Deviation of blower-door fans over years through the analysis of fan calibration certificates

VALÉRIE LEPRINCE – PLEIAQ
CHRISTOPHE DELMOTTE – CSTC/BBRI
ISABELLE CARÉ - CETIAT

1

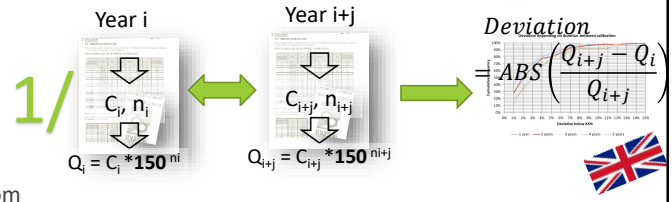
Introduction

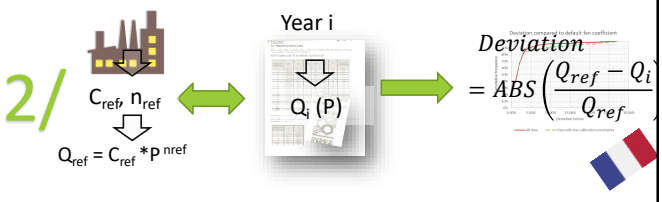
Gathering of calibration certificates from certified bodies
- mainly from UK and France.

Objective:
- Evaluate fan deviation over years

Methodologies
- 1/ Deviation of recalculated fan coefficients from the calibration points
  - systematic adjustment of fan coefficients
- 2/Deviation compared to the manufacturer coefficients.

Results on the impact of the calibration uncertainty





2

Data

4 Sources:

- Stromatech: calibration laboratory in UK
- CEREMA: testers depend on French ministry for building
- Syneole: Trade union of airtightness testers in France
- BCCA: Certification body in Belgium

1/ 12 fans up to 10 configurations per fan + multiple calibration

	1 year	2 years	3 years	4 years	5 years
Stromatech	67	55	43	32	21
Cerema	0	22	0	6	0
Syneole	11	76	10	6	0
BCCA	0	0	0	0	6
Total	78	153	53	44	27

2/ 62 calibration certificates, 325 configurations => 1007 data

Check of calibration uncertainty, reliable data:

$$U < \max\left(\frac{q_{vd} - q_{vr}}{3}; \frac{0.05\, q_{vr}}{3}; \frac{2}{3}\right)$$

3

Part 1

RECALCULATED COEFFICIENTS

4

Results part 1

Keep in mind that results include

- calibration uncertainty
- the error due to the linear regression for the calculation of coefficients.

Large impact of the pressure used to calculate the flowrate

Year i

$Q_i = C_i * 150^{n_i}$

Year i+j

$Q_{i+j} = C_{i+j} * 150^{n_{i+j}}$

$$Deviation = ABS\left(\frac{Q_{i+j} - Q_i}{Q_{i+j}}\right)$$

Deviate of more than 10%:

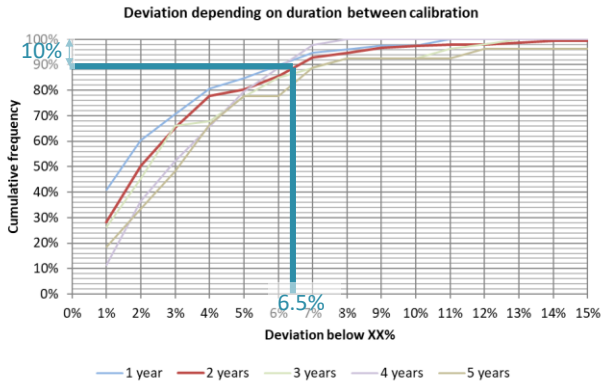
P↘ => Deviation ↗ 10% for 50 Pa

P↗ => Deviation ↘ 6.5% for 150 Pa

→ The linear regression of 3 points may induce large error

5

Part 1: Deviation according to the duration in-between calibration

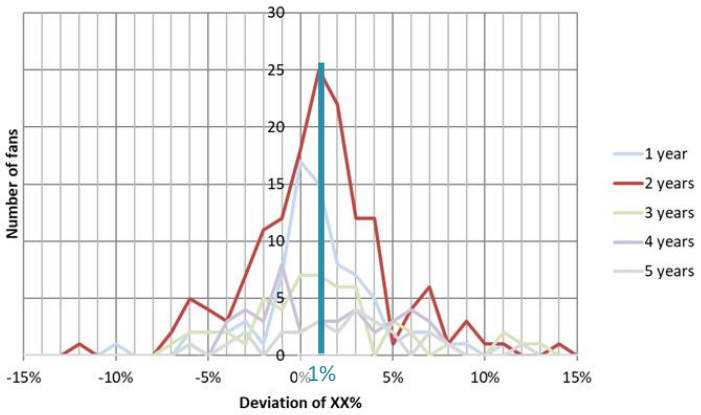


	Time between calibrations				
	1 year	**2 years**	3 years	4 years	5 years
Median	1.5%	**1.9%**	2.2%	2.5%	3.1%
Average	2.4%	**2.9%**	3.3%	3.1%	3.8%
Minimum	0.0%	**0.0%**	0.0%	0.1%	0.1%
Maximum	10.9%	**22.4%**	12.9%	7.9%	15.5%

10% of fans deviate of more than 6.5% after 2 years
5% of more than 8%.

