | | | | | - |
| Water & Sewage | - | - | 10.00 | - | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 8.00 |
| Chimneys | - | - | - | - | | | | | - |

| | |
|---|---|
| **V50 total** | 340.70 |
| **Volume** | 389.97 |
| **n50w** | 0.87 |

## Estimated airtightness of House 4

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **21.42** |
| Concrete floor/concrete wall | - | - | - | - | | | | | - |
| Concrete floor/wood-frame wall | 40.08 | - | - | Sill membrane | Sill membrane - High Load | 0.45 | | | 17.99 |
| Concrete wall/wood-frame wall | - | - | - | - | | | | | - |
| Intermediate floor | 15.84 | - | - | Double wind-barrier: Gypsum boards and Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 3.43 |
| **Vertical joints** | - | - | - | | | | | | **2.99** |
| Concrete/concrete | - | - | - | - | | | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 13.80 | - | - | Double wind-barrier: Gypsum boards and Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 2.99 |
| **Junctions wall/roof** | - | - | - | | | | | | **17.35** |
| Side walls/roof | 22.38 | - | - | Rolled wind-barrier pulled contiunuosly around the eaves. | Eaves - rolled wind-barrier | 0.22 | | | 4.85 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | 27.44 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 5.94 |
| Roof against higher walls | 2.77 | - | - | The wind-barriers are fastened together with battens. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 0.60 |
| Roof/roof (roof valley) | 11.75 | - | - | Wind-barrier fastened against the roof beams | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 2.55 |
| Ridge of roof | 15.73 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 3.41 |
| **Joint window and door** | - | - | - | | | | | | **15.91** |
| Window against wood | 50.00 | - | - | Special desinged "fiber-strips" for windows and insulation | strips for windows" | 0.31 | | | 15.50 |
| Window against masonry | - | - | - | - | | | | | - |
| Door against wood | 13.40 | - | - | Backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.41 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **62.27** |
| Concrete wall | - | - | - | - | | | | | - |
| Wood-frame wall | - | 120.12 | - | Double wind-barrier: Gypsum boards and Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 18.02 |
| Roof | - | 128.78 | - | TYVEK Pro Super | Roof Surface - Tyvek Pro / Pro Super [Tech Approv] | - | 0.10 | | 12.88 |
| Floor | - | 95.99 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 19.92 | - | - | Window area - calculated from maximum value | - | 1.25 | | 24.83 |
| Door | - | 5.25 | - | - | Door area - calculated from maximum value | - | 1.25 | | 6.54 |
| **Penetrations** | - | - | - | | | | | | **12.11** |
| Electrical cables | - | - | 7.00 | No sealing! | Electrical 16 mm plumbing in 16 mm opening - - - or unsealed electrical plumbings | - | - | 0.93 | 6.51 |
| Ventilation ducts | - | - | 3.00 | Sealed with collar/flashing. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 2.40 |
| Water & Sewage | - | - | 4.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 3.20 |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 132.06 |
| **Volume** | 322.73 |
| **n50w** | 0.41 |

## Estimated airtightness of House 5

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **30.98** |
| Concrete floor/concrete wall | - | - | - | - | Concrete floor/concrete wall (component leakage not available) | - | | | - |
| Concrete floor/wood-frame wall | - | - | - | - | | | | | - |
| Concrete wall/wood-frame wall | 31.58 | - | - | Sill membrane | Sill membrane - High Load & Structural floor with Rolled wind-barrier | 0.67 | | | 21.02 |
| Intermediate floor | 45.98 | - | - | Double wind-barrier: Ashpalt boards + Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 9.96 |
| **Vertical joints** | - | - | - | | | | | | **6.24** |
| Concrete/concrete | 9.60 | - | - | - | Assumed airtight | - | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 28.80 | - | - | Double wind-barrier: Ashpalt boards + Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 6.24 |
| **Junctions wall/roof** | - | - | - | | | | | | **12.71** |
| Side walls/roof | 22.19 | - | - | Wind-barrier pulled around the eaves, 3 pieces of wind-barrier - the two joints are sealed with tape | Eaves - rolled wind-barrier | 0.22 | | | 4.81 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | 20.69 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 4.48 |
| Roof against higher walls | 7.00 | - | - | The wind-barriers are fastened together with battens. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 1.52 |
| Roof/roof (roof valley) | - | - | - | - | | | | | - |
| Ridge of roof | 8.80 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 1.91 |
| **Joint window and door** | - | - | - | | | | | | **2.18** |
| Window against wood | 48.20 | - | - | Special desinged "fiber-strips" for windows, taped wind-barrier, PU foam, | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 1.49 |
| Window against masonry | 3.05 | - | - | Special desinged "fiber-strips" for windows, taped wind-barrier, PU foam, | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.12 |
| Door against wood | 18.40 | - | - | Special desinged "fiber-strips" for windows, taped wind-barrier, PU foam, | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.57 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **65.33** |
| Concrete wall | - | 72.75 | - | - | Wall Surface - assumed airtight | - | - | | - |
| Wood-frame wall | - | 191.22 | - | Double wind-barrier: Ashpalt boards + Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 28.68 |
| Roof | - | 79.23 | - | Tyvek Super Pro and Sutak HUNTON | Roof Surface - Tyvek Pro / Pro Super [Tech Approv] | - | 0.10 | | 7.92 |
| Floor | - | 61.54 | - | Basement | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 16.95 | - | - | Window area - calculated from maximum value | - | 1.25 | | 21.13 |
| Door | - | 6.09 | - | - | Door area - calculated from maximum value | - | 1.25 | | 7.59 |
| **Penetrations** | - | - | - | | | | | | **3.30** |
| Electrical cables | - | - | 5.00 | Taped wind-barrier around the openings | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | - | - | 0.66 | 3.30 |
| Ventilation ducts | - | - | - | - | | | | | - |
| Water & Sewage | - | - | - | - | | | | | - |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 120.74 |
| **Volume** | 387.19 |
| **n50w** | 0.31 |

