



Physical Test Methods Sub-Group

Technical Report

**6th Round Robin Test for
Multi-Capillary Ventilation
Calibration Standards
(2017/2018)**

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1. Introduction and Background

The CORESTA Physical Test Methods (PTM) Sub-Group organizes a nominally annual series of Round Robin tests to establish the capability to calibrate standards used in physical test instrumentation. It is open to member laboratories that have a calibration laboratory. This report covers the results of the 6th ventilation (FV) standards test conducted between October 2017 and October 2018. This testing provides a baseline of ventilation instrument performance across the industry since this standard type is used in the pressure drop (PD) / ventilation instrumentation of each supplier. Each laboratory is also able to use the result set in internal and external audit assessments.

The four participating laboratories in the 6th ventilation standards Round Robin test are listed in Table 1.

Table 1: Participating Laboratories

Participating Laboratories	Function	Accreditation
Borgwaldt KC, Hamburg, Germany	Calibration lab & instrumentation supplier	ISO 9001 & 17025
Cerulean, Milton Keynes, UK	Calibration lab & instrumentation supplier	ISO 9001 & 17025
SODIM, Fleury-les-Aubrais, France	Calibration lab & instrumentation supplier	ISO 9001 & 17025
ZTRI of CNTC, Zhengzhou, PRC	Calibration laboratory	

The laboratory identities are coded in the results presented below; the coding is the same as used in previous reports of FV Round Robin tests.

The standards that were circulated between the four laboratories were a set of three ventilation standards at nominally:

- 20 % tip ventilation
- 50 % tip ventilation
- 80 % tip ventilation.

The three instrumentation suppliers use the same physical test piece design and test pieces that are all supplied from a single source, thus only a single set of standards is circulated.

The relevant international standard is ISO 9512:2002 “Cigarettes — Determination of ventilation — Definitions and measurement principles”. This standard is currently being revised following the work done by the PTM Sub-Group in updating CRM No. 6.

The ventilation standards are glass rods of 120 mm length by approximately 8 mm diameter that contain 10 parallel capillaries along their length. Additional holes are drilled perpendicular to the long axis of the rod at 12 mm from one end to admit the ventilation flow into one or more of the capillaries; these mimic the ventilation holes in the filter section of a ventilated cigarette. The (nominal) 20 % ventilation standard has one ventilation inlet hole, the 50 % standard has three and the 80 % standard has eight. The standards are calibrated under measured conditions of outlet flow rate (which is close to 17.5 ml/s), pressure, temperature and humidity. During calibration the ventilation flow is measured at the *inlet* side of the standard. This is corrected using the measured pressure drop across the standard to give the corresponding flow at the *outlet* side. The reported ventilation is the percentage of the outlet flow that has passed along the ventilation pathway.

Unlike for pressure drop standards, there is no compensation model for the effects of flow rate, temperature, ambient pressure or ambient humidity on the ventilation percentage, so it is reported as-found. All the participating laboratories operate under conditions that lie within the limits for measurements specified in ISO 3402:1999. During this test all the measurements were made within ranges of:

- temperature (21.1 – 22.3) °C
- humidity (59 % – 61 %) RH
- pressure (976 – 1023) hPa

2. Experimental Protocol

The protocol involved:

- acclimatisation of the standards to laboratory conditions
- testing to the method originally described in ISO 9512:2002 and updated in the latest version of CRM No. 6 (September 2016)
- making three ventilation determinations under repeatability conditions for each standard on two separate days.

After circulation of the calibration standards, the standards were re-checked by the originator laboratory.

3. 06 FV Results

3.1 Overall Results

The overall results of the participants are presented below in Table 2 and as a scatterplot of global coefficient of variation (CoV) of the laboratory means against the global mean ventilation of each test piece in Figure 1.

Since ventilation is expressed as a percentage, where ventilation values are *compared* in percentage terms this is specifically indicated as ‘relative %’ or ‘% of mean’ in the case of coefficient of variation (CoV).

