webinar
2023.06.19

This webinar is organised by the **Air Infiltration and Ventilation Centre** (www.aivc.org).

Facilitated by INIVE

NOTE: The webinar will be recorded and published at www.aivc.org within a couple of weeks, along with the presentation slides.

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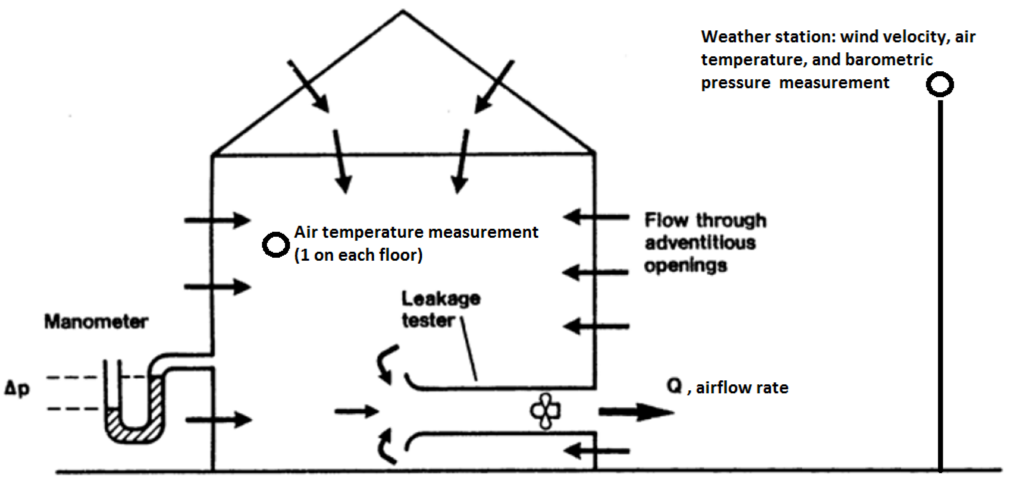
Alternative methodologies to evaluate airtightness



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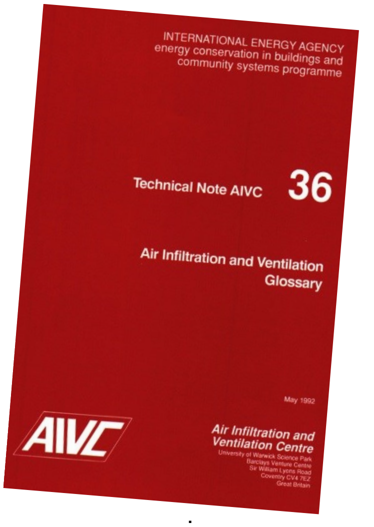
Alternative methodologies to evaluate airtightness

Tghtvent FAQs

AIVC TN36



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Alternative methodologies to evaluate airtightness

AGENDA

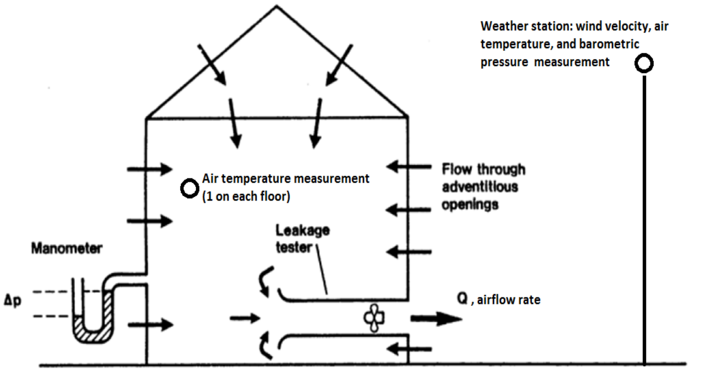
- 10:00 | Introduction to alternative methodologies used to evaluate airtightness, *Benjamin Jones (University of Nottingham, UK)*
- 10:05 | The pulse technique, *Christopher Wood (University of Nottingham, UK) and Luke Smith (Build Test Solutions, UK)*
- 10:20 | Questions and answers
- 10:30 | The Air Tightness Tester (ATT), *Niek-Jan Bink (ACIN, The Netherlands)*
- 10:45 | Questions and answers
- 10:55 | Novel IR and acoustic methods, *Benedikt Kölsch (Cerema/DLR, France)*
- 11:10 | Questions and answers
- 11:30 | End of webinar

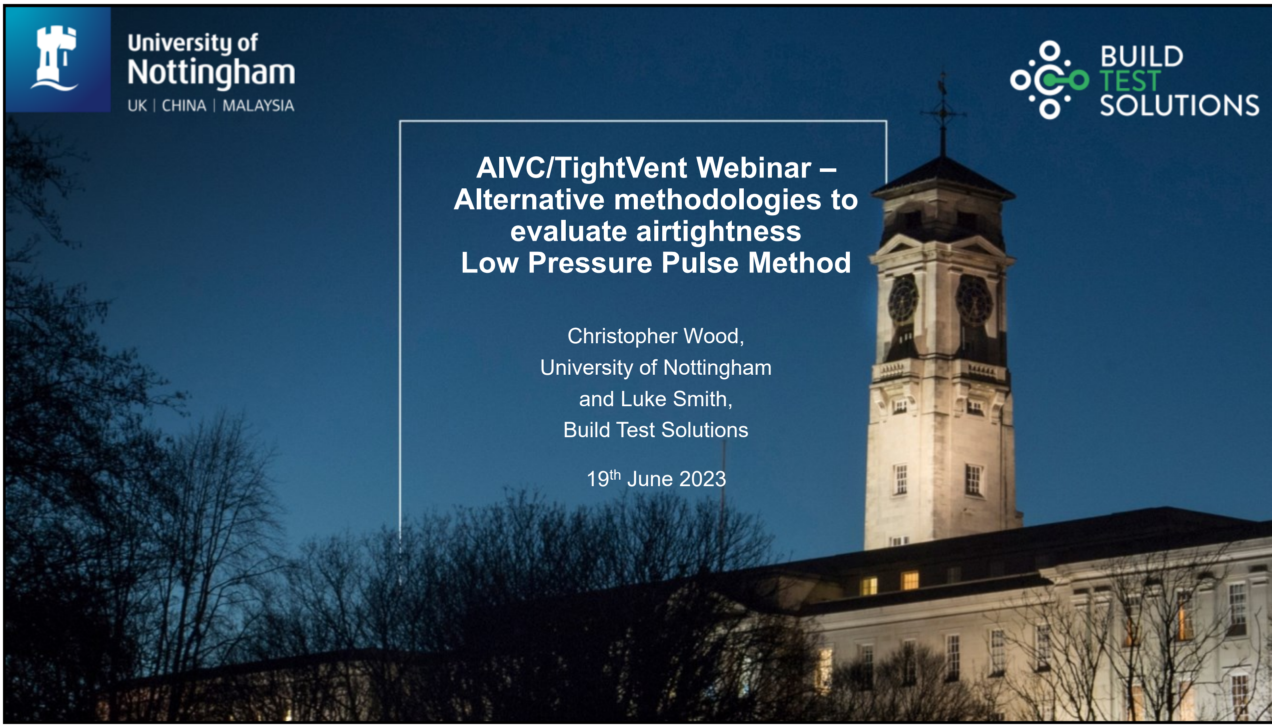
For further information please scroll down to download the flyer.

webinar
2023.06.19

Alternative methodologies to evaluate airtightness

Thanks for joining us!