## Estimated airtightness of House 6

| Component leakage category | Quantity | | | | | [m3/h] per | | | V50 |
|---|---|---|---|---|---|---|---|---|---|
| | [m] | [m2] | pcs | Description from site | Description of component leakage data used | m | m2 | pcs | |
| **Horizontal joints** | | | | | | | | | **33.45** |
| Concrete floor/concrete wall | - | - | - | - | | | | | - |
| Concrete floor/wood-frame wall | 46.08 | - | - | Sill membrane | Sill membrane - High Load | 0.45 | | | 20.68 |
| Concrete wall/wood-frame wall | - | - | - | - | | | | | - |
| Intermediate floor | 58.92 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 12.77 |
| **Vertical joints** | - | - | - | | | | | | **8.32** |
| Concrete/concrete | - | - | - | - | | | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 38.40 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 8.32 |
| **Junctions wall/roof** | - | - | - | | | | | | **17.79** |
| Side walls/roof | 22.62 | - | - | Rolled wind-barrier pulled over the eaves, roof wind-barrier fastened at the bottom of the roof, wall wind-barrier fastened at the top sill | Eaves - rolled wind-barrier | 0.22 | | | 4.90 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | 25.30 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 5.48 |
| Roof against higher walls | 19.65 | - | - | The wind-barriers are fastened together with battens. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 4.26 |
| Roof/roof (roof valley) | - | - | - | - | | | | | - |
| Ridge of roof | 14.52 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 3.15 |
| **Joint window and door** | - | - | - | | | | | | **35.10** |
| Window against wood | 112.00 | - | - | Special desinged "fiber-strips" for windows, insulation | Window(or door)/wood-frame wall - Wind-Barrier-strips - - - or specially designed "fiber-strips for windows" | 0.31 | | | 34.72 |
| Window against masonry | - | - | - | - | | | | | - |
| Door against wood | 12.20 | - | - | Backer rod and mastic, insulation | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.38 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **93.62** |
| Concrete wall | - | - | - | - | | | | | - |
| Wood-frame wall | - | 202.48 | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 30.37 |
| Roof | - | 115.08 | - | Tyvek wind-barrier (same as on walls) | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 17.26 |
| Floor | - | 115.11 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 32.79 | - | - | Window area - calculated from maximum value | - | 1.25 | | 40.87 |
| Door | - | 4.10 | - | - | Door area - calculated from maximum value | - | 1.25 | | 5.11 |
| **Penetrations** | - | - | - | | | | | | **10.12** |
| Electrical cables | - | - | 2.00 | Taped wind-barrier around the openings | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | - | - | 0.66 | 1.32 |
| Ventilation ducts | - | - | 4.00 | Taped wind-barrier around the openings | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 3.20 |
| Water & Sewage | - | - | 7.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 5.60 |
| Chimneys | - | - | - | - | | | | | - |

3 stk gjennomføringer

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| **V50 total** | 198.39 |
| **Volume** | 448.58 |
| **n50w** | 0.44 |

## Estimated airtightness of House 8

| Component leakage category | Quantity [m] | Quantity [m2] | Quantity pcs | Description from site | Description of component leakage data used | [m3/h] per m | [m3/h] per m2 | [m3/h] per pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **27.55** |
| Concrete floor/concrete wall | - | - | - | - | | | | | - |
| Concrete floor/wood-frame wall | 41.40 | - | - | Sill membrane | Sill membrane - High Load | 0.45 | | | 18.58 |
| Concrete wall/wood-frame wall | - | - | - | - | | | | | - |
| Intermediate floor | 41.40 | - | - | Double wind-barrier: Asphalt board and Glave Vempro | Structural floor with Rolled wind-barrier | 0.22 | | | 8.97 |
| **Vertical joints** | - | - | - | | | | | | **7.04** |
| Concrete/concrete | - | - | - | - | | | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 32.50 | - | - | Double wind-barrier: Asphalt board and Glave Vempro | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 7.04 |
| **Junctions wall/roof** | - | - | - | | | | | | **140.14** |
| Side walls/roof | | - | - | - | - | | | | - |
| Side walls/roof - penetrating beams | 21.40 | | | Wind-barrier fastened against the roof beams. | Rolled wind-barrier penetrated by roof beams | 5.99 | | | 128.08 |
| Gable wall/roof | 24.72 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 5.36 |
| Roof against higher walls | 3.60 | - | - | The wind-barriers are fastened together with battens. | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 0.78 |
| Roof/roof (roof valley) | 10.71 | - | - | The wind-barrier is fastened with battens against the roof beams | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 2.32 |
| Ridge of roof | 16.65 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 3.61 |
| **Joint window and door** | - | - | - | | | | | | **2.95** |
| Window against wood | 81.80 | - | - | Wind-barrier overlap, backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 2.53 |
| Window against masonry | - | - | - | - | | | | | - |
| Door against wood | 13.40 | - | - | Wind-barrier overlap, backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.41 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **104.15** |
| Concrete wall | - | - | - | - | | | | | - |
| Wood-frame wall | - | 166.28 | - | Double wind-barrier: Asphalt board and Glave Vempro | Wall Surface - Vempro | - | 0.10 | | 16.63 |
| Roof | - | 119.77 | - | Divorol | Roof Surface - Divoroll [Tech Approv] | - | 0.45 | | 53.90 |
| Floor | - | 96.90 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 21.72 | - | - | Window area - calculated from maximum value | - | 1.25 | | 27.08 |
| Door | - | 5.25 | - | - | Door area - calculated from maximum value | - | 1.25 | | 6.54 |
| **Penetrations** | - | - | - | | | | | | **12.80** |
| Electrical cables | - | - | - | - | | | | | - |
| Ventilation ducts | - | - | 8.00 | Mastic | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 6.40 |
| Water & Sewage | - | - | 8.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 6.40 |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 294.63 |
| **Volume** | 392.37 |
| **n50w** | 0.75 |

