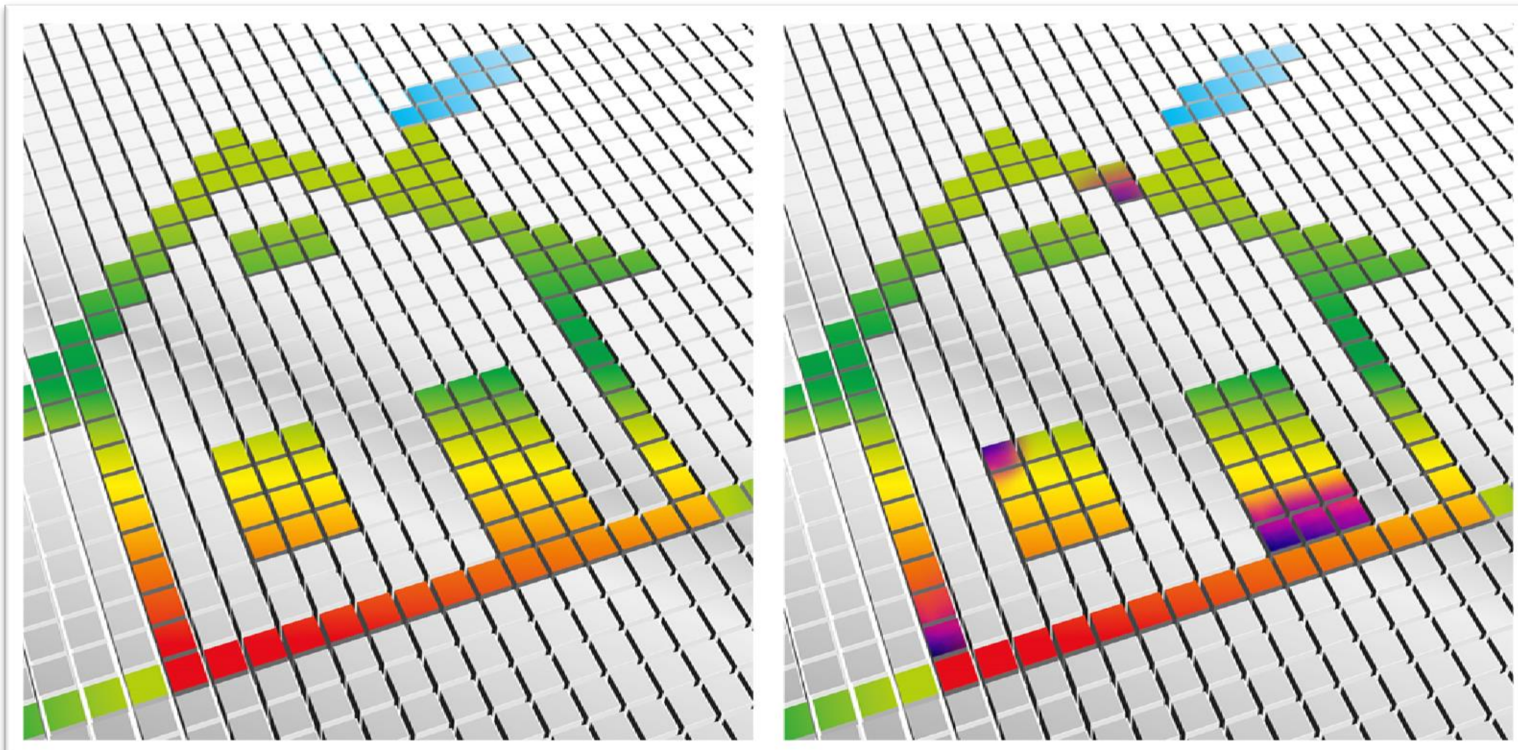
„I spy with my little eye …“

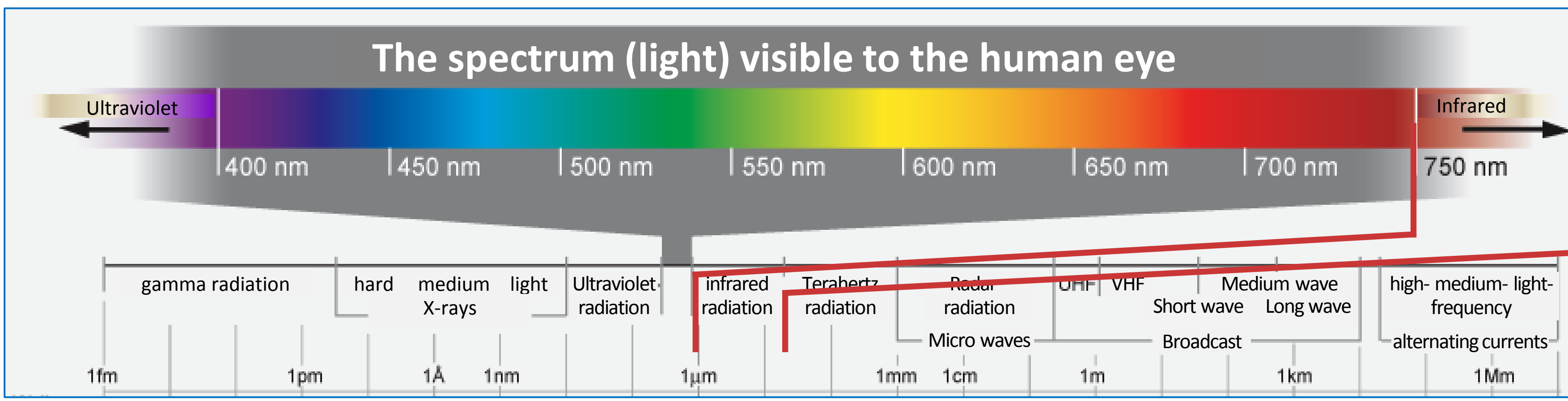


Leakage Detection with Thermography

Thermography – what is it?

Thermography is an imaging method for visualizing the surface temperature of objects, i.e. the radiated thermal energy of a body.

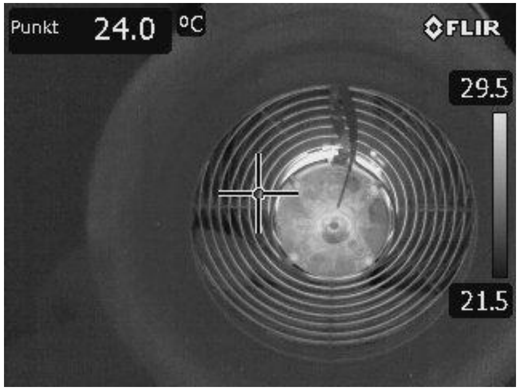
Every body warmer than the absolute zero point (0 Kelvin = -273.15°C) emits electromagnetic waves of different wavelengths, so-called infrared radiation. This cannot be perceived by the human eye.