University of
Nottingham
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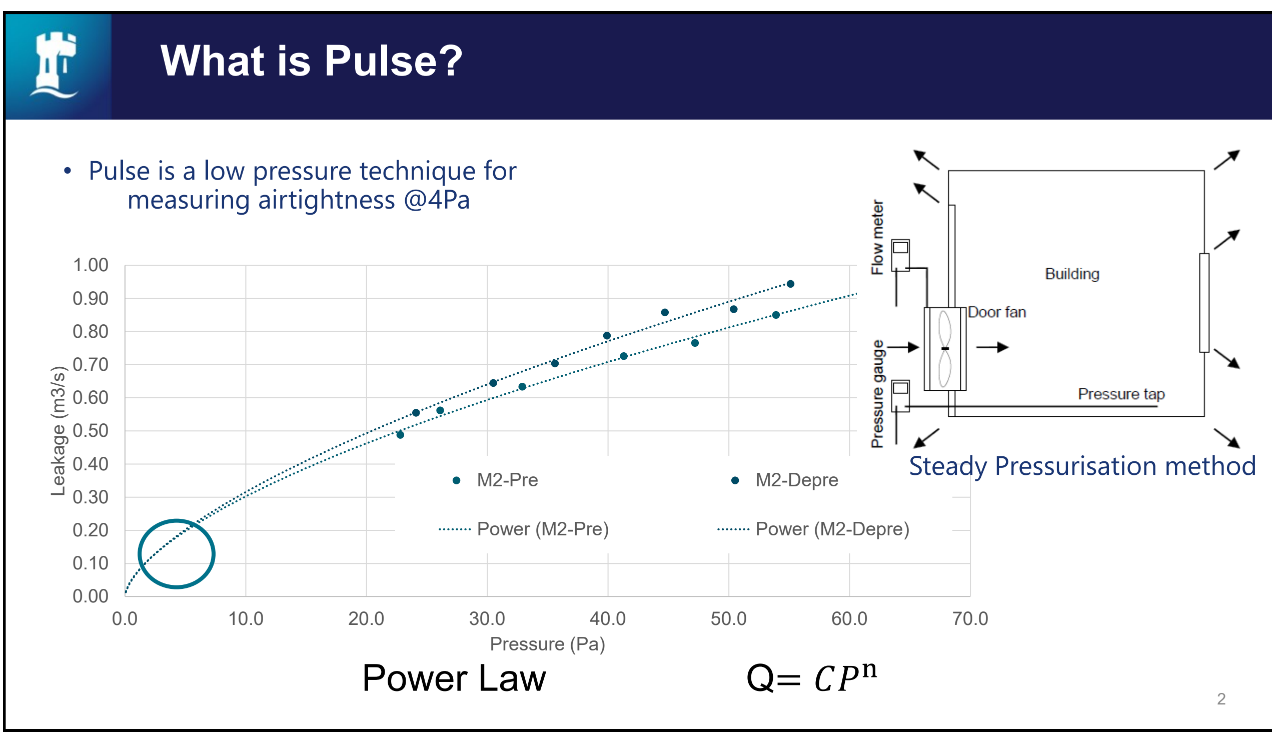
BUILD
TEST
SOLUTIONS
AIVC/TightVent Webinar –
Alternative methodologies to
evaluate airtightness
Low Pressure Pulse Method
Christopher Wood,
University of Nottingham
and Luke Smith,
Build Test Solutions
19th June 2023

1

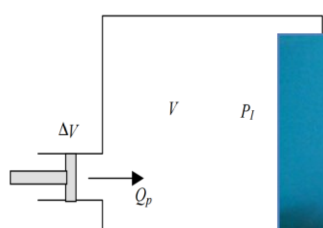

What is Pulse?
• Pulse is a low pressure technique for measuring airtightness @4Pa
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Leakage (m3/s)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Pressure (Pa)
M2-Pre
M2-Depre
Power (M2-Pre)
Power (M2-Depre)
Flow meter
Pressure gauge
Door fan
Building
Pressure tap
Steady Pressurisation method
Power Law
Q= CPⁿ
2

2

Research Motivation

- Primary motivation was a pursuit to develop a method for testing the air leakage of **large buildings** *circa mid 1990's*
- To develop method that didnt require large air flow
- To develop a method which was quicker to perform
- A method that could be performed at low pressures whilst still accounting for effects of wind and bouyancy

Underlying Principle – Temporal inertia model



- The continuity equ
Inertia model

$\frac{1}{\rho_i} V \frac{d\rho_i}{dt} = Q_p\{t\} - q$

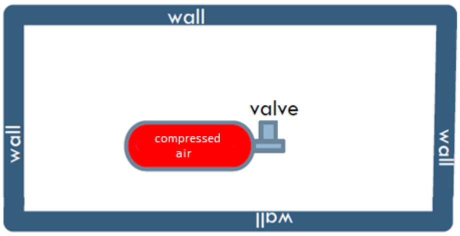
$p_i/\rho_i{}^{\gamma} = C$

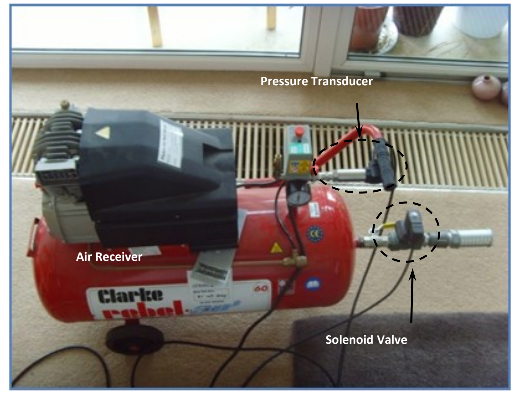
$q\{t\} = Q_p\{t\} - \frac{V}{\gamma p_i}\frac{dp_i}{dt}$