## Estimated airtightness of House 9

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **31.14** |
| Concrete floor/concrete wall | 15.17 | - | - | Foundation wall | Concrete floor/concrete wall (component leakage not available) | - | | | - |
| Concrete floor/wood-frame wall | 18.02 | - | - | Sill membrane and mastic | Sill membrane - High Load | 0.45 | | | 8.09 |
| Concrete wall/wood-frame wall | 15.17 | - | - | Sill membrane | Sill membrane - High Load & Structural floor with Rolled wind-barrier | 0.67 | | | 10.10 |
| Intermediate floor | 59.81 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 12.96 |
| **Vertical joints** | - | - | - | | | | | | **13.07** |
| Concrete/concrete | 4.80 | - | - | | Assumed airtight | - | | | - |
| Concrete/wood-frame wall | 4.80 | - | - | Sill membrane | Vertical concrete/wood - Sill membrane - Low Load | 0.48 | | | 2.32 |
| Wood-frame wall/wood-frame wall | 49.60 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 10.75 |
| **Junctions wall/roof** | - | - | - | | | | | | **9.05** |
| Side walls/roof | 41.79 | - | - | Flat roof | Eaves - rolled wind-barrier | 0.22 | | | 9.05 |
| Side walls/roof - penetrating beams | - | | | Flat roof… | | | | | |
| Gable wall/roof | - | - | - | Flat roof… | | | | | - |
| Roof against higher walls | - | - | - | Flat roof… | | | | | - |
| Roof/roof (roof valley) | - | - | - | Flat roof… | | | | | - |
| Ridge of roof | - | - | - | Flat roof… | | | | | - |
| **Joint window and door** | - | - | - | | | | | | **3.96** |
| Window against wood | 95.40 | - | - | Wind-barrier over joint, mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 2.95 |
| Window against masonry | - | - | - | - | | | | | - |
| Door against wood | 32.60 | - | - | Wind-barrier over joint, mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 1.01 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **91.66** |
| Concrete wall | - | 36.41 | - | - | Wall Surface - assumed airtight | - | - | | - |
| Wood-frame wall | - | 203.09 | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 30.46 |
| Roof | - | 80.91 | - | Isola Mestertrekk | - | - | - | | - |
| Floor | - | 81.49 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 37.23 | - | - | Window area - calculated from maximum value | - | 1.25 | | 46.41 |
| Door | - | 11.86 | - | - | Door area - calculated from maximum value | - | 1.25 | | 14.78 |
| **Penetrations** | - | - | - | | | | | | **20.16** |
| Electrical cables | - | - | 10.00 | Collars, not properly mounted | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | - | - | 0.66 | 6.60 |
| Ventilation ducts | - | - | 6.00 | The penetration is placed in position prior to casting, taped | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | - | - | 0.66 | 3.96 |
| Water & Sewage | - | - | 12.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 9.60 |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 169.05 |
| **Volume** | 463.61 |
| **n50w** | 0.36 |

## Estimated airtightness of House 10

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **131.39** |
| Concrete floor/concrete wall | 46.74 | - | - | Foundation wall | Concrete floor/concrete wall (component leakage not available) | - | | | - |
| Concrete floor/wood-frame wall | - | - | - | - | | | | | - |
| Concrete wall/wood-frame wall | 46.74 | - | - | Sill membrane | Sill membrane - Low Load & Structural floor with Gypsum board wind-barrier | 2.15 | | | 100.34 |
| Intermediate floor | 18.68 | - | - | Asphalt cardboard - VERIFY TYPE | Structural floor with Gypsum board wind-barrier | 1.66 | | | 31.05 |
| **Vertical joints** | - | - | - | | | | | | **64.76** |
| Concrete/concrete | 14.40 | - | - | - | Assumed airtight | - | | | - |
| Concrete/wood-frame wall | 4.80 | - | - | | Vertical concrete/wood - non specified / Low Load | 0.63 | | | 3.00 |
| Wood-frame wall/wood-frame wall | 37.15 | - | - | Asphalt cardboard - VERIFY TYPE | Vertical wood/wood - Gypsum board wind-barrier | 1.66 | | | 61.76 |
| **Junctions wall/roof** | - | - | - | | | | | | **13.03** |
| Side walls/roof | 28.07 | - | - | Wind-barrier rolled continuously around the eaves and fastened against the top sill | Eaves - rolled wind-barrier | 0.22 | | | 6.08 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | 25.20 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 5.46 |
| Roof against higher walls | 2.12 | - | - | The wind-barriers are fastened together with battens. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 0.46 |
| Roof/roof (roof valley) | 4.75 | - | - | The wind-barrier is fastened against the roof beams with battens | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 1.03 |
| Ridge of roof | 17.85 | - | - | No joint at the ridge | The roof is assumed completely airtight | - | | | - |
| **Joint window and door** | - | - | - | | | | | | **2.20** |
| Window against wood | 58.26 | - | - | Special desinged "fiber-strips" for windows, PU foam | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 1.80 |
| Window against masonry | 6.20 | - | - | Ikke oppgitt. Antar at det skummes siden gjort på de andre vinduene! | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.23 |
| Door against wood | 12.40 | - | - | Tape and insulation, | Window(or door)/wood-frame wall - TAPE | - | | | - |
| Door against masonry | 4.20 | - | - | Ikke oppgitt. Antar at det skummes siden gjort på de andre vinduene! | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.16 |
| **Surfaces** | - | - | - | | | | | | **202.59** |
| Concrete wall | - | 86.08 | - | - | Wall Surface - assumed airtight | - | - | | - |
| Wood-frame wall | - | 159.37 | - | Asphalt cardboard - VERIFY TYPE | Wall Surface - HUNTON asfalt [Tech Approv] | - | 0.70 | | 111.56 |
| Roof | - | 108.76 | - | Sutak and Divoroll | Roof Surface - Divoroll [Tech Approv] | - | 0.45 | | 48.94 |
| Floor | - | 107.01 | - | Basement | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 25.36 | - | - | Window area - calculated from maximum value | - | 1.25 | | 31.61 |
| Door | - | 8.40 | - | - | Door area - calculated from maximum value | - | 1.25 | | 10.47 |
| **Penetrations** | - | - | - | | | | | | **28.18** |
| Electrical cables | - | - | 9.00 | Sealed with collar/flashing. | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | - | - | 0.66 | 5.94 |
| Ventilation ducts | - | - | 4.00 | The penetration is placed in position prior to casting, taped | Ventilation 100 mm in 105 mm hole - - -generally mounted in wall without any sealing | - | - | 2.36 | 9.44 |
| Water & Sewage | - | - | 16.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 12.80 |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 442.15 |
| **Volume** | 440.64 |
| **n50w** | 1.00 |

