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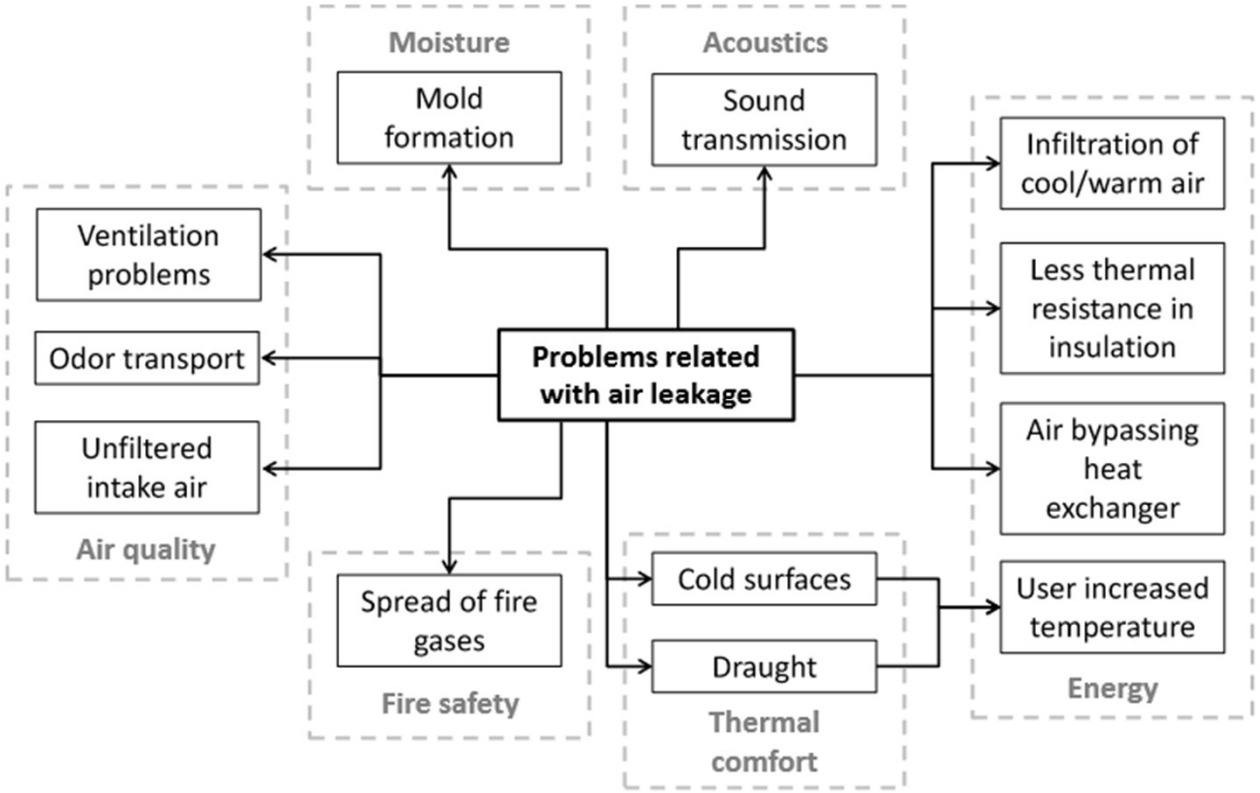
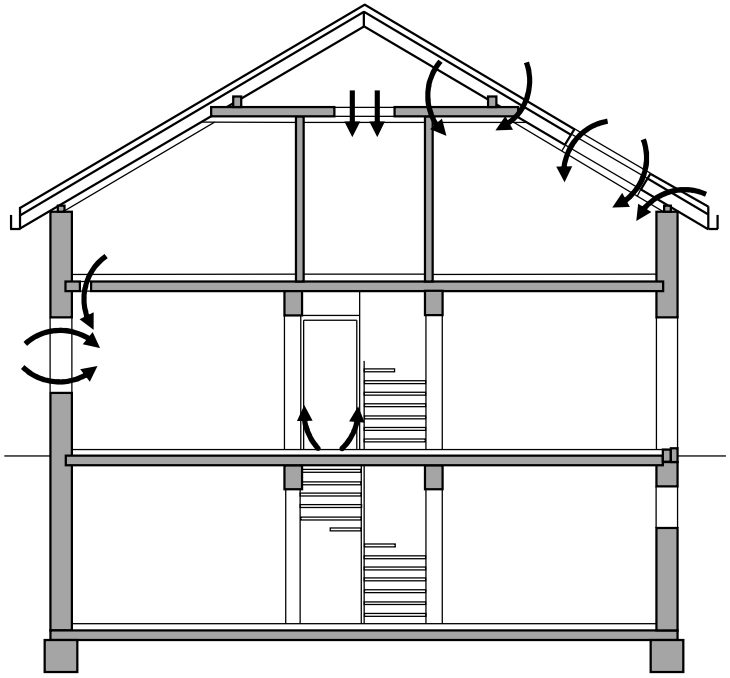
ISO 9972: AN OVERVIEW OF DIFFICULTIES WITH THE CURRENT STANDARD