inertia term

$\Delta p\{t\} = aq\{t\}^2 + bq\{t\} + \rho_i \frac{l_e}{A}\frac{dq}{dt}$

Underlying Principle – Nozzle technique





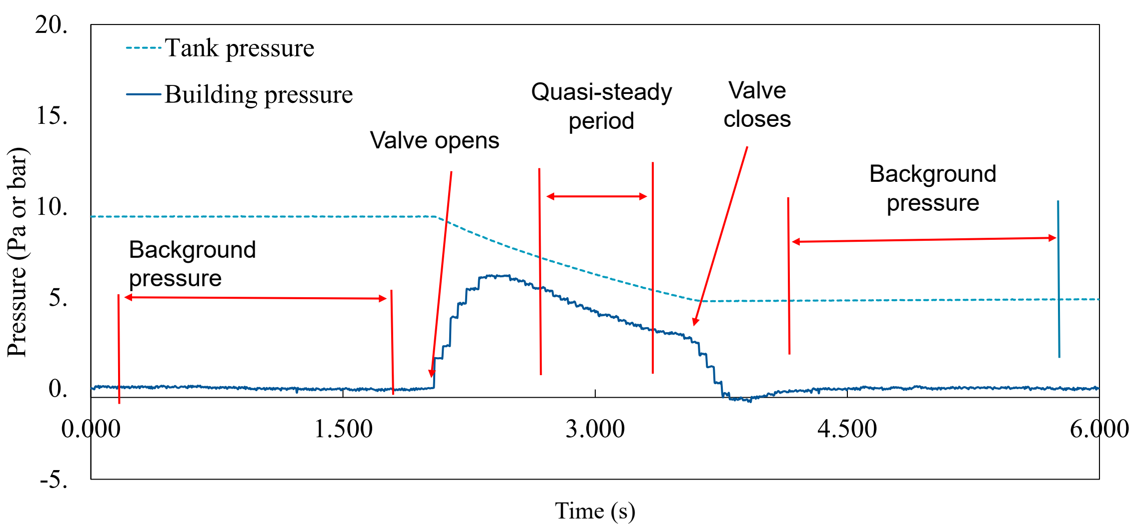
Mass flow rate

$$\dot{m}_p(t) = -V'[P(t)/P_0]^{(1-\gamma)/\gamma}\dot{P}(t)/(\gamma R T_0)$$

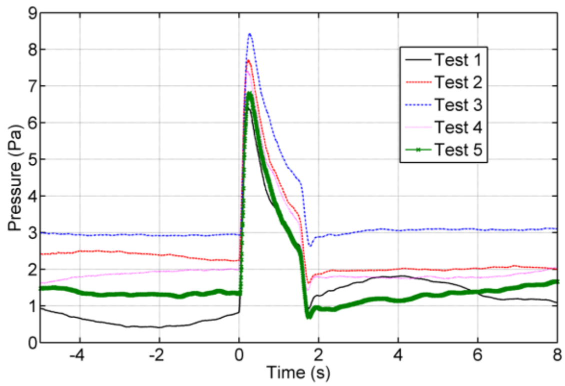
Uniform internal density

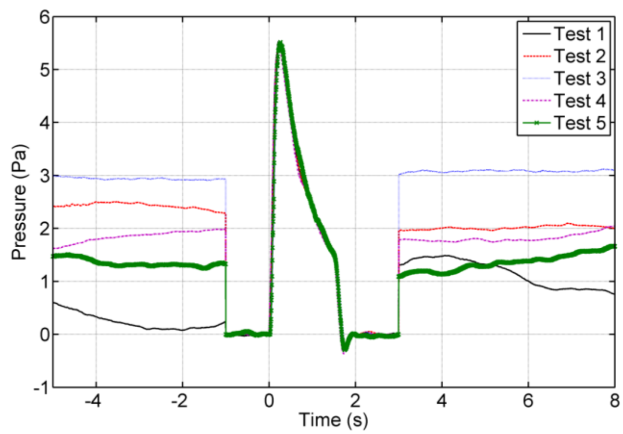
$$Q_p\{t\} = \dot{m}_p(t)/\rho_i$$

Pulse shape



Background pressure change correction



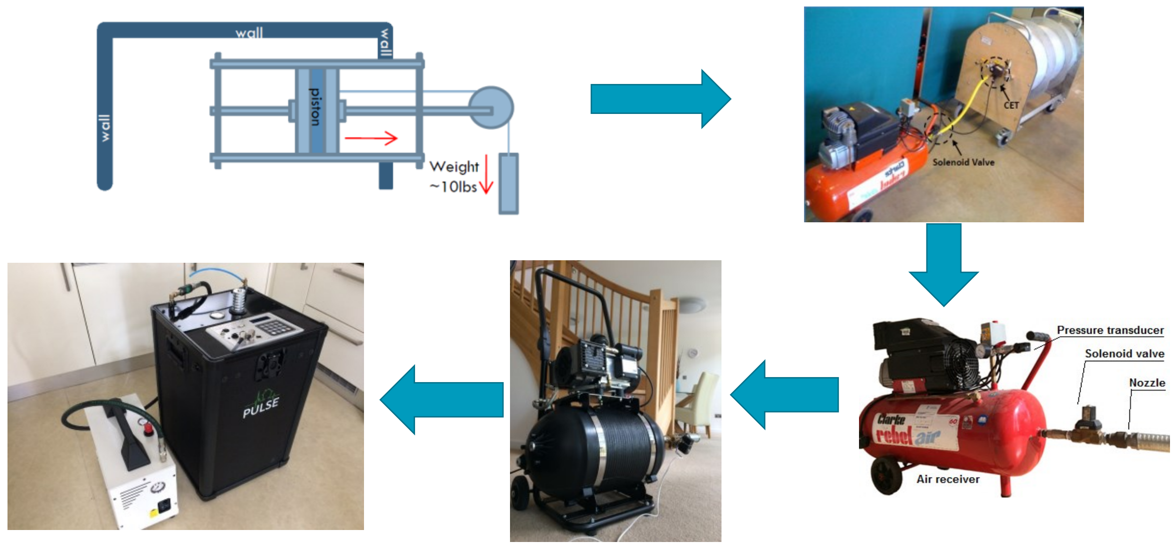


Testing & Validation

Early testing:

- Repetitive testing in lab chambers and real buildings, in sheltered and unsheltered environments
- CFD modelling of pressure distribution within the air receiver (Pulse tank)
- CFD modelling and experimental validation of the pressure distribution in a building