## Estimated airtightness of House 11

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **26.10** |
| Concrete floor/concrete wall | - | - | - | - | | | | | - |
| Concrete floor/wood-frame wall | 43.39 | - | - | Sill membrane | Sill membrane - High Load | 0.45 | | | 19.47 |
| Concrete wall/wood-frame wall | - | - | - | - | | | | | - |
| Intermediate floor | 30.59 | - | - | Double wind-barrier: Asphalt boards and Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 6.63 |
| **Vertical joints** | - | - | - | | | | | | **7.55** |
| Concrete/concrete | - | - | - | - | | | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 34.86 | - | - | Double wind-barrier: Asphalt boards and Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 7.55 |
| **Junctions wall/roof** | - | - | - | | | | | | **11.47** |
| Side walls/roof | 24.40 | - | - | Wind-barrier rolled around the eaves, fastened and sealed with mastic against the top sill. | Eaves - rolled wind-barrier | 0.22 | | | 5.29 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | 16.39 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 3.55 |
| Roof against higher walls | 12.14 | - | - | The wind-barriers are fastened together with battens. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 2.63 |
| Roof/roof (roof valley) | - | - | - | - | | | | | - |
| Ridge of roof | 17.10 | - | - | No joint at the ridge | The roof is assumed completely airtight | - | | | - |
| **Joint window and door** | - | - | - | | | | | | **2.37** |
| Window against wood | 60.00 | - | - | Special desinged "fiber-strips" for windows and PU foam | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 1.86 |
| Window against masonry | - | - | - | - | | | | | - |
| Door against wood | 16.60 | - | - | Special desinged "fiber-strips" for windows and PU foam | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.51 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **56.00** |
| Concrete wall | - | - | - | - | | | | | - |
| Wood-frame wall | - | 143.66 | - | Double wind-barrier: Asphalt boards and Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 21.55 |
| Roof | - | 95.77 | - | Tyvek Pro Supra | Roof Surface - Tyvek Pro / Pro Super [Tech Approv] | - | 0.10 | | 9.58 |
| Floor | - | 81.42 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 15.00 | - | - | Window area - calculated from maximum value | - | 1.25 | | 18.70 |
| Door | - | 4.95 | - | - | Door area - calculated from maximum value | - | 1.25 | | 6.17 |
| **Penetrations** | - | - | - | | | | | | - |
| Electrical cables | - | - | - | - | | | | | - |
| Ventilation ducts | - | - | - | - | | | | | - |
| Water & Sewage | - | - | - | - | | | | | - |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 103.49 |
| **Volume** | 265.26 |
| **n50w** | 0.39 |

## Estimated airtightness of House 12

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **40.88** |
| Concrete floor/concrete wall | 61.43 | - | - | Støpt på plass mot hverandre. | Concrete floor/concrete wall (component leakage not available) | - | | | - |
| Concrete floor/wood-frame wall | - | - | - | - | | | | | - |
| Concrete wall/wood-frame wall | 61.43 | - | - | Sill membrane | Sill membrane - High Load & Structural floor with Rolled wind-barrier | 0.67 | | | 40.88 |
| Intermediate floor | - | - | - | - | | | | | - |
| **Vertical joints** | - | - | - | | | | | | **10.83** |
| Concrete/concrete | 24.00 | - | - | Støpt på plass. Isopor innside og utside. | Assumed airtight | - | | | - |
| Concrete/wood-frame wall | 7.20 | - | - | Sill membrane | Vertical concrete/wood - Sill membrane - Low Load | 0.48 | | | 3.48 |
| Wood-frame wall/wood-frame wall | 33.90 | - | - | Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 7.35 |
| **Junctions wall/roof** | - | - | - | | | | | | **23.08** |
| Side walls/roof | 62.80 | - | - | Wind-barrier rolled continuously around the eaves and fastened at the top sill. | Eaves - rolled wind-barrier | 0.22 | | | 13.61 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | - | - | - | hip roof… | | | | | - |
| Roof against higher walls | - | - | - | - | | | | | - |
| Roof/roof (roof valley) | 29.92 | - | - | The wind-barrier is fastened against the roof beams with battens | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 6.48 |
| Ridge of roof | 13.80 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 2.99 |
| **Joint window and door** | - | - | - | | | | | | **3.95** |
| Window against wood | 101.56 | - | - | Wind-barrier over joint, PU foam and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 3.14 |
| Window against masonry | 3.24 | - | - | Ikke oppgitt. Antar at det er skummet siden det for tre | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.12 |
| Door against wood | 16.90 | - | - | Wind-barrier over joint, PU foam and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.52 |
| Door against masonry | 4.20 | - | - | Ikke oppgitt. Antar at det er skummet siden det for tre | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.16 |
| **Surfaces** | - | - | - | | | | | | **113.17** |
| Concrete wall | - | 96.80 | - | | Wall Surface - assumed airtight | - | - | | - |
| Wood-frame wall | - | 194.58 | - | Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 29.19 |
| Roof | - | 162.62 | - | Ventex and Tyvek Pro Super | Roof Surface - Tyvek Pro / Pro Super [Tech Approv] (same airtightness on Tyvek Pro Super and Ventex) | - | 0.10 | | 16.26 |
| Floor | - | 171.51 | - | Basement | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 41.31 | - | - | Window area - calculated from maximum value | - | 1.25 | | 51.50 |
| Door | - | 13.02 | - | - | Door area - calculated from maximum value | - | 1.25 | | 16.23 |
| **Penetrations** | - | - | - | | | | | | **155.06** |
| Electrical cables | - | - | - | - | | | | | - |
| Ventilation ducts | - | - | 2.00 | Mastic | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 1.60 |
| Water & Sewage | - | - | 11.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 8.80 |
| Chimneys | 3.06 | - | 28.93 | LWAC element chimney, not properly plastered in the floors, mastic against the floors | LWAC element - Normal/Board/One layer | 0.38 | - | 4.96 | 144.66 |