AIVC Workshop, Tokyo (JP) – 19.05.2023

Benedikt Kölsch, Valérie Leprince & Adeline Mélois

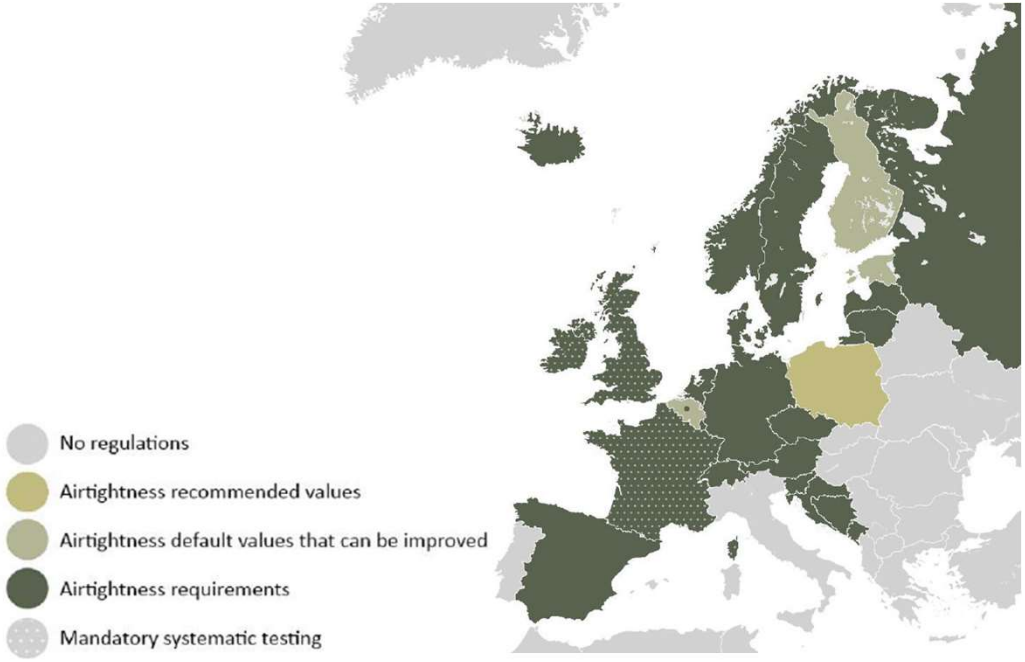
IMPORTANCE OF AIRTIGHTNESS





AIRTIGHTNESS REGULATIONS IN EUROPE

- Increasing number of tests performed in Europe
- Testing → important part in national energy regulations
- Test is used for :
  - **Measuring air leakage** in buildings to fulfill energy performance standards
  - **Comparing relative airtightness** of buildings
  - **Determining reduction** or air permeability after implementation of improvements