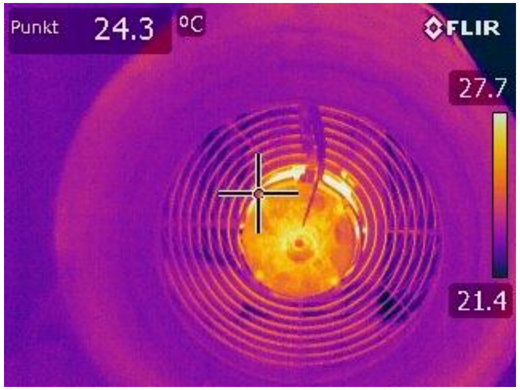
Visualization of infrared radiation

A thermographic camera converts this "invisible" infrared radiation into electrical impulses to produce an image in grayscale. In the original or grayscale image, lighter areas are warmer than darker areas.

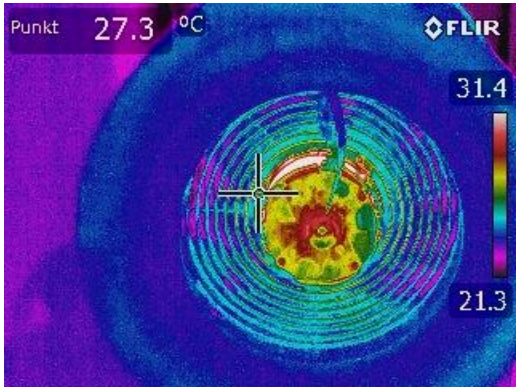
These images are then often displayed with false colors. The color assignment is inserted later. It serves the better representation, in order to make fine nuances clearly distinguishable.