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|---|---|
| **V50 total** | 346.97 |
| **Volume** | 720.00 |
| **n50w** | 0.48 |

## Estimated airtightness of House 13

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **21.42** |
| Concrete floor/concrete wall | - | - | - | - | | | | | - |
| Concrete floor/wood-frame wall | 40.08 | - | - | Sill membrane | Sill membrane - High Load | 0.45 | | | 17.99 |
| Concrete wall/wood-frame wall | - | - | - | - | | | | | - |
| Intermediate floor | 15.84 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 3.43 |
| **Vertical joints** | - | - | - | | | | | | **2.99** |
| Concrete/concrete | - | - | - | - | | | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 13.80 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 2.99 |
| **Junctions wall/roof** | - | - | - | | | | | | **18.05** |
| Side walls/roof | 22.38 | - | - | Wind-barrier rolled around the eaves and fastened in the top sill. | Eaves - rolled wind-barrier | 0.22 | | | 4.85 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | 27.44 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 5.94 |
| Roof against higher walls | 6.95 | - | - | The wind-barriers are fastened together with battens. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 1.51 |
| Roof/roof (roof valley) | 10.81 | - | - | The wind-barrier is fastened against the roof beams with battens | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 2.34 |
| Ridge of roof | 15.73 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 3.41 |
| **Joint window and door** | - | - | - | | | | | | **15.91** |
| Window against wood | 50.00 | - | - | Special desinged "fiber-strips" for windows and insulation | Window(or door)/wood-frame wall - Wind-Barrier-strips - - - or specially designed "fiber-strips for windows" | 0.31 | | | 15.50 |
| Window against masonry | - | - | - | - | | | | | - |
| Door against wood | 13.40 | - | - | Backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.41 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **68.29** |
| Concrete wall | - | - | - | - | | | | | - |
| Wood-frame wall | - | 117.28 | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 17.59 |
| Roof | - | 128.80 | - | Tyvek wind-barrier (same as walls) | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 19.32 |
| Floor | - | 95.99 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 19.92 | - | - | Window area - calculated from maximum value | - | 1.25 | | 24.83 |
| Door | - | 5.25 | - | - | Door area - calculated from maximum value | - | 1.25 | | 6.54 |
| **Penetrations** | - | - | - | | | | | | **5.60** |
| Electrical cables | - | - | - | - | | | | | - |
| Ventilation ducts | - | - | 3.00 | Sealed with collar/flashing. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 2.40 |
| Water & Sewage | - | - | 4.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 3.20 |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 132.27 |
| **Volume** | 321.64 |
| **n50w** | 0.41 |

## Estimated airtightness of House 14

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **27.15** |
| Concrete floor/concrete wall | - | - | - | - | | | | | - |
| Concrete floor/wood-frame wall | 40.80 | - | - | Sill membrane | Sill membrane - High Load | 0.45 | | | 18.31 |
| Concrete wall/wood-frame wall | - | - | - | - | | | | | - |
| Intermediate floor | 40.80 | - | - | Double wind-barrier: ashpalt boards and Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 8.84 |
| **Vertical joints** | - | - | - | | | | | | **3.48** |
| Concrete/concrete | - | - | - | - | | | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 16.06 | - | - | Double wind-barrier: ashpalt boards and Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 3.48 |
| **Junctions wall/roof** | - | - | - | | | | | | **12.03** |
| Side walls/roof | 25.80 | - | - | Loose eaves. Wind-barriers are fastened with battens in the joint. | Eaves - rolled wind-barrier | 0.22 | | | 5.59 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | 16.83 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 3.65 |
| Roof against higher walls | - | - | - | - | | | | | - |
| Roof/roof (roof valley) | - | - | - | - | | | | | - |
| Ridge of roof | 12.90 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 2.80 |
| **Joint window and door** | - | - | - | | | | | | **1.94** |
| Window against wood | 50.40 | - | - | Backer rod and mastic, PU foam | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 1.56 |
| Window against masonry | - | - | - | - | | | | | - |
| Door against wood | 12.40 | - | - | Backer rod and mastic, PU foam | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.38 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **50.80** |
| Concrete wall | - | - | - | - | | | | | - |
| Wood-frame wall | - | 109.73 | - | Double wind-barrier: ashpalt boards and Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 16.46 |
| Roof | - | 108.59 | - | Tyvek Pro Super | Roof Surface - Tyvek Pro / Pro Super [Tech Approv] | - | 0.10 | | 10.86 |
| Floor | - | 96.75 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 14.64 | - | - | Window area - calculated from maximum value | - | 1.25 | | 18.25 |
| Door | - | 4.20 | - | - | Door area - calculated from maximum value | - | 1.25 | | 5.24 |
| **Penetrations** | - | - | - | | | | | | **11.02** |
| Electrical cables | - | - | 7.00 | Sealed with collar/flashing. | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | - | - | 0.66 | 4.62 |
| Ventilation ducts | - | - | 3.00 | Sealed with collar/flashing. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 2.40 |
| Water & Sewage | - | - | 5.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 4.00 |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 106.43 |
| **Volume** | 339.48 |
| **n50w** | 0.31 |