Poza-Casado et al. (2020)

ISO 9972: FAN PRESURIZATION METHOD

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN ISO 9972

September 2015

ICS: 91.120.10

Supersedes EN 13829:2000

English Version

Thermal performance of buildings —
Determination of air permeability of buildings —
Fan presurization method
(ISO 9972:2015)

Performance thermique des bâtiments —
Détermination de la perméabilité à l'air des bâtiments —
Méthode de pressurisation par ventilateur
(ISO 9972:2015)

Wärmetechnisches Verhalten von Gebäuden —
Bestimmung der Luftdurchlässigkeit von Gebäuden —
Differenzdruckverfahren
(ISO 9972:2015)

ISO 9972: FAN PRESURIZATION METHOD

- Describes measurement procedure and calculation methods for determining airtightness
- To obtain comparable and credible results, it needs to be
  - ➢ Reliable and valid for different kinds of buildings
  - ➢ Reproducible under challenging environmental conditions
  - ➢ Consistant with other standards
- Recent scientific works + more experience in field testing → **need to improve ISO 9972!**

WORKING GROUP ON ISO 9972

Collection of data and knowledge from experts in the field

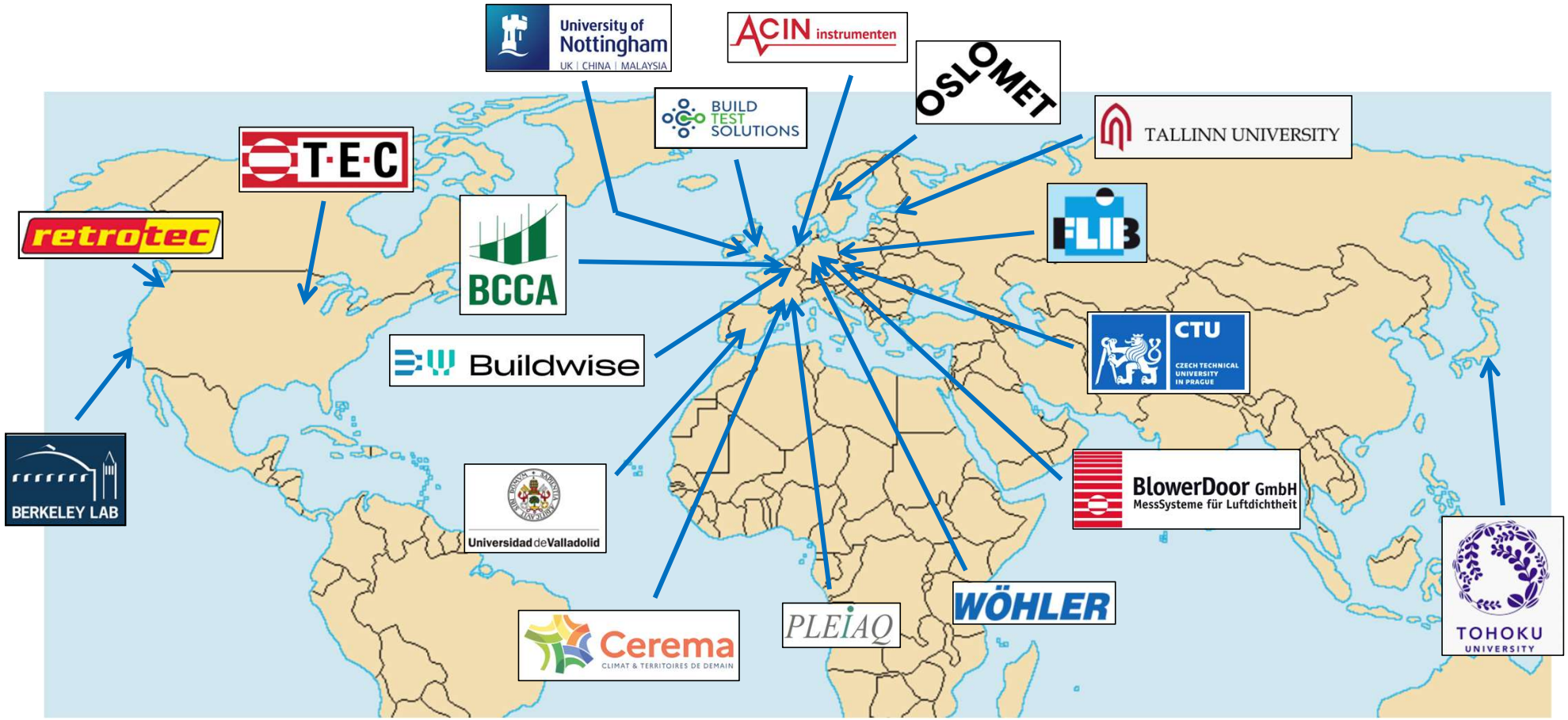
Provision of a proposal for revision of ISO 9972, that

