

## Detecting points of unintentional ventilation

Jommi SUONKETO<sup>1</sup>, Minna KORPI<sup>1</sup>, Anu AALTONEN<sup>1</sup>

<sup>1</sup> *Department of Civil Engineering, Tampere University of Technology, Finland,  
jommi.suonketo@tut.fi*

### Abstract

Unintentional ventilation through exterior walls, ceilings and base floors has many harmful effects. This paper presents the results of surveys on three quite similar buildings built in the 1940's or 1950's.

The initial condition of the buildings was inspected thoroughly by several thermal surveys. The air tightness of the houses was tested by the fan pressurisation method

The points of air leakage were located by comparing the thermal images taken before and during depressurisation.

The owners of the houses received instructions on how to improve the air tightness of their houses. After the repairs were done, the test procedure was repeated.

Comparison of the results of before-and-after measurements indicated the effect of the repairs. In most cases the repairs were not done as well as possible or not as comprehensively as instructed. Yet, the air tightness of all buildings improved.

### Résumé

La ventilation non désirée filtrant à travers les murs, plafonds et sols a de nombreux effets néfastes. Cet article présente les résultats et les observations d'une étude menée sur trois édifices présentant de nombreuses similitudes et construits dans les années 1940 ou 1950.

L'état initial des édifices a été analysé minutieusement. L'élaboration des tests comprend plusieurs études thermiques. La méthode de pressurisation par ventilateur a permis de tester l'étanchéité à l'air des édifices. Les points de fuite d'air ont été localisés en comparant les images thermiques prises avant et après la dépressurisation. Des conseils ont été donnés aux habitants pour améliorer l'étanchéité à l'air de leurs logements. Après les réparations, la même batterie de tests a été répétée. La comparaison des résultats de ces deux mesures a montré l'efficacité des réparations. Dans la plupart des cas, les réparations n'ont cependant pas été à la hauteur des instructions fournies. Cependant, une amélioration de l'étanchéité à l'air de tous les édifices est apparue.

### Keywords

Air tightness, air leakage, single-family houses, apartments, field study

## 1 Introduction

The air tightness of Finnish single-family houses has been studied during the past five years in many research projects by the Department of Civil Engineering at Tampere University of Technology [1]. Some studies on techniques to improve air tightness have also been conducted.

Poor air tightness means that a remarkable amount of ventilation actually occurs through structures, not through air intakes or other ventilation devices. In a building where the air change rate is, for example, 5 1/h under 50 Pa fan pressurisation, the unintentional air change rate is normally roughly 0.25 1/h. That is half of the recommend ventilation rate in Finland.

Unintentional ventilation through exterior walls, ceilings and base floors has many harmful effects. In cold climates it reduces the thermal comfort of occupants and increases heating costs by up to 20 %. It can also transport moist air which condenses on roof structures resulting in serious moulding. The supply flow, again, can pollute indoor air with harmful particles or chemicals.

This paper shows how the actual air flow paths were detected in the test houses before and after repairs.

## 2 Studied houses

The three timber-framed single-family houses from the 1940's and 1950's were selected as the test subjects (Fig.1). The main structures and materials were very similar. Walls, roofs and intermediate floors were timber-framed and insulated with sawdust. The facades and all interior surfaces were of wood or fibreboard. One building had a basement of concrete, another had a wooden base floor and a ventilated crawl space while the third one was a combination of the two others. All buildings had natural ventilation mainly caused by chimney draft.



*Figure 1. The studied houses represent the typical single-family houses built in the 1940's and 1950's. Their air tightness is relatively low according to recent studies.*

## 3 Test procedure

The test procedure was a combination of thermographic survey and pressurisation test.

### 3.1 Initial thermographic survey

Thermographic surveys were done with a normal infrared camera suitable for field surveys in cold temperatures. The survey was done early in the morning when the interference of the radiating heat of the sun was minimal. The outside and inside surfaces were examined and all abnormal areas were recorded.