## Estimated airtightness of House 15

| Component leakage category | Quantity [m] | Quantity [m2] | Quantity pcs | Description from site | Description of component leakage data used | [m3/h] per m | [m3/h] per m2 | [m3/h] per pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **43.80** |
| Concrete floor/concrete wall | 25.40 | - | - | Antas tett. | Concrete floor/concrete wall (component leakage not available) | - | | | - |
| Concrete floor/wood-frame wall | 33.80 | - | - | Sill membrane | Sill membrane - High Load | 0.45 | | | 15.17 |
| Concrete wall/wood-frame wall | 25.40 | - | - | Sill membrane | Sill membrane - Low Load & Structural floor with Rolled wind-barrier | 0.70 | | | 17.80 |
| Intermediate floor | 50.00 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 10.83 |
| **Vertical joints** | - | - | - | | | | | | **8.95** |
| Concrete/concrete | 4.80 | - | - | | Assumed airtight | - | | | - |
| Concrete/wood-frame wall | 4.80 | - | - | Sill membrane | Vertical concrete/wood - Sill membrane - Low Load | 0.48 | | | 2.32 |
| Wood-frame wall/wood-frame wall | 30.60 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 6.63 |
| **Junctions wall/roof** | - | - | - | | | | | | **215.65** |
| Side walls/roof | | - | - | - | - | | | | - |
| Side walls/roof - penetrating beams | 33.70 | - | - | The wind-barrier is fastened against the roof beams (also with mastic) and pulled over the roof boards. | Rolled wind-barrier penetrated by roof beams | 5.99 | | | 201.69 |
| Gable wall/roof | 27.27 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 5.91 |
| Roof against higher walls | - | - | - | - | | | | | - |
| Roof/roof (roof valley) | 12.18 | - | - | The wind-barrier is fastened to the roof beams with battens. | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 2.64 |
| Ridge of roof | 24.95 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 5.41 |
| **Joint window and door** | - | - | - | | | | | | **3.09** |
| Window against wood | 78.28 | - | - | Backer rod and mastic, insulation | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 2.42 |
| Window against masonry | 1.32 | - | - | Backer rod and mastic, insulation | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.05 |
| Door against wood | 17.50 | - | - | Backer rod and mastic, insulation | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.54 |
| Door against masonry | 2.10 | - | - | Backer rod and mastic, insulation | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.08 |
| **Surfaces** | - | - | - | | | | | | **175.45** |
| Concrete wall | - | 57.54 | - | | Wall Surface - assumed airtight | - | - | | - |
| Wood-frame wall | - | 220.60 | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 33.09 |
| Roof | - | 190.00 | - | Divorol | Roof Surface - Divoroll [Tech Approv] | - | 0.45 | | 85.50 |
| Floor | - | 167.59 | - | Basement | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 35.11 | - | - | Window area - calculated from maximum value | - | 1.25 | | 43.77 |
| Door | - | 10.50 | - | - | Door area - calculated from maximum value | - | 1.25 | | 13.09 |
| **Penetrations** | - | - | - | | | | | | **8.80** |
| Electrical cables | - | - | - | - | | | | | - |
| Ventilation ducts | - | - | - | - | | | | | - |
| Water & Sewage | - | - | 11.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 8.80 |
| Chimneys | - | - | - | - | | | | | - |

13.00

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|---|---|
| **V50 total** | 455.74 |
| **Volume** | 791.66 |
| **n50w** | 0.58 |

## Estimated airtightness of House 16

| Component leakage category | Quantity [m] | Quantity [m2] | Quantity pcs | Description from site | Description of component leakage data used | [m3/h] per m | [m3/h] per m2 | [m3/h] per pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **37.79** |
| Concrete floor/concrete wall | - | - | - | - | | | | | - |
| Concrete floor/wood-frame wall | 68.95 | - | - | Sill membrane | Sill membrane - High Load | 0.45 | | | 30.95 |
| Concrete wall/wood-frame wall | - | - | - | - | | | | | - |
| Intermediate floor | 31.60 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 6.85 |
| **Vertical joints** | - | - | - | | | | | | **11.05** |
| Concrete/concrete | - | - | - | - | | | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 50.98 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 11.05 |
| **Junctions wall/roof** | - | - | - | | | | | | **24.62** |
| Side walls/roof | 40.15 | - | - | Wind-barrier rolled around the eaves. | Eaves - rolled wind-barrier | 0.22 | | | 8.70 |
| Side walls/roof - penetrating beams | - | | | | | | | | |
| Gable wall/roof | 36.31 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 7.87 |
| Roof against higher walls | 4.90 | - | - | The wind-barriers are fastened together with battens. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 1.06 |
| Roof/roof (roof valley) | 7.80 | - | - | Vindsperre er klemt langs rennene. | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 1.69 |
| Ridge of roof | 24.45 | - | - | The wind-barrier is mounted with battens along the ridge | Roof/roof or roof ridnge - Rolled wind-barrier | 0.22 | | | 5.30 |
| **Joint window and door** | - | - | - | | | | | | **4.17** |
| Window against wood | 110.52 | - | - | PU foam, backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 3.42 |
| Window against masonry | - | - | - | - | | | | | - |
| Door against wood | 24.20 | - | - | PU foam, backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.75 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **105.23** |
| Concrete wall | - | - | - | - | | | | | - |
| Wood-frame wall | - | 202.78 | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 30.42 |
| Roof | - | 185.42 | - | Tyvek Pro Supra | Roof Surface - Tyvek Pro / Pro Super [Tech Approv] | - | 0.10 | | 18.54 |
| Floor | - | 169.29 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 30.65 | - | - | Window area - calculated from maximum value | - | 1.25 | | 38.21 |
| Door | - | 14.49 | - | - | Door area - calculated from maximum value | - | 1.25 | | 18.06 |
| **Penetrations** | - | - | - | | | | | | **41.35** |
| Electrical cables | - | - | 5.00 | Sealed with collar/flashing. | Electrical 16 mm plumbing in 16 mm opening with collar- - - or PU foam | - | - | 0.66 | 3.30 |
| Ventilation ducts | - | - | 1.00 | Sealed with collar/flashing. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 0.80 |
| Water & Sewage | - | - | 10.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 8.00 |
| Chimneys | - | - | - | - | | | | | - |
| Electrical lightbulbs | - | - | 26.00 | | Electrical plumbing - light spotsdifference between "W5" and "W2" in ref. average of over and underpressure | - | - | 1.13 | 29.25 |
| | | | | | | | | **V50 total** | 224.21 |
| | | | | | | | | **Volume** | 625.61 |
| | | | | | | | | **n50w** | 0.36 |