- allows performing tests even under **challenging conditions**
- is a more **reliable** calculation procedure + improved uncertainty estimation
- Is **consistent** with other standards

Collecting a comprehensive **list of relevant issues** with survey among experts

No formal revision → **provision of best knowledge** for official revision process in ISO/TC 163/SC 1 technical committee

WORKING GROUP AFFILIATIONS



REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **reliability**

= result's consistency over time
+
reproducibility

- Building preparation
- Wind speed and temperature measurements
- Placement of external pressure taps
- Duration of pressure/airflow measurements
- Induced pressure differences
- Type of regression

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **reliability**

- **Building preparation**
- Wind speed and temperature measurements
- Placement of external pressure taps
- Duration of pressure/airflow measurements
- Induced pressure differences
- Type of regression

- How intentional openings should be sealed, closed, or left open during tests
- Influences final results *

➢ Avoid ambiguities in the standard

Work has not started yet

* Rolfsmeier et al. (2011), Leprince & Carrié (2014)

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **reliability**

- Building preparation
- **Wind speed and temperature measurements**
- Placement of external pressure taps
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- Induced pressure differences
- Type of regression

Unclear information on where and how (or if) to measure wind speed and ambient temperatures ISO 9972

➢ Recommendations are given for temperature and wind measurements *

Proposal finished

* Novák (2019)

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **reliability**

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- **Placement of external pressure taps**
- Duration of pressure/airflow measurements
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REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **reliability**

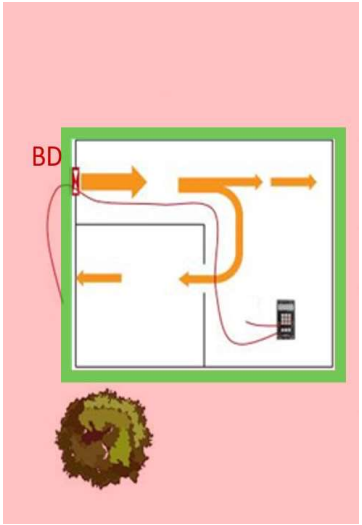
- **Placement of external pressure taps**

ISO 9972

Location of pressure taps used as reference for every pressure measurement → location not clearly stated

➢ Especially for zero-flow pressure measurements, clarification if taps should be placed *

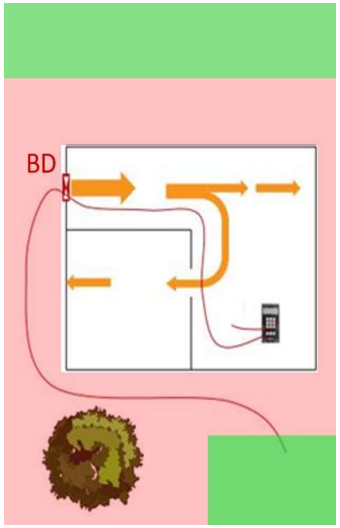
Next to the building



Pressure difference across envelope

OR

Further away from the building



Equilibrium internal pressure

Work has started - more research needed

* Delmotte (2021), Hurel & Leprince (2021)

