Measurement of **airflow rates** at **air terminal devices**: an overview

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Overview of methods at air terminal device

Vane anemometers

Small probe + specific cone

- Thermal or vane anemometer

Standard hoods

Compensation method

And more…

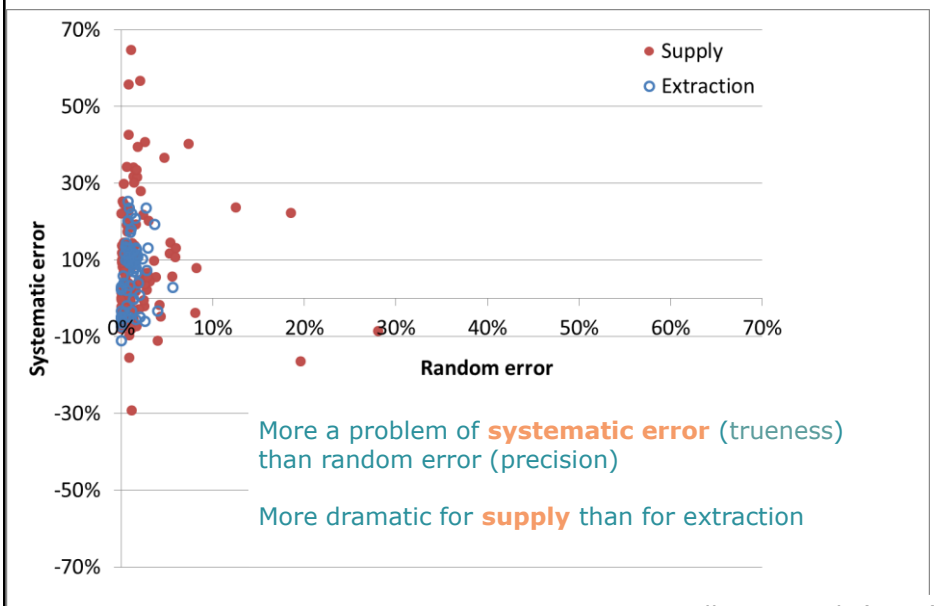
Overview presentation

Integrating results from different teams

- BBRI, Belgium
- BSRIA, UK
- Cetiat, France
- LBNL, USA

- Different methodologies
  - Comparison with reference flow rate (in lab only)
  - Comparison with reference instrument (field study possible)
- Comparison of methods
  - But also trademarks… and calibration by the manufacturers

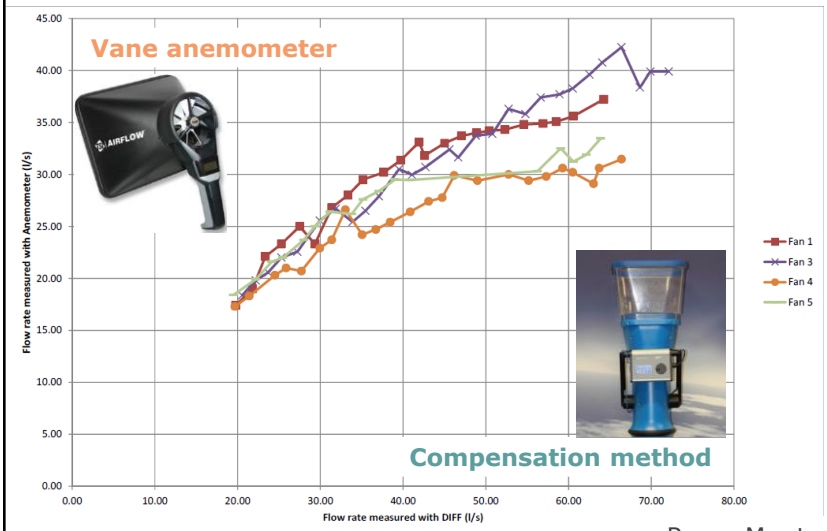
Overview of the problem



Caillou S. et al. (BBRI)