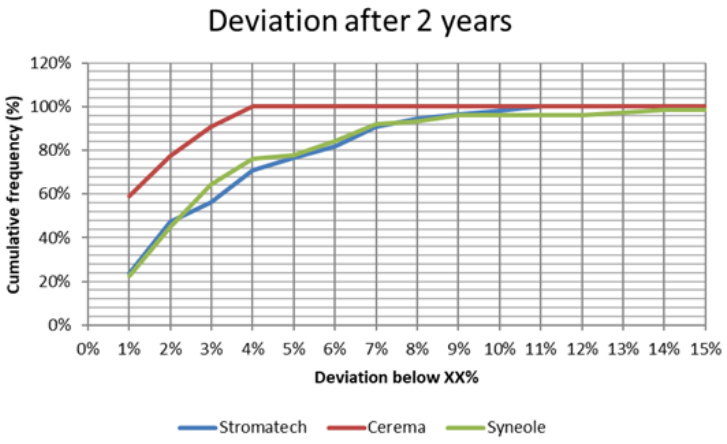
6

Part 1: Positive and negative deviation



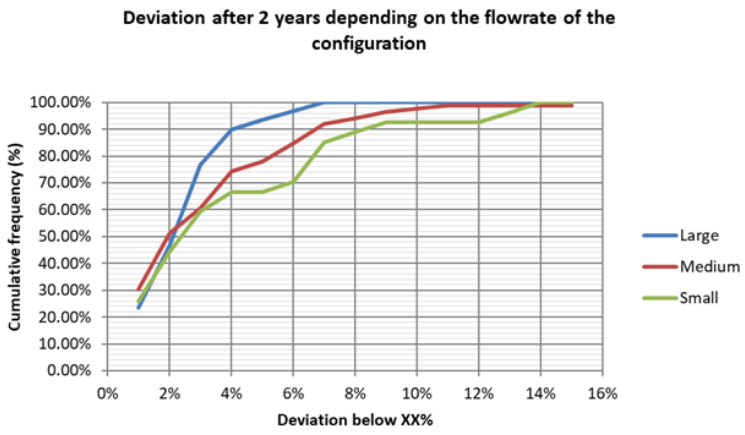
The flowrate measured by fans shows a very small increase but varies mostly randomly.

Part 1: Deviation according to the data provider



Smaller deviation of CEREMA's fan (well stored little used) than others.

Part 1: Deviation according to the flowrate of the configuration



Larger deviation for small flowrate:

10% of small flowrate configurations show a deviation of more than 8%, while for large flowrate configuration the deviation drops to 4%.

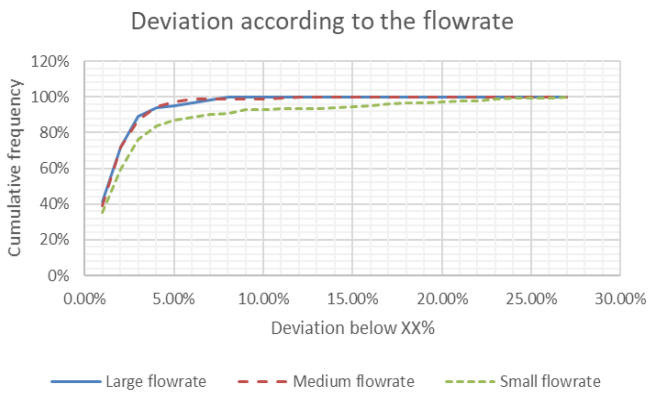
9

Part 2

COMPARISON WITH MANUFACTURER COEFFICIENTS

10

Part 2 : Deviation according to the flowrate



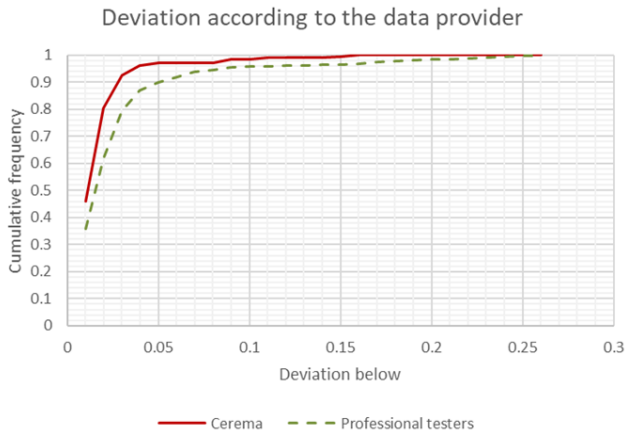
Medium and large flowrate configurations have a similar low deviation