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **reliability**

- Building preparation
- Wind speed and temperature measurements
- Placement of external pressure taps
- **Duration of pressure/airflow measurements**
- Induced pressure differences
- Type of regression

- Averaging test results makes readings more reliable in presence of wind

➢ Recommend extending the duration to 60 s, recording 1 data point per second *

Work on proposal has started

* Prignon et al. (2021), Hurel & Leprince (2021)

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **reliability**

- Building preparation
- Wind speed and temperature measurements
- Placement of external pressure taps
- Duration of pressure/airflow measurements
- **Induced pressure differences**
- Type of regression

- Number and level of pressure differences may influence test reproducibility

➢ Adding option of single-point test? *

Work has not started yet

* Hurel & Leprince (2021)

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **reliability**

- Building preparation
- Wind speed and temperature measurements
- Placement of external pressure taps
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- **Type of regression**

REASONS BEHIND A NECESSARY REVISION

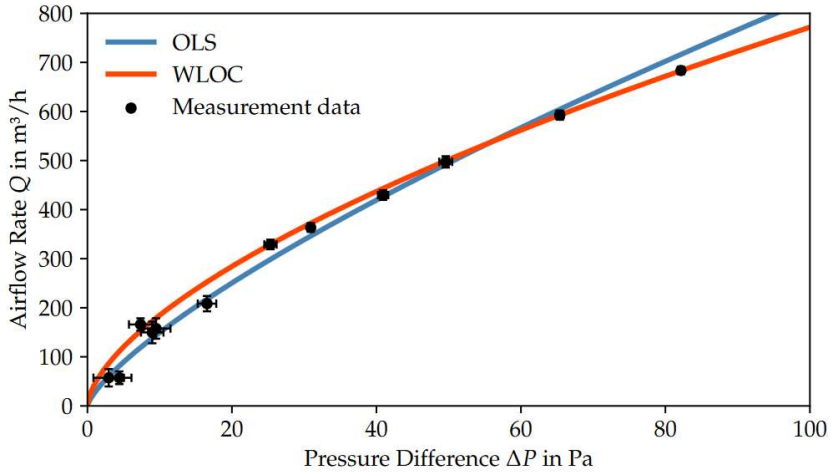
Limitations on measurement **reliability**

- **Type of regression**

ISO 9972

Least square regression shall be used to determine airflow coefficient *C* and pressure exponent *n*

- Weighted line of organic correlation **(WLOC)** uses standard uncertainty at each pressure/flow data point as a weight + optimizes in x and y-direction
- **Improves predictability** of airflows and **reduces variability** in *C* and *n* *



Work on proposal has started

* Delmotte (2017), Prignon et al. (2018), Kölsch & Walker (2020)

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

= determination of the value intended to be measured

- Airflow corrections
- Calculation of building volume and area
- Limits on zero-flow pressure measurements
- Knowledge of uncertainty
  - Errors due to measurement instruments, measurement protocol and analysis
  - Errors arising from physical model assumptions

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

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REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

- **Airflow corrections**

ISO 9972

Airflows must be corrected to standard conditions of temperatures/pressures → tests can be compared

- Simplifications assume:
  - barometric pressure negligible,
  - blower door calibrated close to reference conditions
  - *n* close to 0.5 *

$$q_{env} = q_m \left(\frac{\rho_{int}}{\rho_e} \right) \approx q_m \left(\frac{T_e}{T_{int}} \right)$$

$$C_L = C_{env} \left(\frac{\rho_e}{\rho_0} \right)^{1-n} \approx C_{env} \left(\frac{T_0}{T_e} \right)^{1-n}$$