Problem n°1

Back pressure or insertion losses



Roper M. et al. (BSRIA)

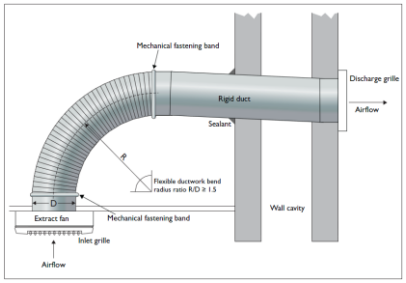
n°1: Back pressure or insertion losses

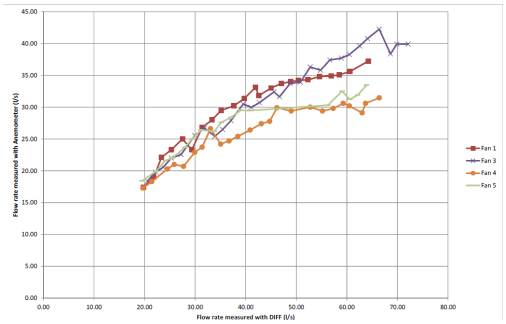
- The measurement instrument creates an **additional pressure drop**
  - Modifies ductwork characteristic and/or fan working point
  - Reduces the (apparent) measured flow rate
- For both **supply** and **extraction** ATD
- Depends on
  - Ductwork type: branched or not
  - Pressure drop of the ductwork: low vs. high
  - Fan characteristic: axial vs. centrifugal
- Solution? **Compensation method**

n°1: Back pressure or insertion losses

BSRIA study

- Decentralized ventilation systems
  - Wall- or ceiling-mounted
  - Axial fans
  - Low pressure, especially at higher flow rates





Roper M. et al. (BSRIA)

Problem n°2

Non-uniformity of the flow

- More problematic for supply than for extraction ATD
- Several causes of non-uniformity (ATD)
  - Flow pattern of the ATD
  - Swirl
  - Directional flow
  - High local velocities
  - Presence of an elbow before the ATD
  - Changed flow pattern after regulation of the ATD (too closed)
  - …

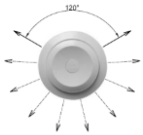
n°2: Non-uniformity of the flow

Examples of tested ATD (BBRI)

- Homogeneous
  - Classical ATD
    in normally opened position

- Non-homogeneous
  - ATD with lateral flow
    (high local velocity)

  - ATD with protected angle
    (directional flow pattern)



  - ATD particularly closed (10-50%)

Caillou S. et al. (BBRI)

n°2: Non-uniformity of the flow

Examples of tested ATD (Cetiat)

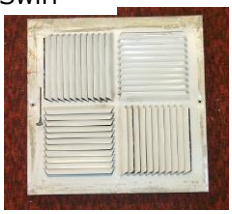
Caré I. et al. (Cetiat)

n°2: Non-uniformity of the flow

Examples of tested ATD (LBNL)

Directional flow

Swirl

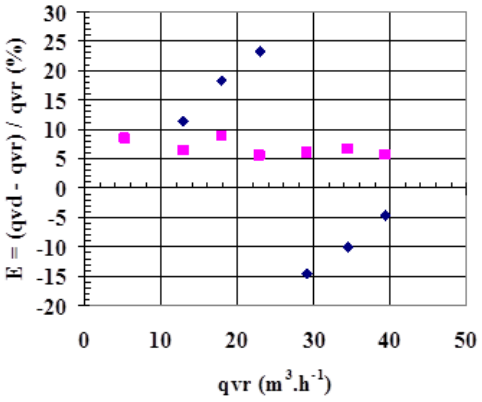


Walker I. et al. (LBNL)