Pulse Progression over the past 20 years



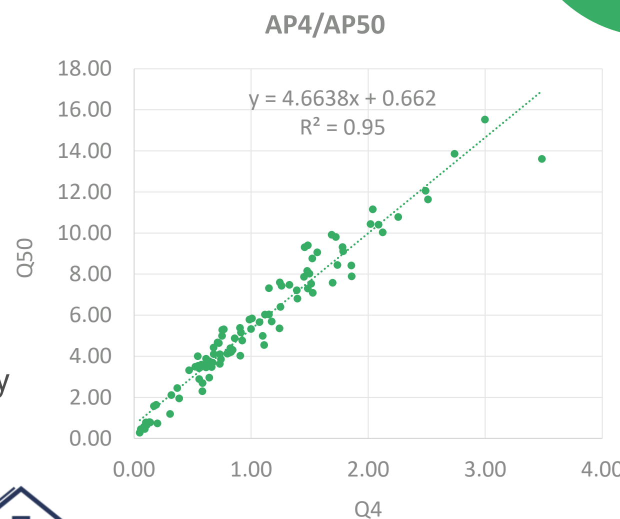
- ‘Low Pressure Pulse (LPP)’ = the technique
- ‘Pulse’ a patented trademarked product

PULSE

BUILD TEST SOLUTIONS

Further testing and validation

- 119 homes BDT vs Pulse
  - Pulse RPD of 4.4%
  - Strong linear agreement with BDT
- 24 homes – Pulse, blower door and tracer gas decay
- BRE ISO 14034 Environmental Technology Verification (ETV)
- National Physics Laboratory 3rd party review

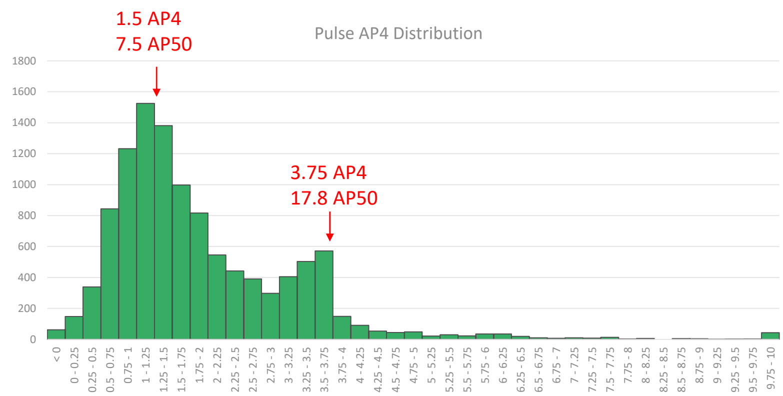


Low Pressure Pulse (LPP) Airtightness

- Low pressure rapid air leakage testing (4Pa)
- Measured air change rates that are representative of normal occupied conditions
- Simple user operation
- Low disruption
- Extensive validation
- Approved under UK Building Regulations (CIBSE TM23)

Low Pressure Pulse (LPP) Airtightness

- 20,000 Pulse tests and counting
- Large proportion in existing homes
- Median air permeability
  1.8 m3/h/m2 @4Pa
  8.9m3/h/m2 @50Pa



Summary

- Air tightness testing needn't be a one size fits all single product market
- UK Regulations have set a precedent with **CIBSE TM23**, a globally accessible third party standard.
- **Global market** for Pulse across numerous fields – new and existing homes, non-residential buildings and specialist environments. Very different to blower door fan and thus offers numerous new opportunities
- There is a large detailed and comprehensive evidence base for LPP and the Pulse product – commercial, academic and 3rd party inc. ETV

Thank you

Christopher.Wood@nottingham.ac.uk
Luke@buildtestsolutions.com

www.buildtestsolutions.com
@BuildTestUK

University of Nottingham
UK | CHINA | MALAYSIA

BUILD TEST SOLUTIONS

The AirTightnessTester

Our new measuring instrument for air tightness

Niek-Jan Bink

ACIN instrumenten

TNO innovation for life

ACIN instrumenten TKI SecureVent TOPSECTOR ENERGIE

The project was carried out with a subsidy from the Ministry of Economic Affairs, National Regulations for Economic Affairs subsidies, Top Sector Energy implemented by the Netherlands Enterprise Agency.

1

Securevent project (2017-2020)

initiated by TNO

(Wouter Borsboom)

- In more than 80% of Dutch dwellings, the integral performance of the air system *upon completion* is found not to meet the minimum requirements of the building code. This has major consequences for the indoor air quality and energy performance of homes.

- The goal of TKI SecureVent is to better secure the integral performance of residential air systems (air quality, sound comfort and energy use).

- An essential condition for this is the availability of simple measuring instruments for the professional market, with which

1) the airtightness of the building envelope,
2) the air volume flow
3) the noise level of the ventilation system can be tested in a fast and affordable manner.

TNO innovation for life

ACIN instrumenten TKI SecureVent TOPSECTOR ENERGIE

The project was carried out with a subsidy from the Ministry of Economic Affairs, National Regulations for Economic Affairs subsidies, Top Sector Energy implemented by the Netherlands Enterprise Agency.

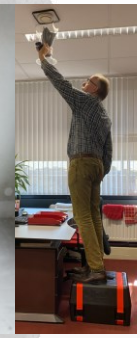
2

Our contribution to TKI SecureVent

Developing simple measuring instruments for the professional market with which

- The air permeability of the building envelope
- The air volume flow of the ventilation system (VentiFlow-mk2)

can be measured quickly and affordably.



TNO innovation for life

ACIN instrumenten TKI SecureVent TOPSECTOR ENERGIE

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3

Methodology Air Tightness

Airtightness is normally measured with a blower door

ACIN has developed the ATT based on a patented idea from TNO for a simplified measurement that the installer can carry out quickly.

It is not meant to replace the blower door but to supplement

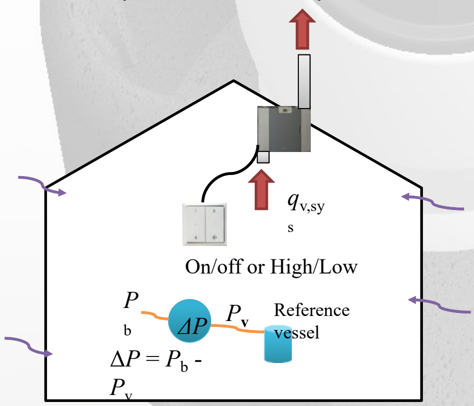
ACIN Air Tightness Tester made in Holland

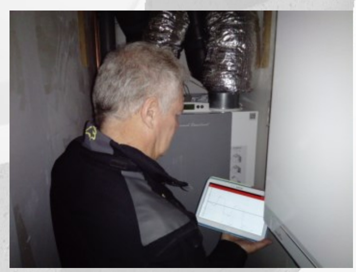
TNO innovation for life

4

The AirTightnessTester (ATT)

In the simplified air permeability measurement, the ventilation system present in the house is used to bring the house to underpressure or overpressure and to measure the air permeability.