* Walker et al. (1998)

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

- **Airflow corrections**

ISO 9972

Airflows must be corrected to standard conditions of temperatures/pressures → tests can be compared

➢ Giving modern computing equipment → **simplification not necessary anymore** *

$$q_{env} = q_m \left(\frac{\rho_{int}}{\rho_e} \right) \approx q_m \left(\frac{T_e}{T_{int}} \right)$$

$$C_L = C_{env} \left(\frac{\rho_e}{\rho_0} \right)^{1-n} \approx C_{env} \left(\frac{T_0}{T_e} \right)^{1-n}$$

Work on proposal has started

* Carrié (2014)

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

- Airflow corrections
- **Calculation of building volume and area**
- Limits on zero-flow pressure measurements
- Knowledge of uncertainty
  - Errors due to measurement instruments, measurement protocol and analysis
  - Errors arising from physical model assumptions

- Every country has different measures for building volume/area → difficult to compare
- ➢ Common standardized method to compare results could be convenient

Work has started - more research needed

Difficulties with ISO 9972

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

- Airflow corrections
- Calculation of building volume and area
- **Limits on zero-flow pressure measurements**
- Knowledge of uncertainty
  - Errors due to measurement instruments, measurement protocol and analysis
  - Errors arising from physical model assumptions

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

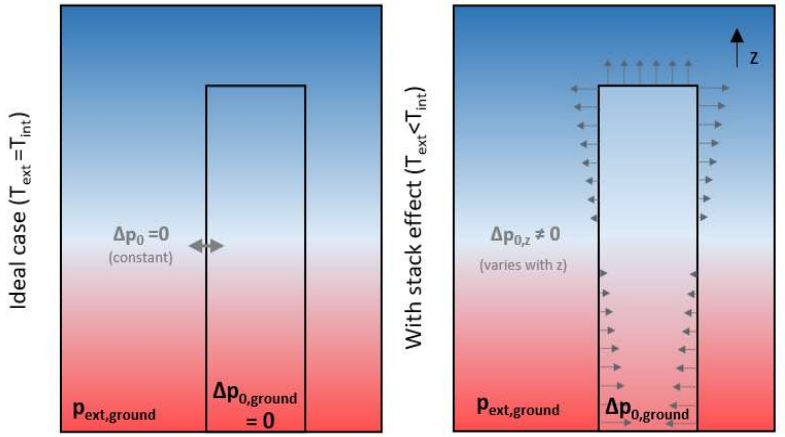
- **Limits on zero-flow pressure measurements**

ISO 9972

ΔP_0 = Pressure difference between inside and outside when building is not artificially pressurised

If **ΔP_0 > 5 Pa → test not valid!**

- This constraint shall limit influence of wind and temperatures on uncertainty – leak distribution has influence as well *



* Carrié et al. (2022), Mèlois (2020)

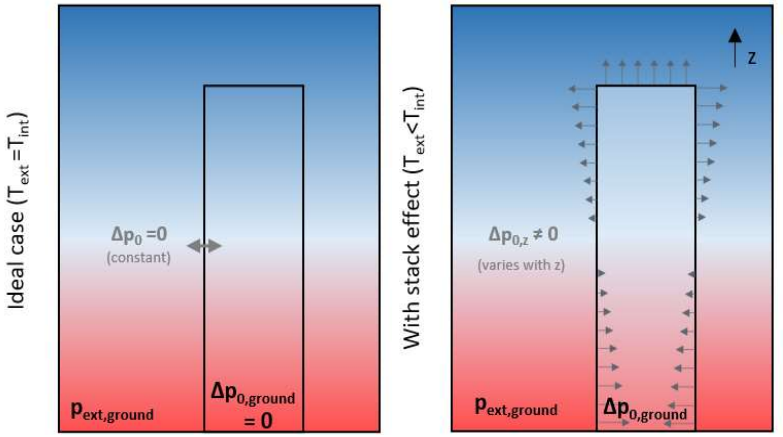
REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