Stratton J. et al. (LBNL)

n°2: Non-uniformity of the flow

Vane anemometer

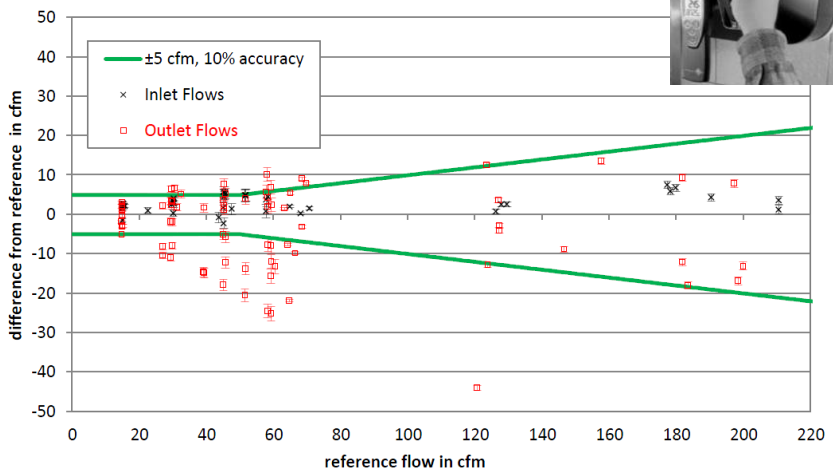


(a) (b)

Caré I. et al. (Cetiat)

n°2: Non-uniformity of the flow

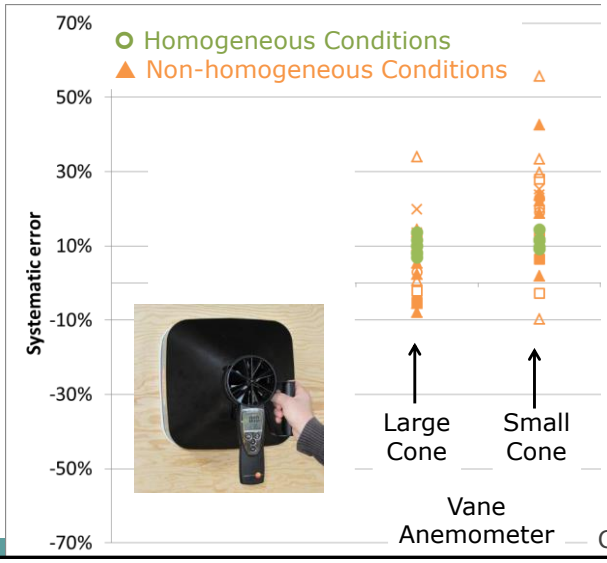
Vane anemometer



Stratton J. et al. (LBNL)

n°2: Non-uniformity of the flow

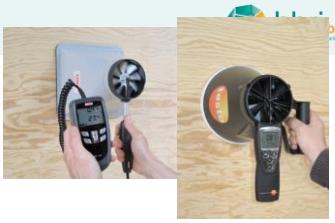
Vane anemometer



Caillou S. et al. (BBRI)

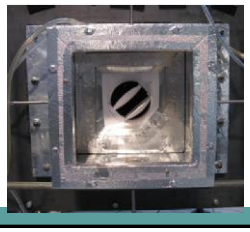
n°2: Non-uniformity of the flow

Vane anemometer (propeller)



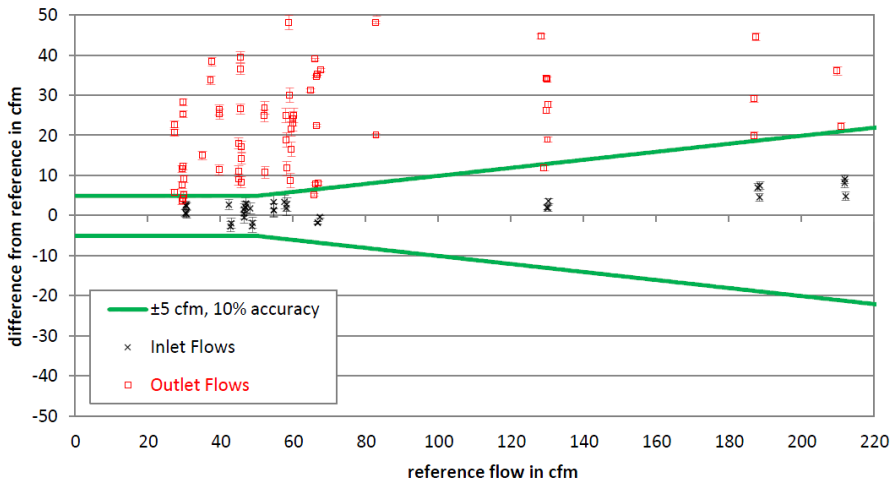
- For extraction ok: < 10-15% error
- For supply
  - Very sensitive to flow pattern
  - Also very sensitive to swirl
    - Same direction as propeller→ overestimated
    - In opposition to propeller → underestimated