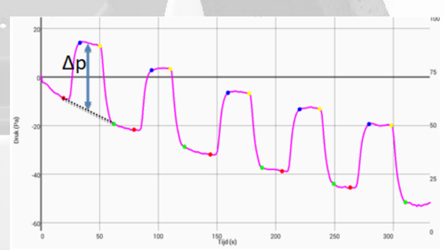


ACIN Air Tightness Tester made in Holland

TNO innovation for life

Measuring with the ATT

- The ATT makes smart use of the ventilation system. The pressure vessel of the ATT serves as a reference (pressure in the house when the ventilation system is off).
- While the ventilation system is switched on and off a number of times, the pressure difference compared to the reference is measured.
- From this pressure difference and the air volume flow of the ventilation system, the air tightness is calculated



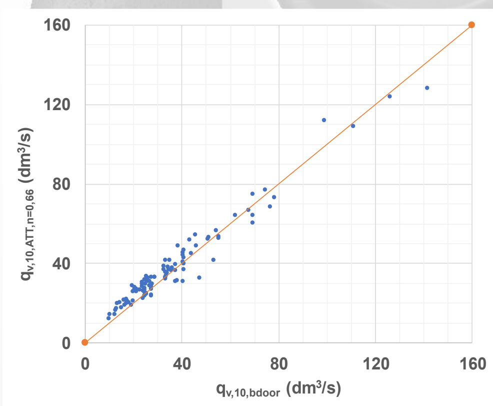
figuur 4: Typisch verloop van het gemeten drukverschil.

ACIN Air Tightness Tester made in Holland

TNO innovation for life

ATT Measurements

The ATT has been tested by Koppen Bouwexperts



Koppen bouwexperts is a specialist in the field of air tightness measurements with the blower door.
In 2018 and 2019, they compared the ATT with the blower door in a large number of homes.

ACIN Air Tightness Tester made in Holland

TNO innovation for life

KOPPEN bouwexperts

7

Jury report

VSK AWARDS 2020 GENOMINEERD

VSK AWARDS 2020 WINNAAR

- Airtightness is the 'dark horse' of the energy transition
- Builders must measurably demonstrate their performance
- For installers, airtightness is an important precondition
- Serial housing and apartments to be tested quickly
- **Supplementary to the blower door test.**
- Installer as total package supplier and sustainability advisor.
- In (renovated) existing buildings, an installer can now really measure.

ACIN Air Tightness Tester made in Holland

TNO innovation for life

8

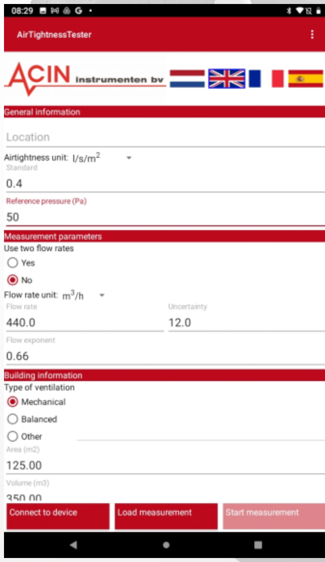
A new dormer

9

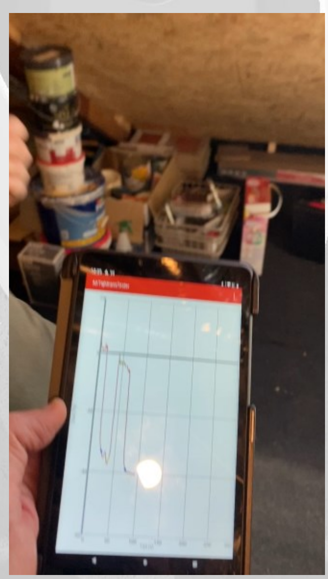
Before…

10

Start measurement



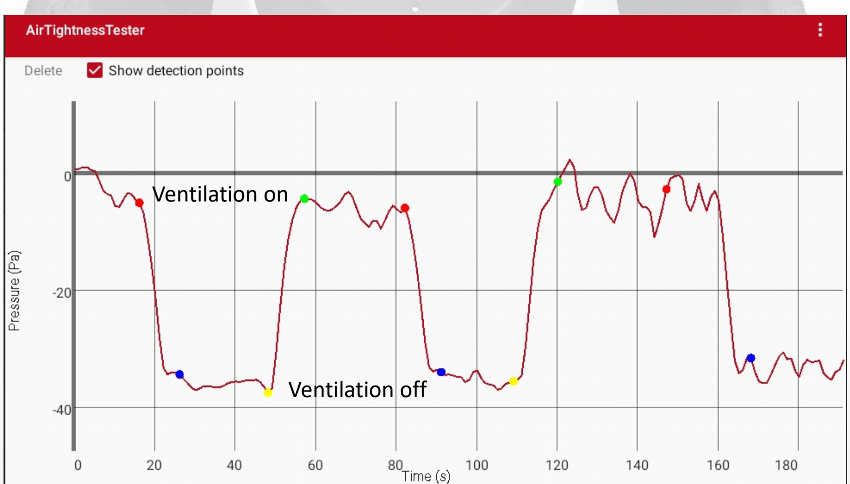
Using the ventilation system



Before…

13

Graph



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Settings

AirTightnessTester

ACIN instrumenten bv

General information	
Date	2023-04-19
Start time	12:23:42
End time	12:28:52
Location	Korenbloem 57
Type of ventilation	Balanced

Measurement parameters		
Standard	0.4 l/s/m^2	
Flow rate (low)	77.0 m^3/h	Edit
Flow rate (high)	445.0 m^3/h	Edit
Flow exponent	0.66	Edit
Area	125.0 m^2	Edit
Volume	Volume not filled in	Edit

Results		
Average pressure	31.5±0.1 Pa	
Airtightness@10Pa	0.44±0.06 l/s/m^2	Edit

Results

AirTightnessTester

ACIN instrumenten bv

General information	
Date	2023-04-19
Start time	12:23:42
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Flow rate (low)	77.0 m^3/h	Edit
Flow rate (high)	445.0 m^3/h	Edit
Flow exponent	0.66	Edit
Area	125.0 m^2	Edit
Volume	Volume not filled in	Edit

Results		
Average pressure	31.5±0.1 Pa	
Airtightness@10Pa	0.44±0.06 l/s/m^2	Edit

15

After ...