Thermogram (Grey)



Thermogram with false colors (Iron)

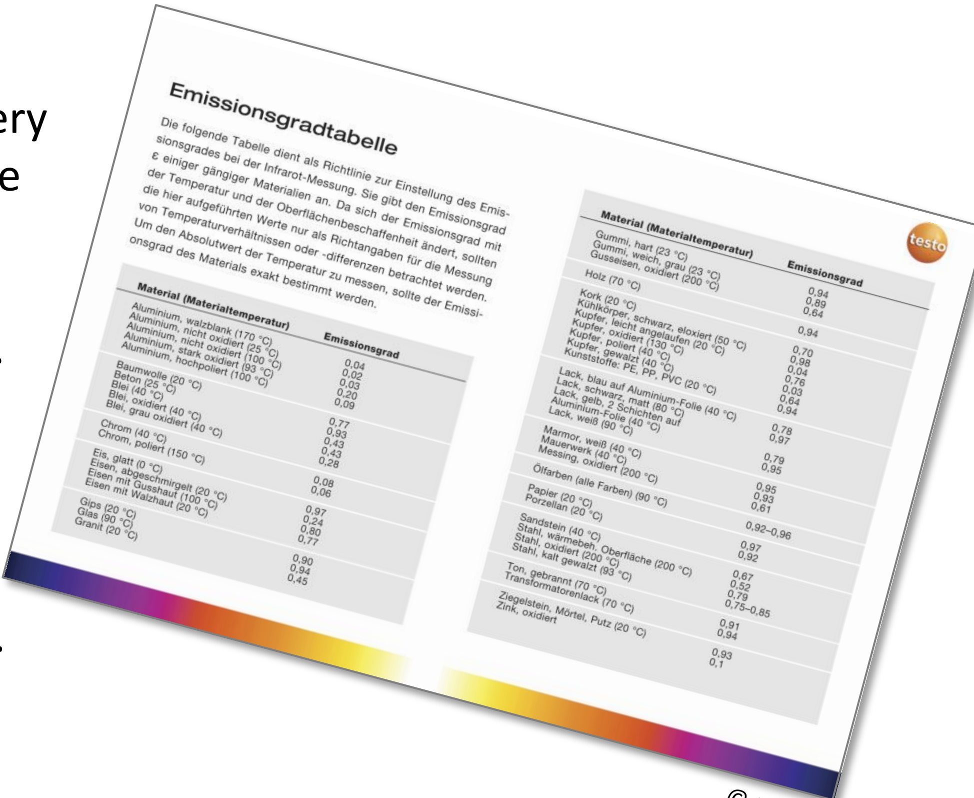


Thermogram with falso colors (Rainbow)

Emissivity ε

The heat radiation of a body is radiated ideally with an emissivity of ε = 1, in this case we also speak of a black radiator.

In reality this emissivity differs ε partly very strongly, this must be considered with the application of a thermography camera. On shining and thus strongly reflecting metal surfaces ε can sink even under 0,1. But with the usually used building materials one can set a value for ε of approximately 0,9. The emission degree of concrete lies for example with ε = 0,93; that of wood with ε = 0,94.



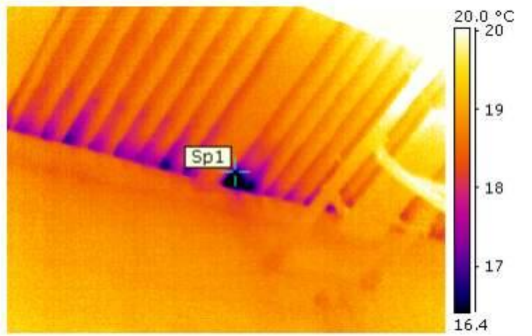
Emissionsgradtabelle

Die folgende Tabelle dient als Richtlinie zur Einstellung des Emissionsgrades bei der Infrarot-Messung. Sie gibt den Emissionsgrad ε einiger gängiger Materialien an. Da sich der Emissionsgrad mit der Temperatur und der Oberflächenbeschaffenheit ändert, sollten die hier aufgeführten Werte nur als Richtangaben für die Messung von Temperaturverhältnissen oder -differenzen betrachtet werden. Um den Absolutwert der Temperatur zu messen, sollte der Emissionsgrad des Materials exakt bestimmt werden.

Material (Materialtemperatur)	Emissionsgrad
Aluminium, walzblank (170 °C)	0,04
Aluminium, nicht oxidiert (25 °C)	0,02
Aluminium, nicht oxidiert (100 °C)	0,03
Aluminium, stark oxidiert (93 °C)	0,20
Aluminium, hochpoliert (100 °C)	0,09
Baumwolle (20 °C)	0,77
Beton (25 °C)	0,93
Blei (40 °C)	0,43
Blei, oxidiert (40 °C)	0,43
Blei, grau oxidiert (40 °C)	0,28
Chrom (40 °C)	0,08
Chrom, poliert (150 °C)	0,06
Eis, glatt (0 °C)	0,97
Eisen, abgeschmirgelt (20 °C)	0,24
Eisen mit Gusshaut (100 °C)	0,80
Eisen mit Walzhaut (20 °C)	0,77
Gips (20 °C)	0,90
Glas (90 °C)	0,94
Granit (20 °C)	0,45