- Improvement
  - Larger cone
  - Longer hood
  - Or additional box (Cetiat)



n°2: Non-uniformity of the flow

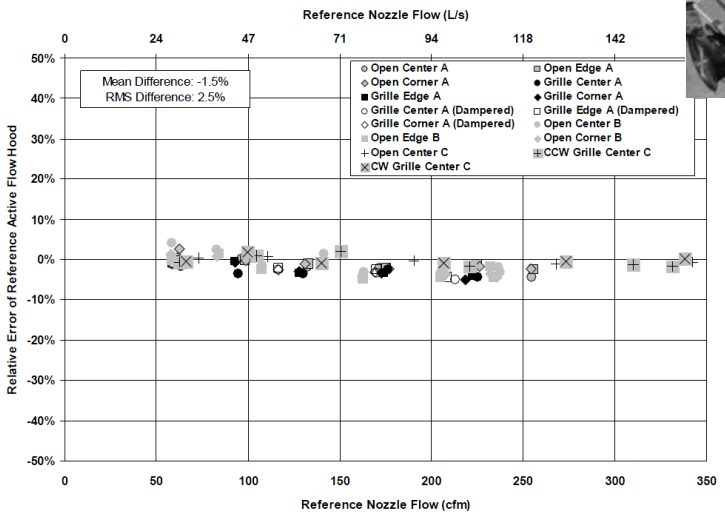
Standard hoods



Stratton J. et al. (LBNL)

n°2: Non-uniformity of the flow

Compensation method



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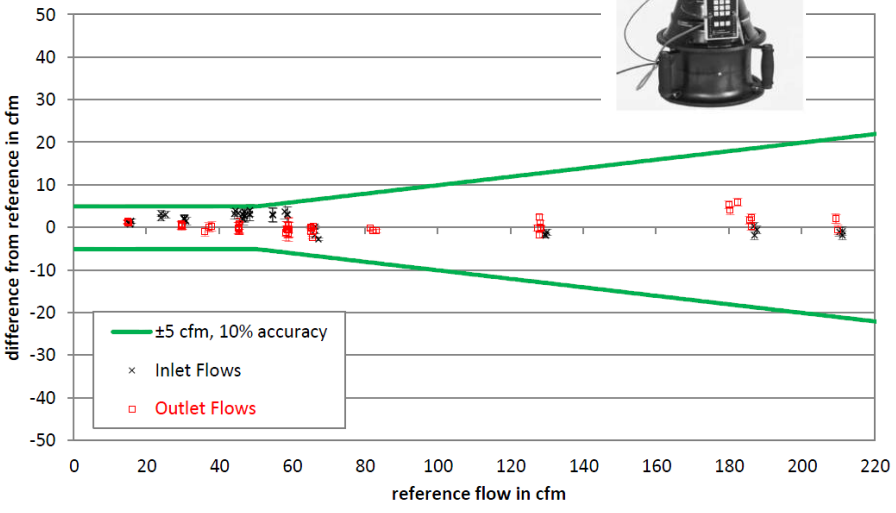
Compensation method