- **Limits on zero-flow pressure measurements**

ISO 9972 If **ΔP_0 > 5 Pa → test not valid!**

- This constraint **excludes testing of high-rise buildings** from being tested according to the standard *
- Possible solution: only recommend that **ΔP_0 < 5 Pa + include ΔP_0** (+ maybe variability) **in uncertainty calculation**



Work on proposal has started

* Peper & Schnieders (2019), Rolfsmeier et al. (2022)

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

- Airflow corrections
- Calculation of building volume and area
- Limits on zero-flow pressure measurements
- **Knowledge of uncertainty**
  - Errors due to measurement instruments, measurement protocol and analysis
  - Errors arising from physical model assumptions

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

- **Knowledge of uncertainty**
  - ➢ Errors due to measurement instruments, measurement protocol and analysis
  - Errors of measurement devices given as maximum permissible measurement error (**MPME**) → used as influence parameter in uncertainty calculation
  - Inclusion of uncertainties from **building preparation**, **reference values** or **sampling**

Proposal finished

Work has not started yet

REASONS BEHIND A NECESSARY REVISION

Limitations on measurement **validity**

- **Knowledge of uncertainty**
  - ➢ Errors arising from physical model assumptions

ISO 9972

Assumes that airflow rate through all leaks can be approximated as flow through a single opening *
→ **Power law**

$$q_{pr} = C_L (\Delta p_r)^n$$

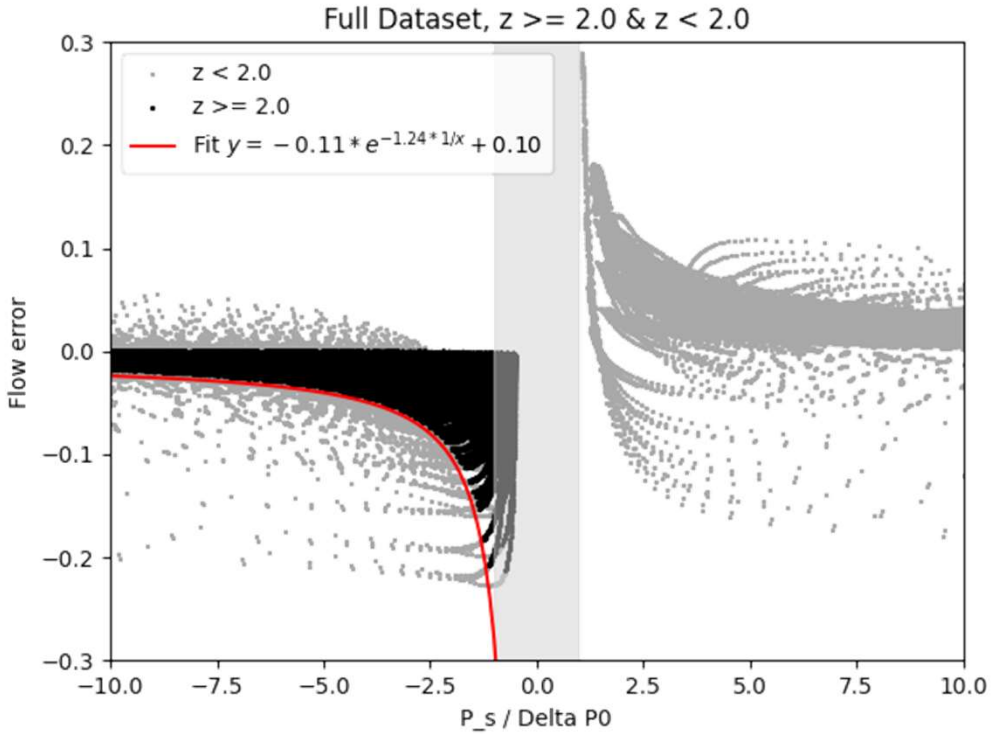
- Model error increases for high wind speed and stack effect
- More work necessary to understand and quantify errors