Material (Materialtemperatur)	Emissionsgrad
Gummi, hart (23 °C)	0,94
Gummi, weich, grau (23 °C)	0,89
Gusseisen, oxidiert (200 °C)	0,64
Holz (70 °C)	0,94
Kork (20 °C)	0,70
Kühlkörper, schwarz, eloxiert (50 °C)	0,98
Kupfer, leicht angelaufen (20 °C)	0,04
Kupfer, oxidiert (130 °C)	0,76
Kupfer, poliert (40 °C)	0,03
Kupfer, gewalzt (40 °C)	0,64
Kunststoffe: PE, PP, PVC (20 °C)	0,94
Lack, blau auf Aluminium-Folie (40 °C)	0,78
Lack, schwarz, matt (80 °C)	0,97
Lack, gelb, 2 Schichten auf Aluminium-Folie (40 °C)	0,79
Lack, weiß (90 °C)	0,95
Marmor, weiß (40 °C)	0,95
Mauerwerk (40 °C)	0,93
Messing, oxidiert (200 °C)	0,61
Ölfarben (alle Farben) (90 °C)	0,92–0,96
Papier (20 °C)	0,97
Porzellan (20 °C)	0,92
Sandstein (40 °C)	0,67
Stahl, wärmebeh. Oberfläche (200 °C)	0,52
Stahl, oxidiert (200 °C)	0,79
Stahl, kalt gewalzt (93 °C)	0,75–0,85
Ton, gebrannt (70 °C)	0,91
Transformatorenlack (70 °C)	0,94
Ziegelstein, Mörtel, Putz (20 °C)	0,93
Zink, oxidiert	0,1

Possible applications of thermography

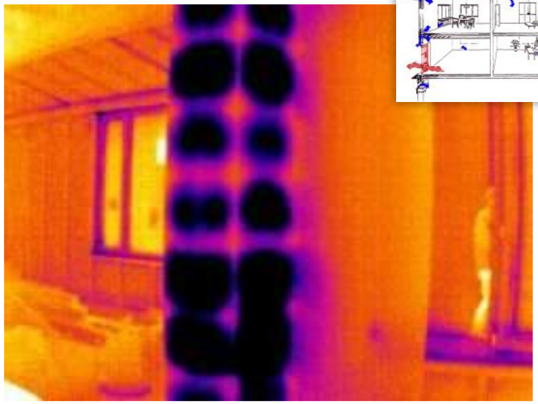


Thermography is a very good tool when measuring large buildings. If you want to inspect components located higher up for leaks, you will otherwise have to use a lifting platform or a ladder.

Thermography and differential pressure:
An example

Normal picture

Thermogram

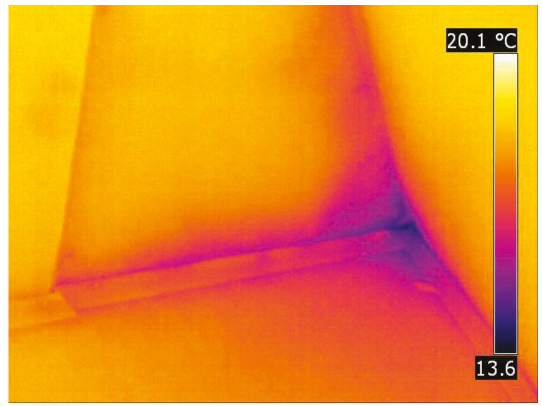


Thermogram with negative pressure

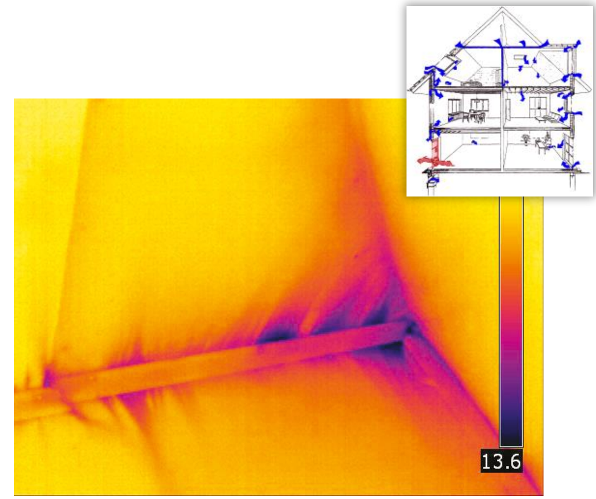
Only at a differential pressure of 50 Pascal does it become clear that the air flows through this chimney, which is made of monolithic concrete blocks. With the combination of BlowerDoor and thermography, it is easy to see that this chimney should be plastered.