### 3.2 Pressurisation test

The air tightness of the houses was tested by the fan pressurisation method (described in European standard EN 13829 2000). Fan pressurisation is a widely used and relatively simple method of determining the air tightness of buildings. The tests were done with a commercial computer-controlled blower-door system. During a blower-door test, all openings of the envelope are closed and sealed if necessary and a fan is mounted securely on one of the building's door or window frames. The pressure difference between the inside and the outside and the airflow through the fan, which is needed to maintain a certain pressure difference, are then measured.

The pressurisation test measures a series of pressure differences and corresponding airflows through the fan. A so-called building leakage curve is then fitted to these results. In the blower-door equipment the curve was fitted to the results automatically by the blower-door software. The airflow corresponding to a pressure difference of 50 Pa divided by the internal volume of the measured buildings called the air change rate at 50 Pa (or air leakage rate at 50 Pa, ACH50,  $n_{50}$  value), which allows comparing the air tightness values of different buildings. The airflow measured in a pressurisation test can also be normalised by the area of the envelope (air permeability at 50 Pa, also called air leakage index and  $q_{50}$  value), which has become a common way of reporting air tightness, especially in Europe. In this paper results are mainly reported as air change rates, although both values were calculated.

### **3.3 Steady state pressurisation and follow-up thermographic survey**

After the actual pressurisation test, the blower-door system was allowed to maintain a constant pressure difference of 25 Pa for 20 minutes.

During that period the constant flow of cold air lowered the surface temperature of all air intakes. The follow-up thermographic survey was done exactly the same way as the initial survey. The interference of the radiating heat of the sun was estimated if the circumstances from the initial survey had changed significantly.

### **3.4 Repairs**

The owners of the houses received instructions on how to improve the air tightness of their houses. The workers were given instructions about what to do, and the initial condition of structures and the repairs done were documented by the study group.

The air tightness of building envelopes was increased by installing an extra air tight insulation layer to interior surfaces. In most cases 40 mm thick prefabricated panels of plasterboard and polyurethane insulation were used. The panels were sealed to other structures with polyurethane foam.

After the repairs were done, the test procedure was repeated.

## **4 Results**

### **4.1 The effect of steady state pressurisation**

The points of air leakage were located by comparing the thermal images taken before and during depressurisation (Figs. 2 and 3). Normal heat bridges or other structural abnormalities were not affected by the depressurisation, but the constant flow of cooler outside air decreased inside surface temperatures significantly.

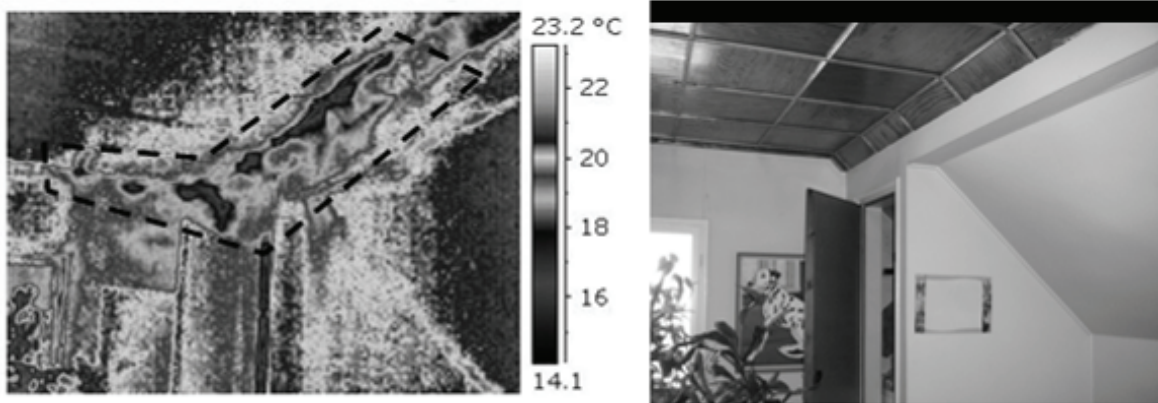


Figure 2. The points of air leakage in the top floor ceiling do not normally show well in a thermal survey. After 20 minutes of pressurisation at -25 Pa, all points were clearly visible in the thermal image.

