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

More a problem of **systematic error** (trueness) than random error (precision)

More dramatic for **supply** than for extraction

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Problem 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

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%)

Examples of tested ATD (BBRI)  Caillou S. et al. (BBRI)

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n°2: Non-uniformity of the flow

Examples of tested ATD (Cetiat)

Examples of tested ATD (Cetiat)  Caré I. et al. (Cetiat)
n°2: Non-uniformity of the flow
Examples of tested ATD (LBNL)

Directional flow

Stratton J. et al. (LBNL)

Swirl

Walker I. et al. (LBNL)

n°2: Non-uniformity of the flow
Vane anemometer

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

Walker I. et al. (LBNL)

n°2: Non-uniformity of the flow
Compensation method

Stratton J. et al. (LBNL)
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 is flow stabilisation!
  - Compensation as such is not enough
  - Stabilisation with a grid (compensation necessary to compensate the pressure drop)

- Or stabilisation with longer hood?
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)

Caillou S. et al. (BBRI)

Problem n°3

Non-centering of the instrument on the ATD

Example for 2 different ATD (in supply, 50 m³/h)

- Center
- In corner 1
- In corner 2

Systematic error

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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*

- References (2)