Thermography and differential pressure:
Another example

Normal picture



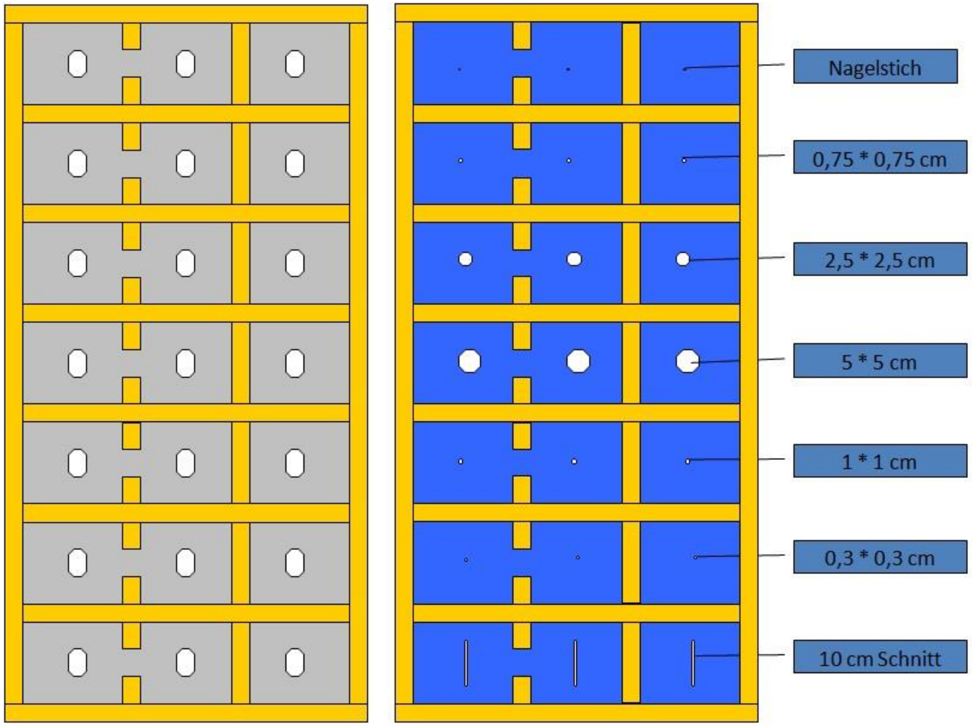
Thermogram



Thermogram with negative pressure

In the case of negative pressure, the typical plume formation for air currents can be seen here. The colder air from the outside cools the components near the leakage and thus makes the existing leakage clearly visible.

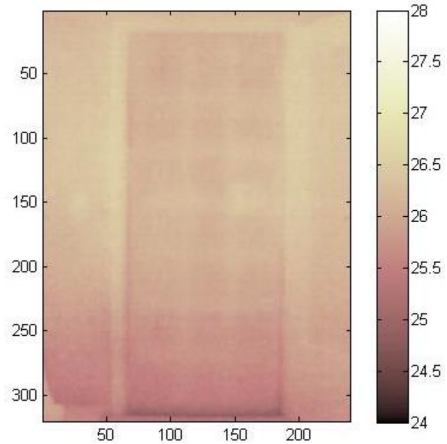
Thermography and BlowerDoor: There's even more to it – from the idea to the experimental setup



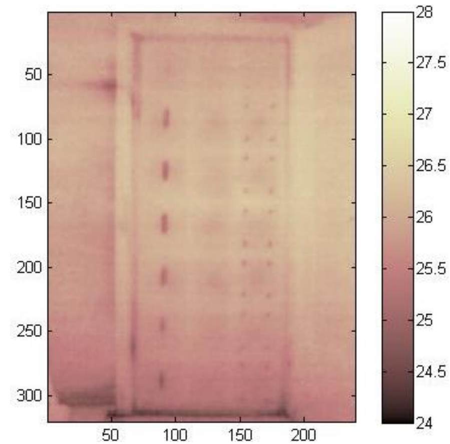
With the support of a BlowerDoor measurement system, you can create better and more meaningful thermograms of the building envelope and perform further analyses. For this reason, Hermann Kaubitzsch of BGK Infrarotservice GmbH has developed the following test setup: He simulated a wide variety of leakage shapes and sizes in an airtight tarpaulin; from a simple nail penetration to a 10 cm long cut.