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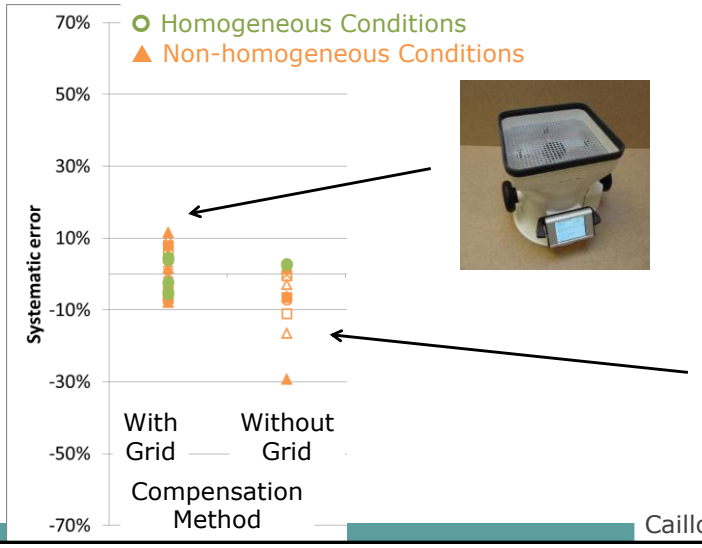

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n°2: Non-uniformity of the flow

Compensation method

- Very good in all conditions: < 10% error
  - For both supply and extraction ATD
  - For all types of ATD and flow patterns
- **But the key point si flow stabilisation!**
  - Compensation as such is not enough
  - Stabilisation with a grid (compensation necessary to compensate the pressure drop)
  - Or stabilisation with longer hood?

Not enough stabilisation

n°2: Non-uniformity of the flow

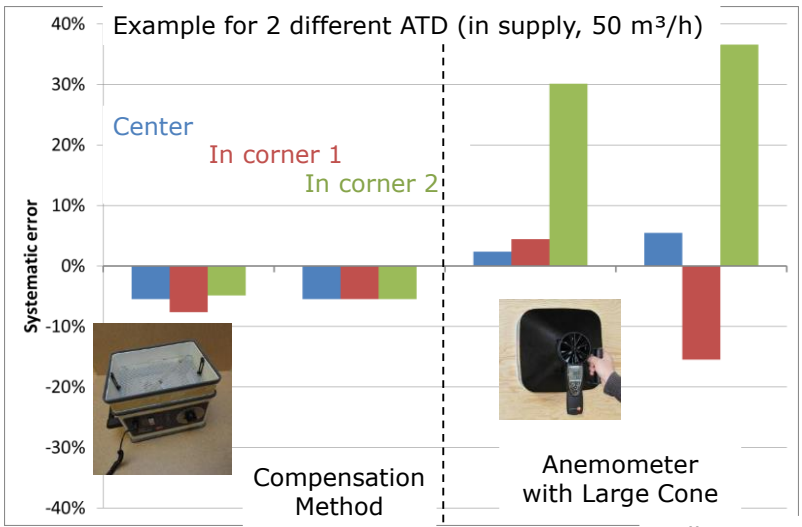
Stabilisation using a duct piece

- Recent innovation
- Principle
  - Same as vane anemometer
  - But with additional duct piece

- Good in all conditions < 10-15% error
  - For both supply and extraction
  - For all types of ATD and flow patterns tested
- But
  - Pressure drop x 1.5 compared to without additional duct
  - See back pressure (problem 1)

Problem n°3

Non-centering of the instrument on the ATD



Solutions - recommandations

- **Compensation method**
  - But stabilisation is the key point: with grid vs. without grid

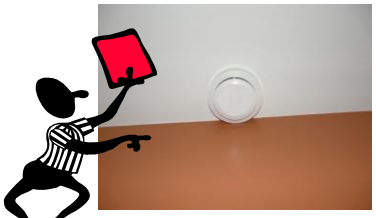
- For non-active methods (no compensation)
  - Ok for extraction ATD
  - But for supply, need additional stabilisation
    - Larger cone, longer hood
    - Or additional duct section (! Back pressure)