## Estimated airtightness of House 18

| Component leakage category | Quantity | | | | | [m3/h] per | | | |
|---|---|---|---|---|---|---|---|---|---|
| | [m] | [m2] | pcs | Description from site | Description of component leakage data used | m | m2 | pcs | V50 |
| **Horizontal joints** | | | | | | | | | **27.25** |
| Concrete floor/concrete wall | 56.60 | - | - | | Concrete floor/concrete wall (component leakage not available) | - | | | - |
| Concrete floor/wood-frame wall | - | - | - | - | | | | | - |
| Concrete wall/wood-frame wall | 56.60 | - | - | Sill membrane and mineral wool strips in PE foil | SM+Mfoil / High Load & Structural floor with Rolled wind-barrier | 0.28 | | | 15.87 |
| Intermediate floor | 52.50 | - | - | Double wind-barrier: ashphalt boards and Daltex wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 11.38 |
| **Vertical joints** | - | - | - | | | | | | **14.96** |
| Concrete/concrete | 38.40 | - | - | 50 mm Isopor utside, 100 mm isolasjon innside. | Assumed airtight | - | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 69.04 | - | - | Double wind-barrier: ashphalt boards and Daltex wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 14.96 |
| **Junctions wall/roof** | - | - | - | | | | | | **226.03** |
| Side walls/roof | | - | - | - | - | | | | - |
| Side walls/roof - penetrating beams | 35.70 | | | The wind-barrier is fastened against the sides of the roof beams with battens. | Rolled wind-barrier penetrated by roof beams | 5.99 | | | 213.68 |
| Gable wall/roof | 36.92 | - | - | Wind-barriers from the roof and wall meet and are fastened together with a batten. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 8.00 |
| Roof against higher walls | 20.09 | - | - | The wind-barriers are fastened together with battens. | Gable wall/roof or roof/higher wall - Rolled wind-barrier | 0.22 | | | 4.35 |
| Roof/roof (roof valley) | 19.70 | - | - | No joints. | | | | | - |
| Ridge of roof | 31.29 | - | - | No joints. | | | | | - |
| **Joint window and door** | - | - | - | | | | | | **5.20** |
| Window against wood | 115.00 | - | - | Wind-barrier over the joint, PU foamVindsperreduk stiftes fast på utside. Skum på innside. | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 3.56 |
| Window against masonry | 11.43 | - | - | Wind-barrier over the joint, PU foamVindsperreduk stiftes fast på utside. Skum på innside. | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.43 |
| Door against wood | 36.80 | - | - | Wind-barrier over the joint, PU foamVindsperreduk stiftes fast på utside. Skum på innside. | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 1.14 |
| Door against masonry | 1.89 | - | - | Wind-barrier over the joint, PU foamVindsperreduk stiftes fast på utside. Skum på innside. | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.07 |
| **Surfaces** | - | - | - | | | | | | **278.74** |
| Concrete wall | - | 120.42 | - | 50 mm Isopor utside, 100 mm isolasjon innside. | Wall Surface - assumed airtight | - | - | | - |
| Wood-frame wall | - | 230.53 | - | Double wind-barrier: ashphalt boards and Daltex wind-barrier | Roof Surface - Daltex [Tech Approv] | - | 0.50 | | 115.26 |
| Roof | - | 178.18 | - | Daltex | Roof Surface - Daltex [Tech Approv] | - | 0.50 | | 89.09 |
| Floor | - | 149.79 | - | Basement | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 43.50 | - | - | Window area - calculated from maximum value | - | 1.25 | | 54.23 |
| Door | - | 16.17 | - | - | Door area - calculated from maximum value | - | 1.25 | | 20.16 |
| **Penetrations** | - | - | - | | | | | | - |
| Electrical cables | - | - | - | - | | | | | - |
| Ventilation ducts | - | - | - | - | | | | | - |
| Water & Sewage | - | - | - | - | | | | | - |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 552.18 |
| **Volume** | 855.16 |
| **n50w** | 0.65 |