Thermography and BlowerDoor: The first results of the experimental setup

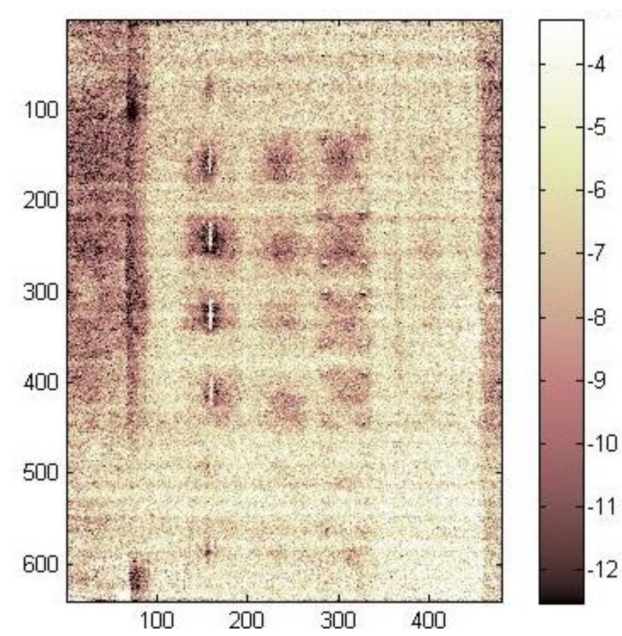
First thermogram



Final thermogram after negativ pressure



Sequential Analysis

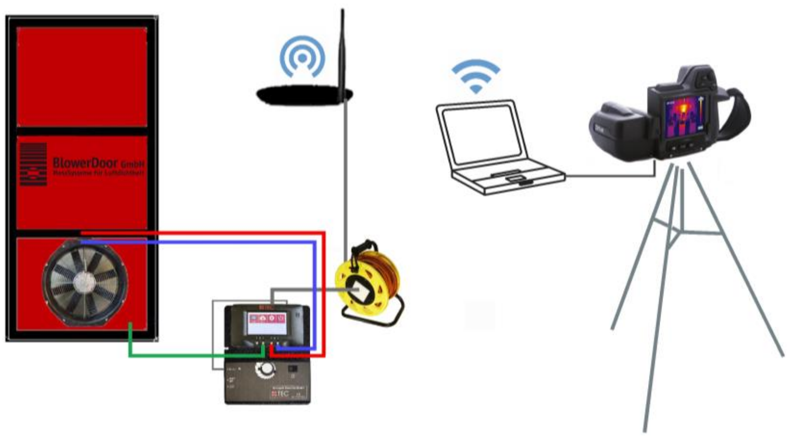


On these pictures of the first experiment it can be seen very well that the small leaks only become visible with the flow at negative pressure.

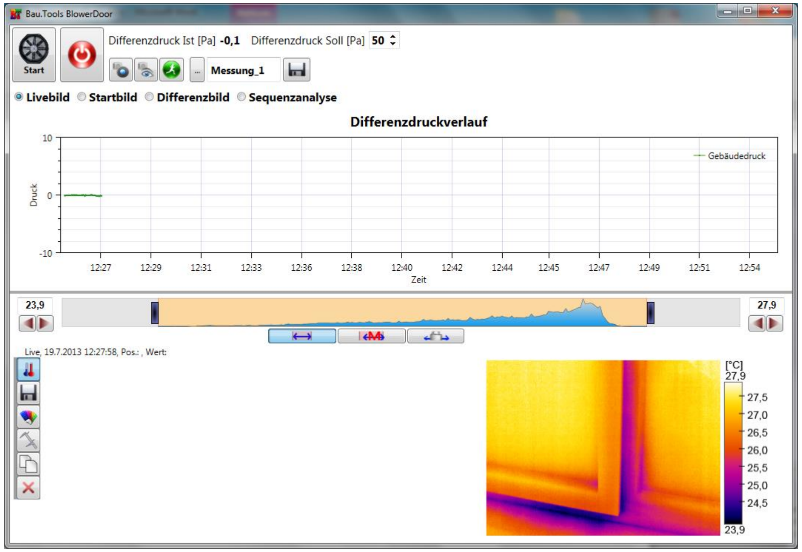
However, if several thermograms are recorded one after the other under negative pressure, this image sequence can be analysed more precisely. Only the temperature changes caused by the inflows are considered.

Thermography and BlowerDoor:
The Software Bau.Tools BlowerDoor

This was followed by the development of the software Bau.Tools BlowerDoor. In the interaction of Minneapolis BlowerDoor measurement system and a FLIR thermography camera, a series of thermograms is usually recorded from a surface under negative pressure.