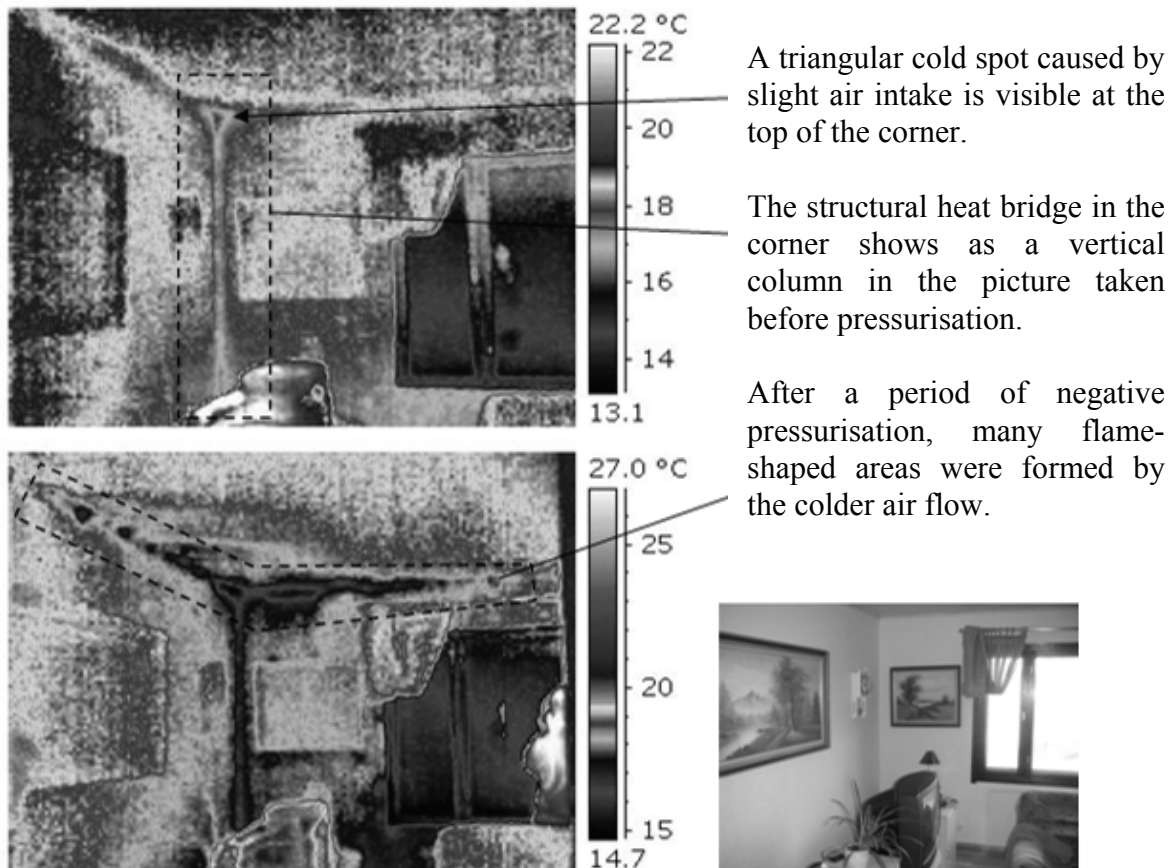


Figure 3. The corner of a living room before (top) and after (bottom) constant negative pressurisation for 20 minutes.

#### 4.2 The effect of repairs

After the repairs were done, the test procedure was repeated. Comparison of the results of before-and-after measurements indicated the effect of the repairs (Fig. 4). In most cases the repairs were not done as well as possible or as comprehensively as instructed. Yet, the air tightness of all buildings improved.

**Table 1.** The air leakage rates of test houses at 50 Pa before and after repairs. The calculation method of the  $n_{50}$  value are described in Chapter 3.2.