- 4% deviate more than 5%.
- => 96% conform to the requirement

Small flowrate configuration have a higher deviation

- 10% deviate more than 7%
- Maximum Permissible Error is also higher (2 m³/h or 5% the highest).

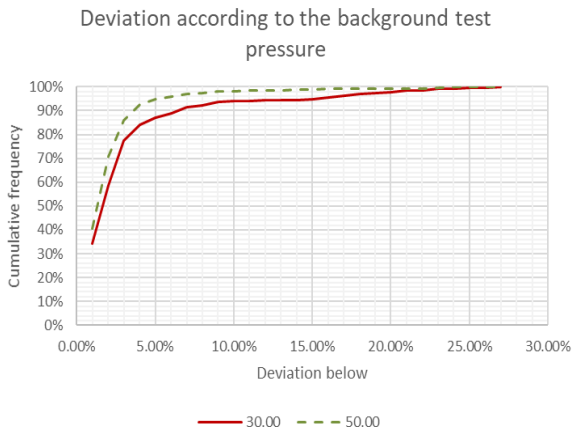
Part 2: Deviation according to the data provider



Cerema has provided 204 data out of 1007 data. Little used and well-stored (CEREMA) fans deviate less than fans used daily.

- 204 out of 1007 data provided by CEREMA
- Statistic biased by the non-representability of devices used and calibration laboratories

Part 2: Deviation according to the background test pressure



Significant difference of deviation according to the background test pressure

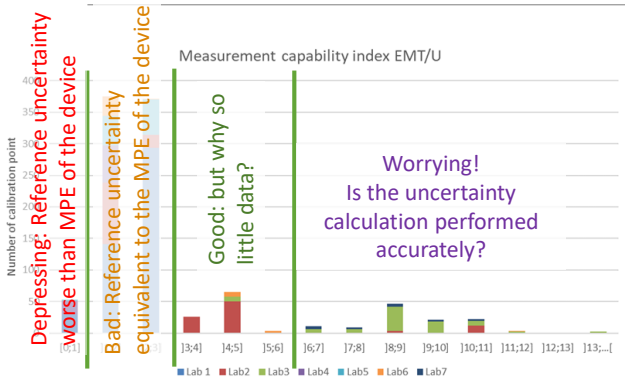
- With a 50 Pa background pressure 10% deviate more than 3.5% and 5% more than 5% which is very low
- With a 30 Pa background pressure 10% deviate more than 5.5% and 5% more than 15%.

Fan coefficients mostly suitable for 50Pa?

- when performing a multiple test point on-site, should the uncertainty due to the variation of the fan coefficient be added to the global uncertainty calculation?
- Further investigation needed

Calibration uncertainty

Calibration uncertainty



Capability index
Cm= Maximal Permissible Error / Calibration uncertainty

Cm low => low probability of the conformity of the verification

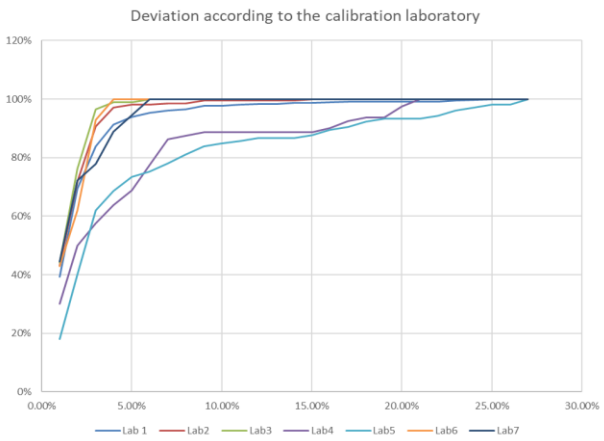
- Cm should be above 3
- If Cm<1, reference device less accurate than the measuring device under calibration

Most laboratories have a Cm between 1 and 3.

Some laboratories get value above 6

- Is the uncertainty correctly estimated?
- Does it include both uncertainties (pressure and flowrate)?