Further thinking

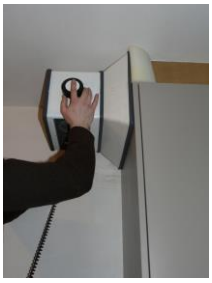
Calibration vs. Field application

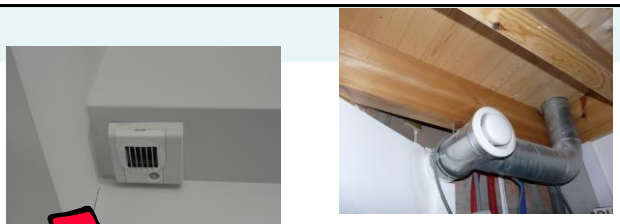
- Of course all these instruments have been calibrated!
  - By the manufacturer (with good claimed accuracy…)
  - But for uniform/homogeneous flow patterns only!
- Calibration is not enough…
- Selective description of « good » and « not good » methods is not a solution…
- Can we imagine a **standard test protocol** ?
  - Defining the main types of non-uniform patterns
  - Allowing to test instrument performances for these patterns
  - Leaving the way open to innovation!

Important to install measurable ATD



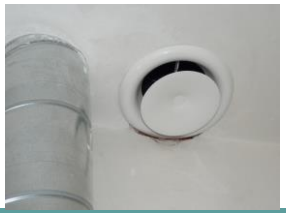
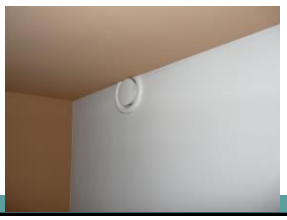











Thank you for your attention

- References
  - NBN EN 12599:2012. *Ventilation for buildings - Test procedures and measurement methods to hand over air conditioning and ventilation systems*
  - prEN 16211 (to be published). *Ventilation for buildings - Measurement of air flows on site –methods*
  - G. Hawkins (2013). *Domestic ventilation systems – A guide to measure airflow rates.* A BSRIA Guide, BG 46/2013. www.bsria.co.uk
  - M. Roper (2013). *Flow Measurement for Domestic Ventilation Fans.* Final Report 57015/2. BSRIA. www.bsria.co.uk
  - A. Gilbert, Ch. Knights (2013). *Quality of ventilation systems in resiedential buildings : statut and perspectives in the UK*, AIVC International Workshop, Brussels, Belgium, 18-19 March 2013
  - J. C. Stratton, W.J.N Turner, C. P. Wray, I. S. Walker (2012). *Measuring Residential Ventilation System Airflows: Part 1 – Laboratory Evaluation of Airflow Meter Devices*. Lawrence Berkeley National Laboratory. http://homes.lbl.gov/sites/all/files/lbnl-5983e.pdf

- References (2)
  - J. Chris Stratton, Iain S. Walker, Craig P. Wray (2012). *Measuring Residential Ventilation System Airflows: Part 2 – Field Evaluation of Airflow Meter Devices and System Flow Verification.* Lawrence Berkeley National Laboratory. http://homes.lbl.gov/sites/all/files/lbnl-5982e.pdf
  - I.S. Walker, C.P. Wray, D.J. Dickerhoff, M.H. Sherman (2001). *Evaluation of flow hood measurements for residential register flows.* Lawrence Berkeley National Laboratory. http://epb.lbl.gov/publications/pdf/lbnl-47382.pdf
  - C.P. Wray, I.S. Walker, M.H. Sherman (2002). *Accuracy of flow hoods in residential applications.* Lawrence Berkeley National Laboratory. http://epb.lbl.gov/publications/pdf/lbnl-49697.pdf
  - I. Carré, P. Chaffois, P. Henry (2013). *Guide des bonnes pratiques des mesures de débit d'air sur site pour les installations de ventilation.* Cetiat, France. http://www.cetiat.fr/fr/chercher/index.cfm
  - I. Caré (2013). *Measurement of flow rate at air terminal device*, Congrès international de Métrologie, Paris, October 2013