16

17

General information		
Date	2023-06-16	
Start time	12:17:37	
End time	12:23:09	
Location		
Type of ventilation	Balanced	

Measurement parameters		
Standard	200.0 l/s/m^2	
Flow rate	440.0 m^3/h	Edit
Flow exponent	0.66	Edit
Area	125.0 m^2	Edit
Volume	350.0 m^3	Edit

Results		
Average pressure	4.2±0.5 Pa	
Airtightness@10Pa	1.73±0.21 l/s/m^2	Edit

18

Thanks!

Combining IR and acoustic methods

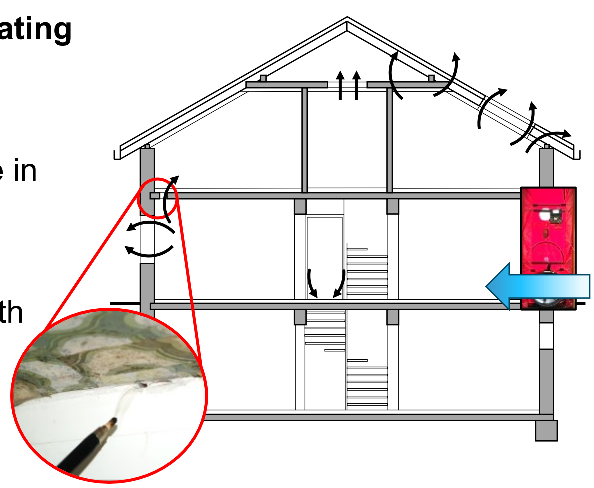
An under-development method to locate air leakage paths

Benedikt Kölsch, Björn Schiricke – DLR (German Aerospace Center)
19.06.2023

1

Motivation

- **Uncontrolled airflow** in buildings → responsible for significant share of **heating** and **cooling energy**
- **Knowledge** of **leak location** and **size** in building envelopes is crucial
- **Leakage detection** in combination with blower-door is **time-consuming**



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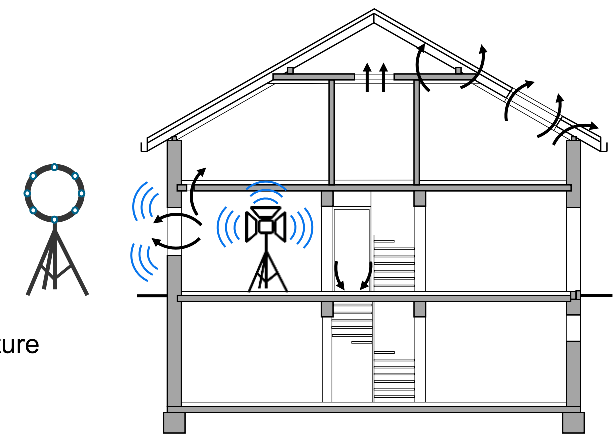
Acoustic Approach

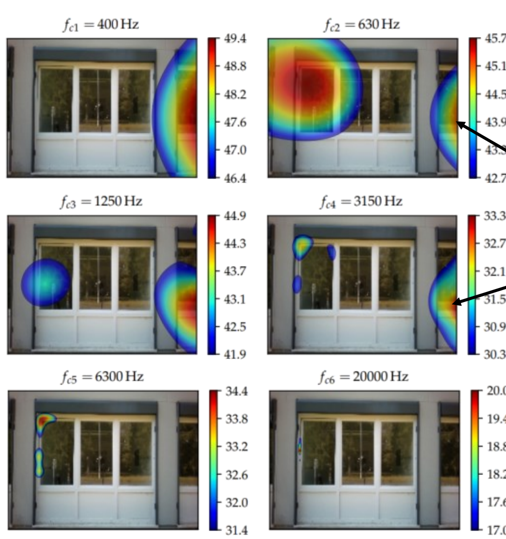
- **Sound** takes predominantly the **same paths** as **air** in fan pressurization method
- Possible approach to identify leak locations in building envelopes: **microphone array + speaker**
- **Advantages:**
  - Independent from pressure and temperature differences
  - Scanning of large areas possible