## Estimated airtightness of House 19

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **31.11** |
| Concrete floor/concrete wall | 44.40 | - | - | | Concrete floor/concrete wall (component leakage not available) | - | | | - |
| Concrete floor/wood-frame wall | - | - | - | - | | | | | - |
| Concrete wall/wood-frame wall | 44.40 | - | - | Sill membrane | Sill membrane - Low Load & Structural floor with Rolled wind-barrier | 0.70 | | | 31.11 |
| Intermediate floor | - | - | - | - | Structural floor with Rolled wind-barrier | 0.22 | | | - |
| **Vertical joints** | - | - | - | | | | | | **3.87** |
| Concrete/concrete | 14.40 | - | - | | Assumed airtight | - | | | - |
| Concrete/wood-frame wall | - | - | - | - | | | | | - |
| Wood-frame wall/wood-frame wall | 17.87 | - | - | Double wind-barrier: Hunton asphalt boards and Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 3.87 |
| **Junctions wall/roof** | - | - | - | | | | | | **9.62** |
| Side walls/roof | 24.30 | - | - | Loose eaves. Wind-barrier rolled around the eaves. | Eaves - rolled wind-barrier | 0.22 | | | 5.27 |
| Side walls/roof - penetrating beams | - | | | | | | | | - |
| Gable wall/roof | 20.10 | - | - | The wind-barrier is rolled around over the gable wall and fastened together with the roof wind-barrier with battens. | Eaves - rolled wind-barrier | 0.22 | | | 4.36 |
| Roof against higher walls | - | - | - | Penthouse/shed roof… | | | | | - |
| Roof/roof (roof valley) | - | - | - | Penthouse/shed roof… | | | | | - |
| Ridge of roof | - | - | - | Penthouse/shed roof… | | | | | - |
| **Joint window and door** | - | - | - | | | | | | **3.77** |
| Window against wood | 98.40 | - | - | Backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 3.05 |
| Window against masonry | 5.76 | - | - | Backer rod and mastic | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.22 |
| Door against wood | 14.00 | - | - | Backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.43 |
| Door against masonry | 1.89 | - | - | Backer rod and mastic | Window(or door)/masonry wall - PU foam - - - or backer rod with mastic | 0.04 | | | 0.07 |
| **Surfaces** | - | - | - | | | | | | **86.48** |
| Concrete wall | - | 103.95 | - | Sundolitt Elementer. | Wall Surface - assumed airtight | - | - | | - |
| Wood-frame wall | - | 123.98 | - | Double wind-barrier: Hunton asphalt boards and Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 18.60 |
| Roof | - | 112.50 | - | Tyvek wind-barrier (same as for the walls) | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 16.88 |
| Floor | - | 112.50 | - | Basement | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 33.15 | - | - | Window area - calculated from maximum value | - | 1.25 | | 41.32 |
| Door | - | 7.77 | - | - | Door area - calculated from maximum value | - | 1.25 | | 9.69 |
| **Penetrations** | - | - | - | | | | | | **4.80** |
| Electrical cables | - | - | - | - | | | | | - |
| Ventilation ducts | - | - | - | - | | | | | - |
| Water & Sewage | - | - | 6.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 4.80 |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 139.65 |
| **Volume** | 509.80 |
| **n50w** | 0.27 |

## Estimated airtightness of House 20

| Component leakage category | Quantity [m] | [m2] | pcs | Description from site | Description of component leakage data used | [m3/h] per m | m2 | pcs | V50 |
|---|---|---|---|---|---|---|---|---|---|
| **Horizontal joints** | | | | | | | | | **31.14** |
| Concrete floor/concrete wall | 15.17 | - | - | Foundation wall | Concrete floor/concrete wall (component leakage not available) | - | | | - |
| Concrete floor/wood-frame wall | 18.02 | - | - | Sill memnbrane and mastic | Sill membrane - High Load | 0.45 | | | 8.09 |
| Concrete wall/wood-frame wall | 15.17 | - | - | Sill membrane | Sill membrane - High Load & Structural floor with Rolled wind-barrier | 0.67 | | | 10.10 |
| Intermediate floor | 59.81 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Structural floor with Rolled wind-barrier | 0.22 | | | 12.96 |
| **Vertical joints** | - | - | - | | | | | | **13.07** |
| Concrete/concrete | 4.80 | - | - | 50 mm isopor utside, 200 mm betong, 50 mm isopor innside, 100 mm mineralull innside. | Assumed airtight | - | | | - |
| Concrete/wood-frame wall | 4.80 | - | - | Sill membrane | Vertical concrete/wood - Sill membrane - Low Load | 0.48 | | | 2.32 |
| Wood-frame wall/wood-frame wall | 49.60 | - | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Vertical wood/wood - Rolled wind-barrier | 0.22 | | | 10.75 |
| **Junctions wall/roof** | - | - | - | | | | | | **9.05** |
| Side walls/roof | 41.79 | - | - | Ikke fullstendig overdekkende. TYVEK lektes i topp av vegg. Sponplate tak møter GU vegg og fuges ved behov. | Eaves - rolled wind-barrier | 0.22 | | | 9.05 |
| Side walls/roof - penetrating beams | - | | | Flat roof… | | | | | |
| Gable wall/roof | - | - | - | Flat roof… | | | | | - |
| Roof against higher walls | - | - | - | Flat roof… | | | | | - |
| Roof/roof (roof valley) | - | - | - | Flat roof… | | | | | - |
| Ridge of roof | - | - | - | Flat roof… | | | | | - |
| **Joint window and door** | - | - | - | | | | | | **3.76** |
| Window against wood | 95.40 | - | - | Wind-barrier over the joint, backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 2.95 |
| Window against masonry | - | - | - | - | | | | | - |
| Door against wood | 26.20 | - | - | Wind-barrier over the joint, backer rod and mastic | Window(or door)/wood-frame wall - PU foam - - - or backer rod with mastic | 0.03 | | | 0.81 |
| Door against masonry | - | - | - | - | | | | | - |
| **Surfaces** | - | - | - | | | | | | **91.66** |
| Concrete wall | - | 36.41 | - | 50 mm isopor utside, 200 mm betong, 50 mm isopor innside, 100 mm mineralull innside. | Wall Surface - assumed airtight | - | - | | - |
| Wood-frame wall | - | 203.09 | - | Double wind-barrier: Gypsum boards + Tyvek rolled wind-barrier | Wall Surface - TYVEK [Tech Approv] - - - | - | 0.15 | | 30.46 |
| Roof | - | 80.91 | - | Isola Mestertrekk | Roof Surface - asphalt roof with seamed joints | - | - | | - |
| Floor | - | 81.49 | - | Cast in place floor of concrete | Concrete floor - - - assumed airtight | - | - | | - |
| Window | - | 37.23 | - | - | Window area - calculated from maximum value | - | 1.25 | | 46.41 |
| Door | - | 11.86 | - | - | Door area - calculated from maximum value | - | 1.25 | | 14.78 |
| **Penetrations** | - | - | - | | | | | | **4.80** |
| Electrical cables | - | - | - | - | | | | | - |
| Ventilation ducts | - | - | - | - | | | | | - |
| Water & Sewage | - | - | 6.00 | The penetration is placed in position prior to casting. | Ventillation 100 mm in 105 mm hole sealed with collar/flashing - - - or PU foam or cast through concrete floor | - | - | 0.80 | 4.80 |
| Chimneys | - | - | - | - | | | | | - |

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|---|---|
| **V50 total** | 153.49 |
| **Volume** | 463.61 |
| **n50w** | 0.33 |

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