Work has started - more research needed

* Delmotte (2021), Carrié (2022)

REASONS BEHIND A NECESSARY REVISION

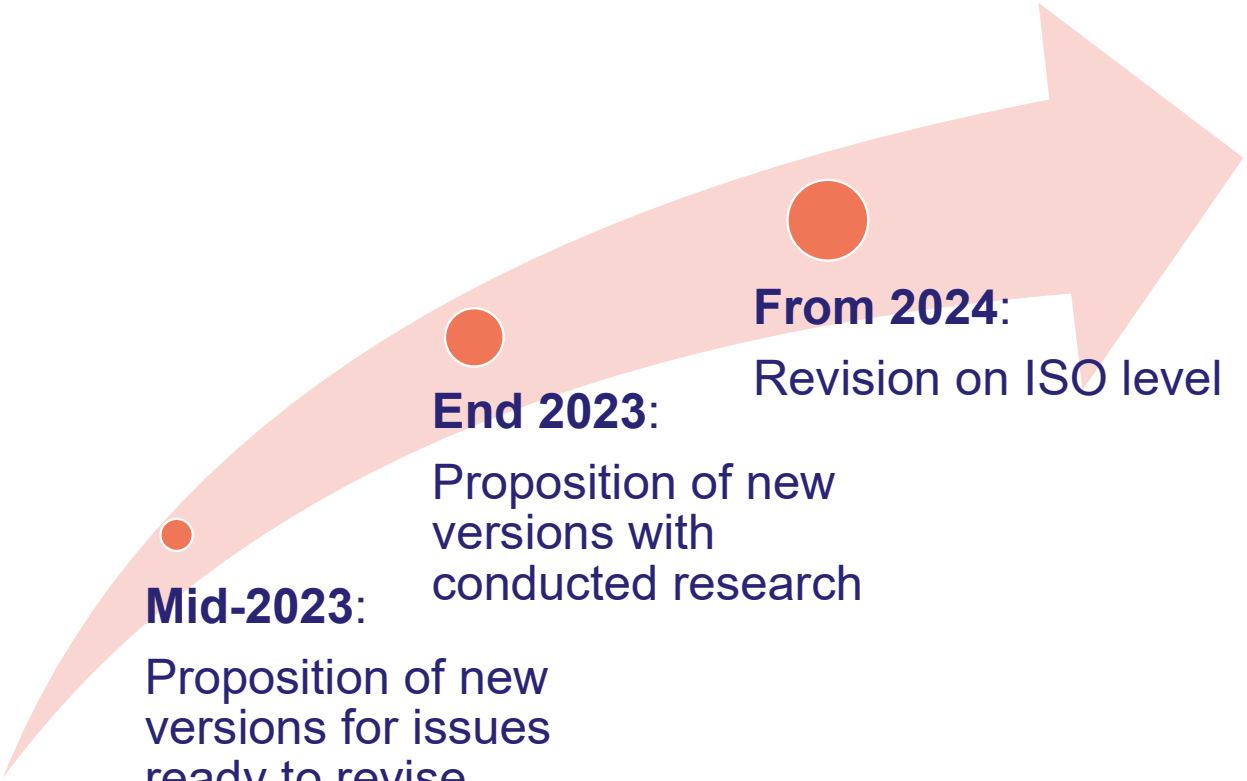
Limitations on measurement **validity**



$$q_{pr} = C_L (\Delta p_r)^n$$

Work has started - more research needed

OUTLOOK



Mid-2023:

Proposition of new versions for issues ready to revise

End 2023:

Proposition of new versions with conducted research

From 2024:

Revision on ISO level

Thank you!

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