Acoustic Measurement Setup

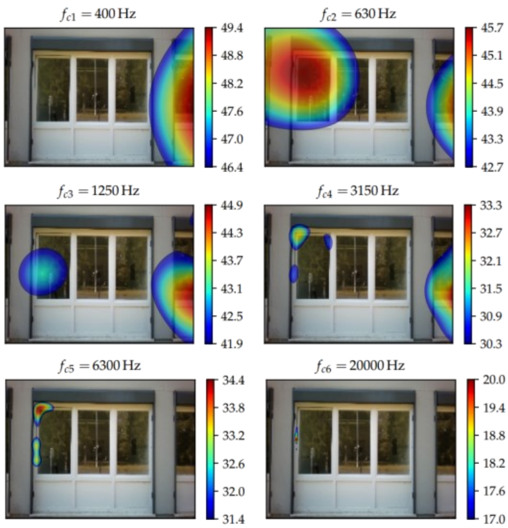
Acoustic Measurement Setup

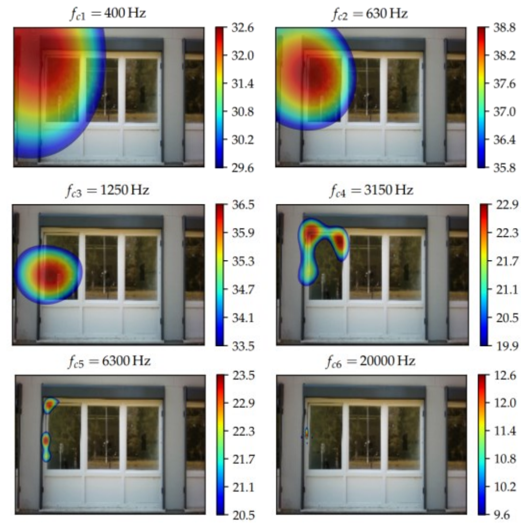
Acoustic Measurement: Tilted Window



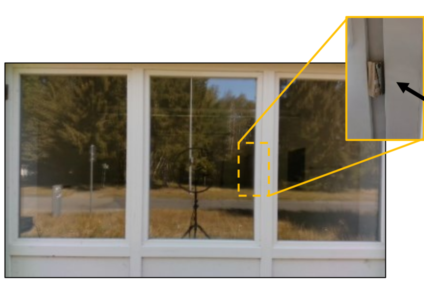
External disturbing sound source

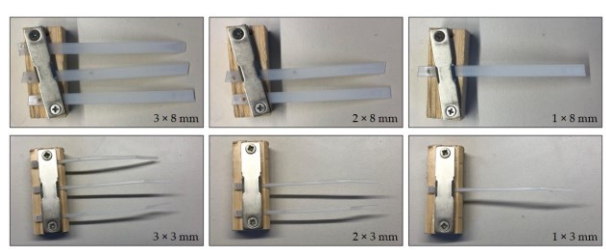
Acoustic Measurement: Tilted Window



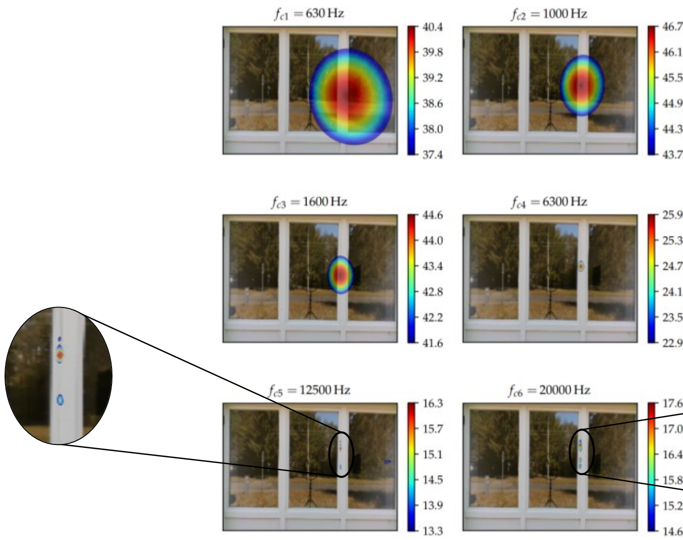


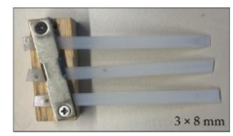
Acoustic Measurement: Cable Ties Window



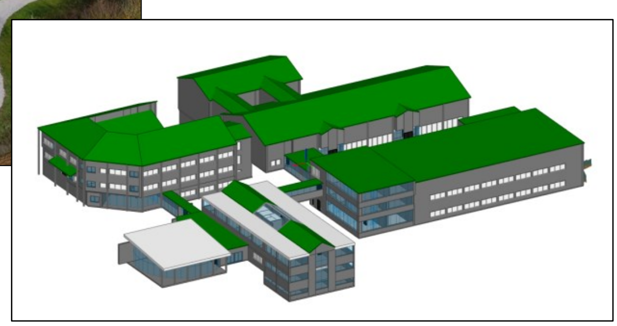


Acoustic Measurement: Cable Ties Window

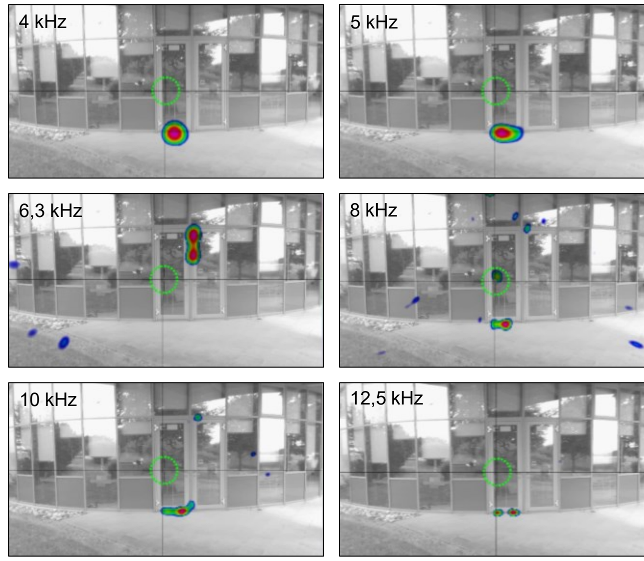




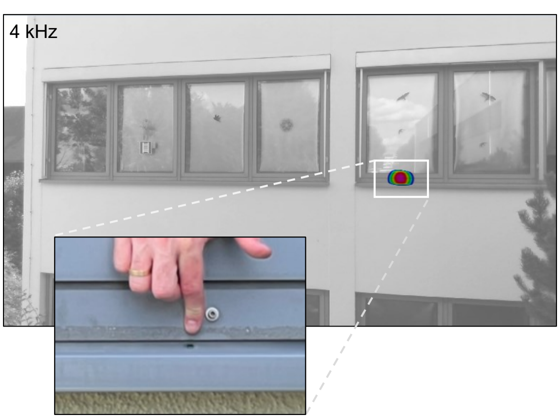
Acoustic Measurement: Large Field Study

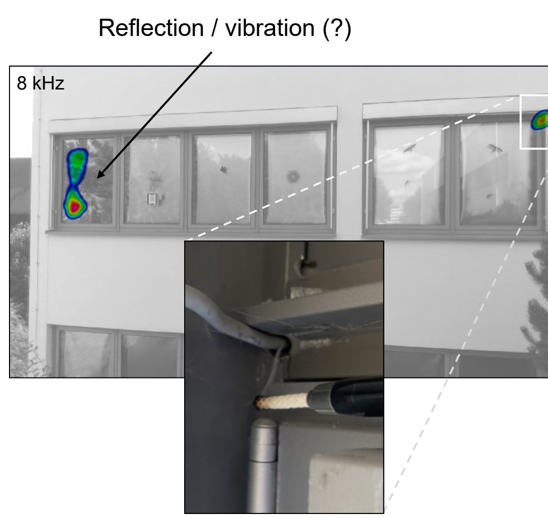


Acoustic Measurement: Leak Detection on Entire Facades

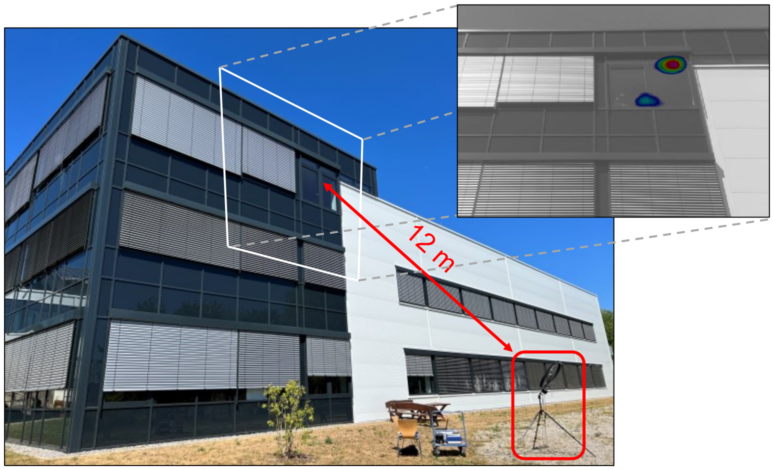


Acoustic Measurement: Evidences of Leaks Found





Acoustic Measurement: Large Distances Possible



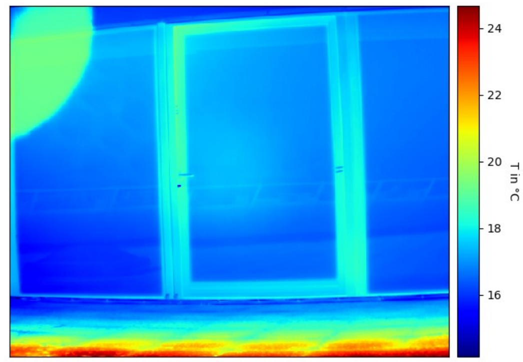
Acoustic Measurement: Strengths and Weaknesses

+	−
• Large-scale façades scan possible • Visualization of sound sources possible	• Susceptible to acoustic interference sources • So far, estimation of leak size is difficult / hardly possible yet • Sometimes difficult to distinguish between leakage, reflection or vibration

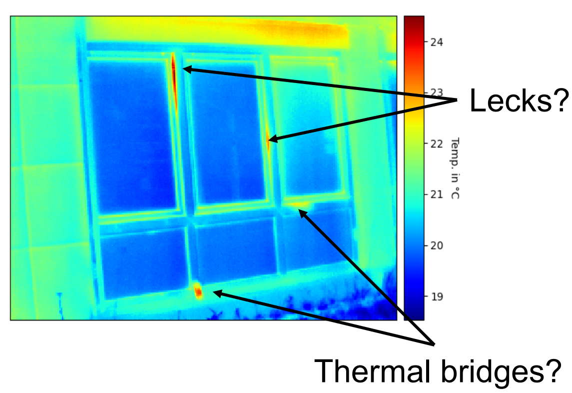
Infrared Measurement Outside

- Another possible method to find leaks: **Infrared Thermography**

- Constraints of IR measurements:
  - High temperature difference between inside and outside
  - Stable temperature differences