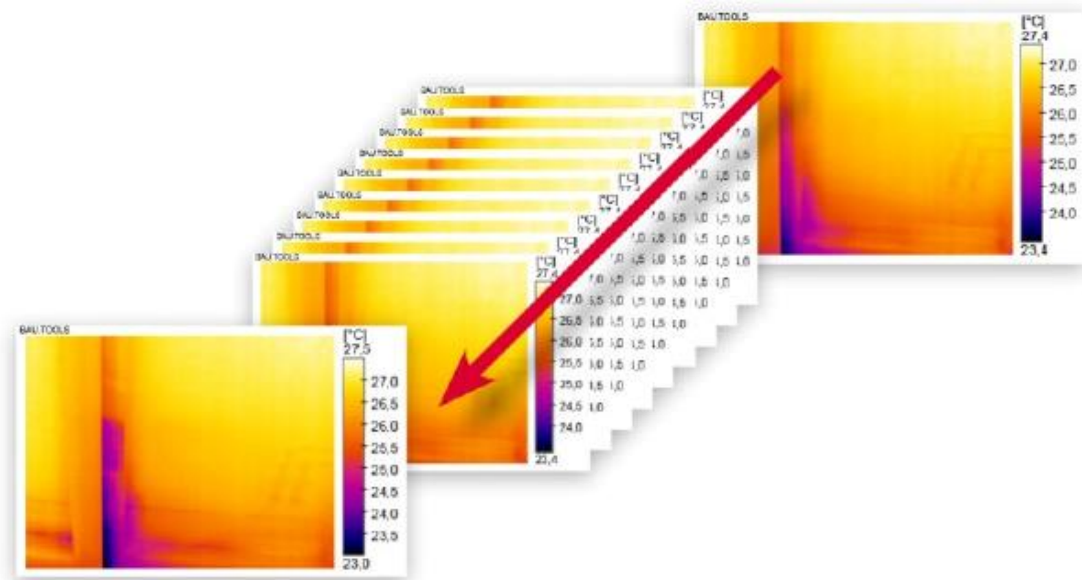


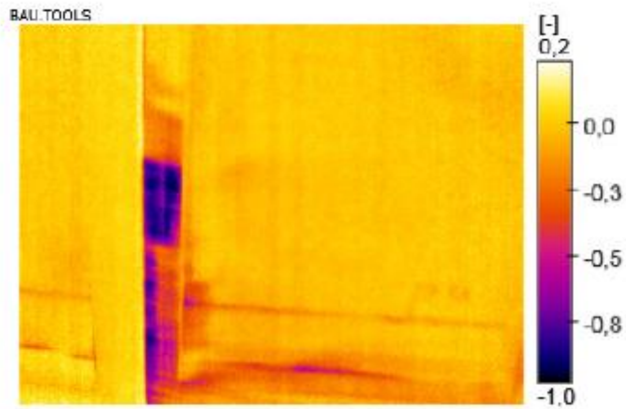
The BlowerDoor measurement system is connected to a computer, which in turn is connected to a suitable FLIR camera on a fixed tripod.



The software Bau.Tools BlowerDoor

Function of the Software Bau.Tools BlowerDoor

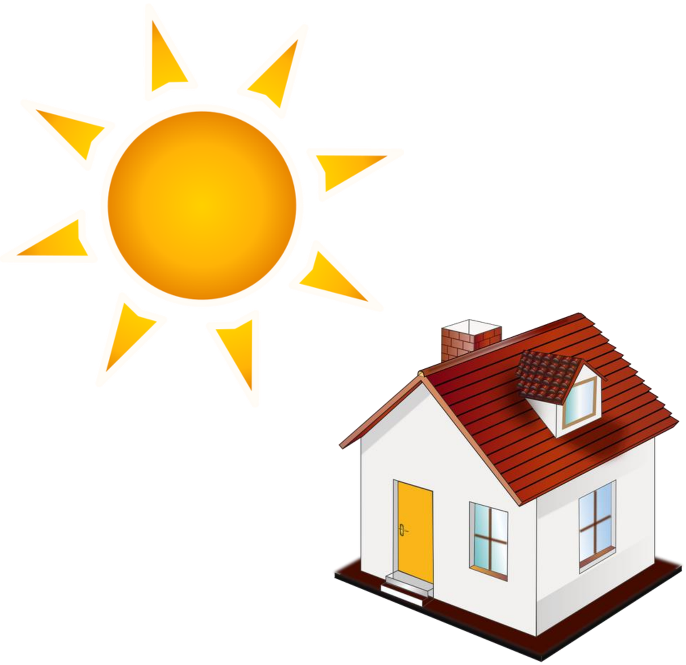




The software Bau.Tools BlowerDoor records 15 to 30 single thermograms, while the BlowerDoor measuring system generates a negative pressure for 30 to 90 seconds. This image sequence is evaluated by the software. Even the smallest temperature differences of 0.15 to 0.4 K can be visualized with the sequence analysis. The method can be used all year round as only very small temperature differences are required.