$n_{50}$ value [1/h] before repairs		after repairs	Result of
Test house 1	4.8	3.8	Partial repair
Test house 2	15.2	5.8	Partial repair
Test house 3	12.0	3.7	Quality workmanship

The thermal surveys showed that in most cases the remaining air leakage was caused by surfaces that had not been repaired. In some instances the quality of workmanship was not good enough resulting in joints that were not air tight (Fig. 5).

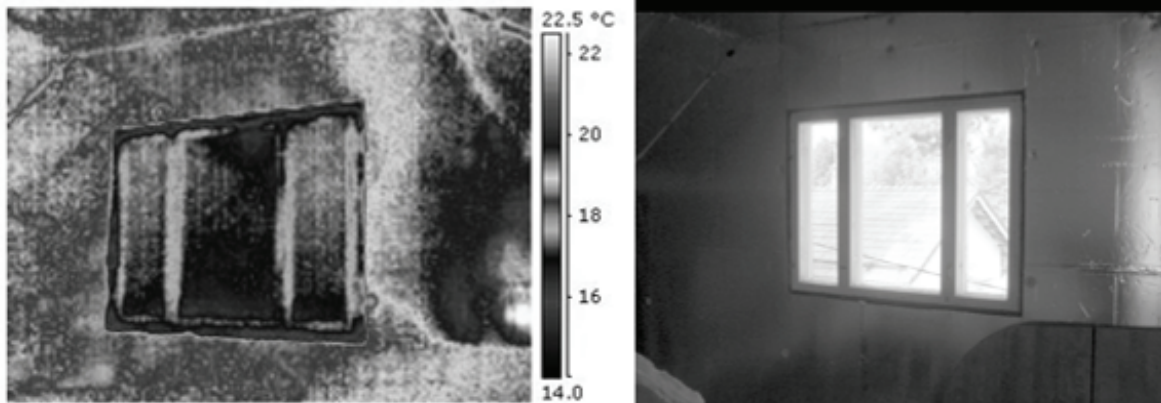


Figure 4. The new interior surfaces were air tight if the quality of workmanship was good.

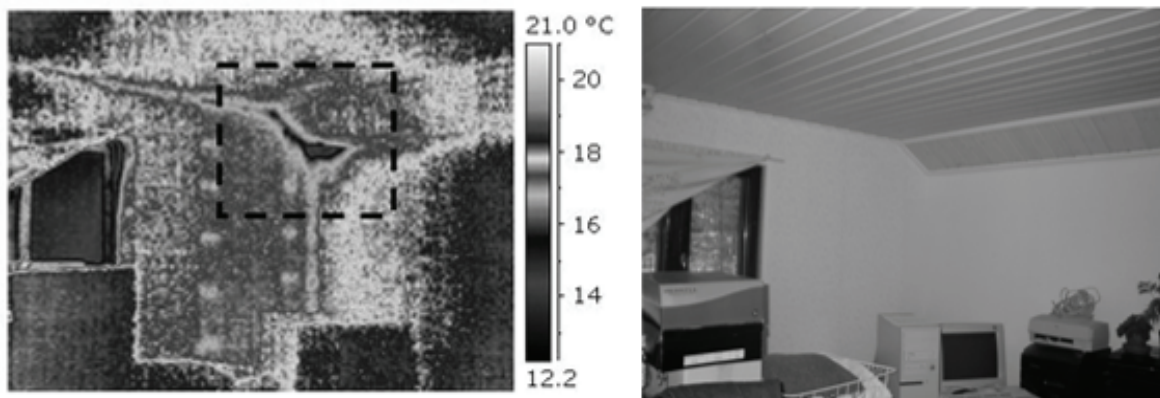


Figure 5. Example of air leakage through a renovated surface.

## 5 Conclusions

The points of air leakage can be detected by combining thermal survey and pressurisation. Without pressurisation all air leakage points cannot be detected.

The air tightness of a building can be improved by installing new air tight insulation layers to interior surfaces. Yet, the degree of improvement is strongly dependent on the quality of workmanship.

## References

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