  - No solar radiation
  - Low wind speed



Infrared Thermography



Infrared Thermography: Strengths and Weaknesses

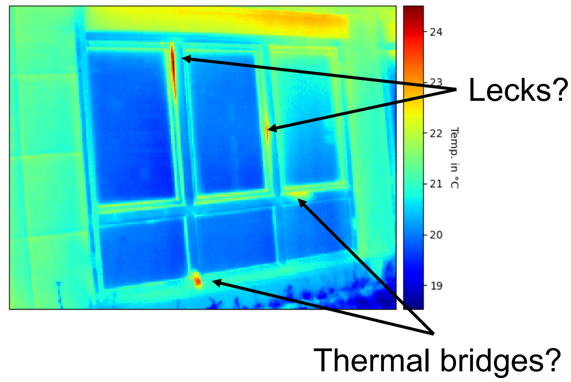
DLR

+

- Large-scale façades scan possible
- Display of thermal image of façade

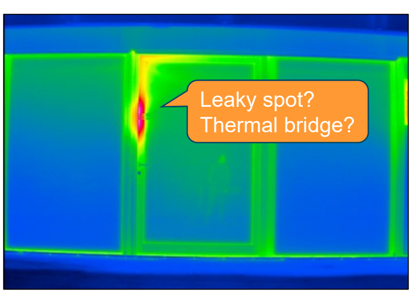
−

- Susceptible of change in environmental conditions
- Sometimes difficult to distinguish between leak and thermal bridge

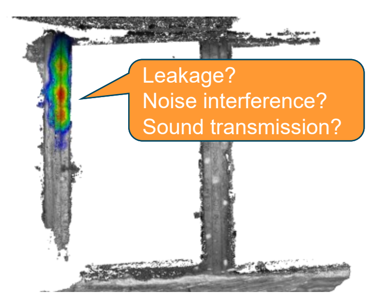


New project: Develop method for combining these methods

DLR



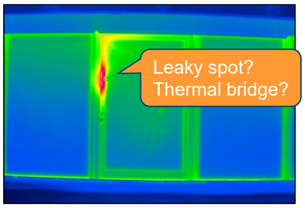
Thermal image of the IR camera



3D model of the acoustic camera with sound localization

New project: Develop method for combining these methods

DLR



Thermal image of the IR camera

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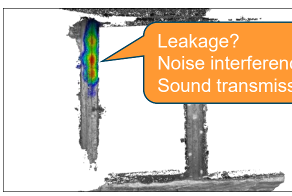
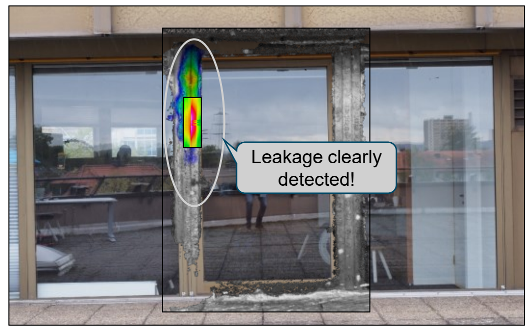


3D model of the acoustic camera with sound localization

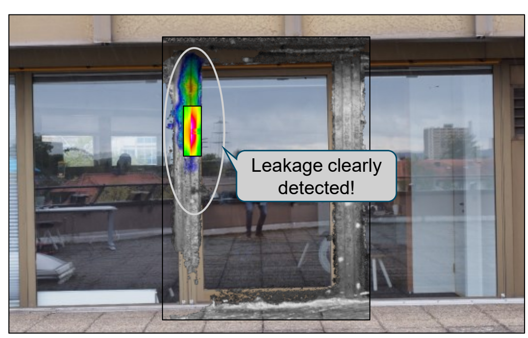


Combination of infrared and acoustic camera

Possible advantages

DLR

- Combination of infrared thermography and acoustic camera to **identify relevant leaks in the building envelope** over large areas.
- **Less sensitive to weather conditions** (wind, outside temperature) that otherwise affect thermal imaging analysis
- Easy **mapping of leakages** on the facade surface.
- (Possibly) **prioritization** of leakages.
- **Scalability**, ease of use, standardized application, easily interpretable results



Thank you!

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