Example window front

As an example for the application of the Bau.Tools BlowerDoor software a sunlit window front was selected. Actually you can't expect satisfactory results with the thermographic camera, as you can see on this "normal thermogram".

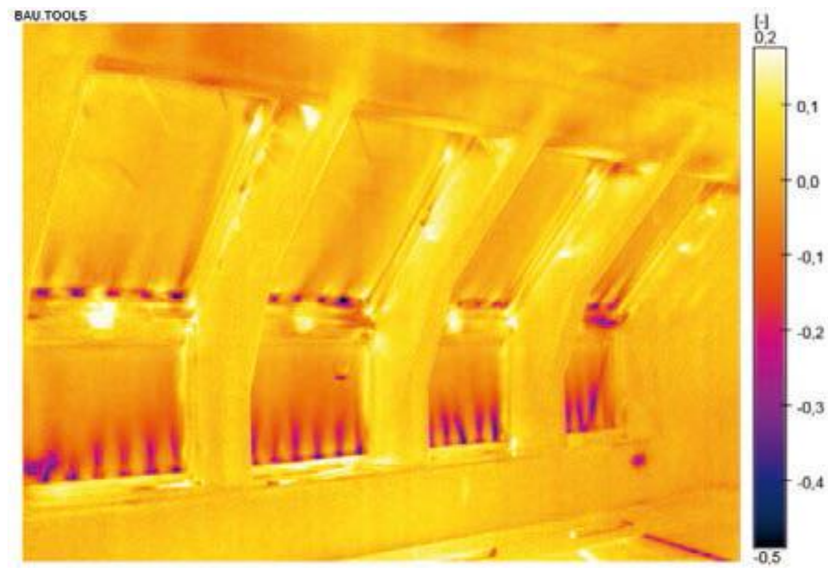


Thermogram of a sunlit window front

Example window front

Even after generating negative pressure with the BlowerDoor measuring system, you can hardly detect a change in the thermogram. The changes only become visible through sequence analysis with the Bau.Tools software. The leaks are now clearly visible. With the software Bau.Tools BlowerDoor, the application possibilities of the thermographic camera for leak detection are enormously increased; the camera thus becomes an aid that can be used almost all year round.

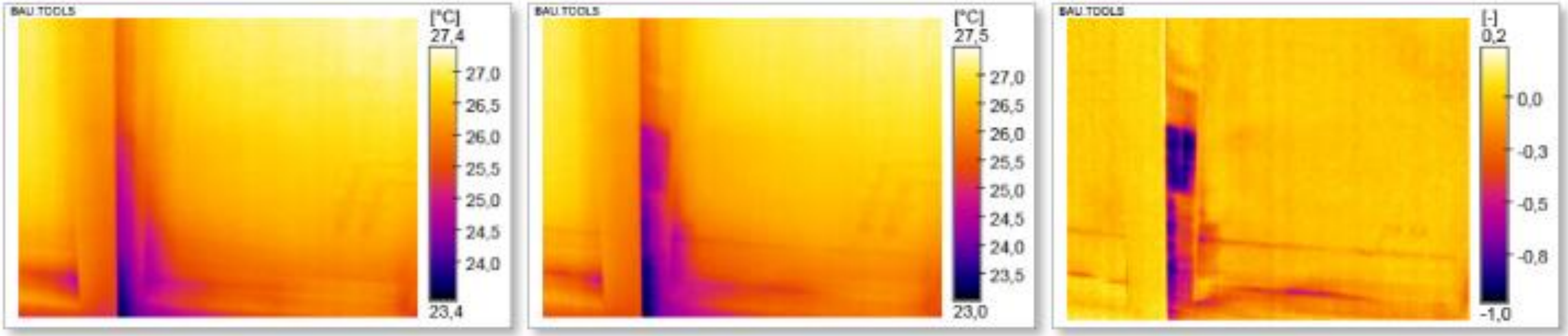
Thermogram with negative pressure



Bau.Tools Sequential Analysis

More examples

Here are two more examples of Bau.Tools Sequential Analysis:



Leakage at the functional joint of a patio door

Leaks in recessed ceiling spotlights (downlights)

Literature

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- FLIR Media: Thermografie für Bau-Anwendungen und erneuerbare Energien
  Links: Deutsch / English / Français / Italiano / Español
- FLUKE: Thermography Principles; Link: English
- TESTO AG: Pocket Guide Thermografie; Links: Deutsch / English