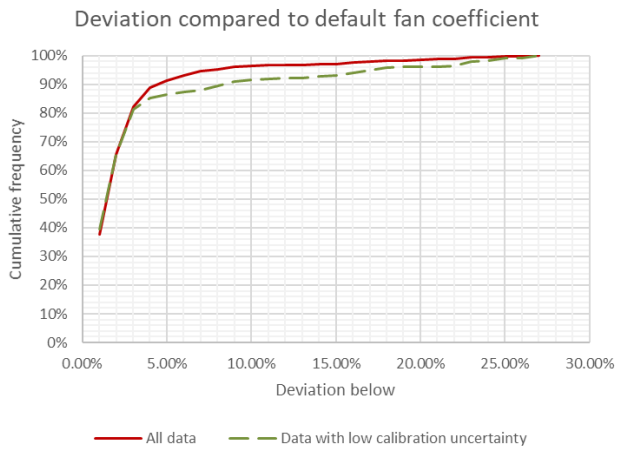
Deviation according to the calibration laboratory



Laboratories which have low measurement capability index also have a higher deviation

- The results may be biased by the fact that these laboratories may also check only certain kind of products.

Part 2: Deviation compare to default fan coefficient



All data:

- 10% deviate more than 4.5% compared to manufacturer coefficients and 5% more than 8.5%.

"Reliable data"

- 10% deviate more than 8.5% and 5% more than 13.5%.

65 data out of the 1007(6.5%) are non-compliant with French standard requirements

- maximum of 5% of deviation or 2 m^3/h

Conclusion

Deviation quite similar in 1st part (recalculation) and 2nd part (manufacturer)

	Part 1:	Part 2
10% vary more than	6.5%	4.5 %
5% vary more than	8 %	8.5 %

6.5% of the configurations do not comply with French requirements

- 10% of certificates get at least 1 non-compliant configuration

The flowrate measured by fans shows a small increase but varies mostly randomly.

Both the first and the second part of the study have shown that little-used and well-stored fans deviate less than fan used on a daily basis.

The significant difference of deviation according to the background test pressure need to be investigated

Requirements need to be made on calibration laboratory to improve the reliability of the verification

What shall we do with calibration?

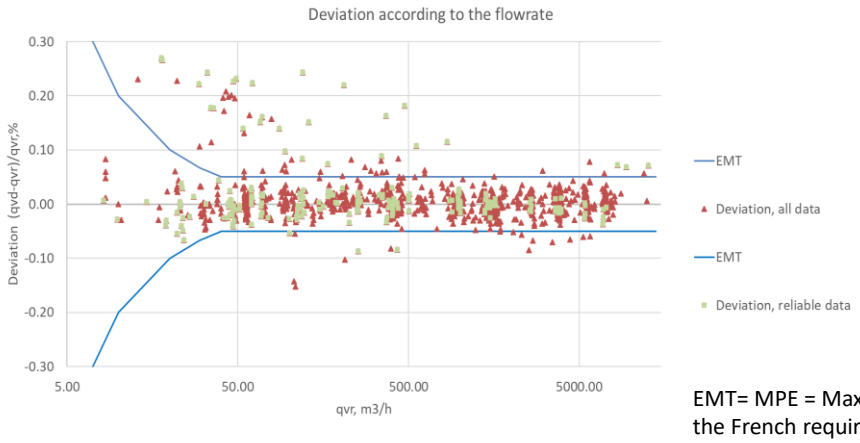
This study:
- Does not stress the need for high-frequency calibration
- Stresses the need for reliable calibration and verification (above all the first one)
  - Clear requirements on laboratory

What kind of requirements for laboratories?
- Having a measurement capability index above 3
- Provide a list of required data and the associated measurement uncertainty

Recalculation of coefficients or verification of manufacturers coefficients?
- No large difference between the 2 parts of the study (for a fan pressure of 150Pa)
- However, calculated coefficients seem less reliable than manufacturer ones
  - Huge difference between deviation of flowrate according the fan pressure
- Maybe better to
  - Verify if manufacturer coefficient remains below MPE
  - Recalculate only if needed but with more calibration points on the full range and perform an adequate regression

Data to be provided:
- Both for calibration and verification of calibration:
  - Reference flowrate
  - Uncertainty on the reference flowrate
  - Device flowrate (calculated with fan coefficients)
  - Fan pressure
  - Uncertainty of fan pressure
  - Background pressure
  - Uncertainty on background pressure
  - Measurement error
  - Uncertainty on measurement error
- In addition in case of verification of calibration
  - Maximal permissible error of the device
  - Probability of conformity
  - Measurement capability index
  - Decision rule
  - Conformity assessment
- In addition in case of adjustments:
  - calibration function, calibration diagram, calibration curve, or calibration table

Part 2: Observed deviation compared to manufacturer default coefficient



235 out of the 1007 have a measurement capability index above 3 and are considered "reliable" in the following graph.

EMT= MPE = Maximum permissible error according to the French requirements: 2m3/h or 5% the highest