Table 2: PTM 06 FV Round Robin - Overall Results

Standard	Global Mean (% ventilation)	Std Dev of Lab Means (% ventilation)	CoV of Lab Means (%)	Range (% ventilation)	Range of Value (relative %)
Nom 20 %	18.8 %	0.19 %	1.03 %	0.4 %	2.32 %
Nom 50 %	51.1 %	0.45 %	0.88 %	0.9 %	1.76 %
Nom 80 %	78.2 %	0.36 %	0.46 %	0.8 %	0.99 %

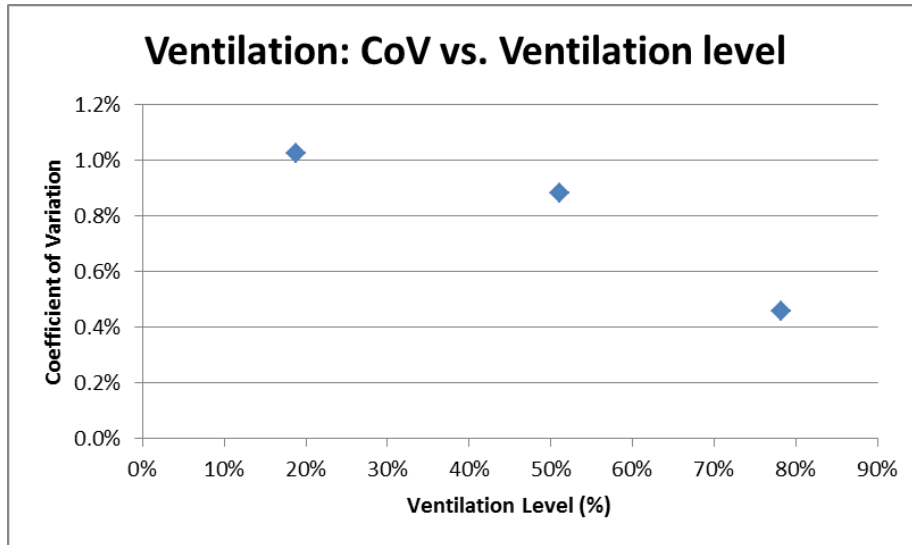


Figure 1: Ventilation CoV of Laboratory Means vs. Ventilation Level

3.2 Individual Laboratory Results

The individual mean values obtained by each laboratory for each FV calibration standard are shown in Table 3. The relative deviation of each laboratory from the global mean value was calculated and is shown in Table 4. The standard deviation and the coefficient of variation are shown by laboratory and calibration standard in Tables 5 and 6, respectively.

The relative deviation from the global mean is also presented by laboratory in Figure 2 and per calibration standard in Figure 3.

Table 3: Lab Mean by Sample (% ventilation)

Sample	LABORATORIES			
	A	B	C	D
Nom 20 %	18.67 %	18.78 %	19.10 %	18.74 %
Nom 50 %	50.64 %	51.41 %	51.54 %	50.77 %
Nom 80 %	77.96 %	78.37 %	78.53 %	77.76 %

Table 4: Deviation from Sample Mean (relative %)

Sample	LABORATORIES			
	A	B	C	D
Nom 20 %	-0.83 %	-0.22 %	1.49 %	-0.44 %
Nom 50 %	-0.88 %	0.62 %	0.89 %	-0.63 %
Nom 80 %	-0.25 %	0.28 %	0.48 %	-0.51 %

Table 5: Lab Std Deviation by Sample (% ventilation)

Sample	LABORATORIES			
	A	B	C	D
Nom 20 %	0.04 %	0.06 %	0.07 %	0.02 %
Nom 50 %	0.04 %	0.07 %	0.04 %	0.06 %
Nom 80 %	0.08 %	0.33 %	0.10 %	0.21 %

Table 6: Lab CoV by Sample (relative %)

Sample	LABORATORIES			
	A	B	C	D
Nom 20 %	0.19 %	0.29 %	0.37 %	0.09 %
Nom 50 %	0.09 %	0.14 %	0.08 %	0.12 %
Nom 80 %	0.10 %	0.42 %	0.13 %	0.27 %

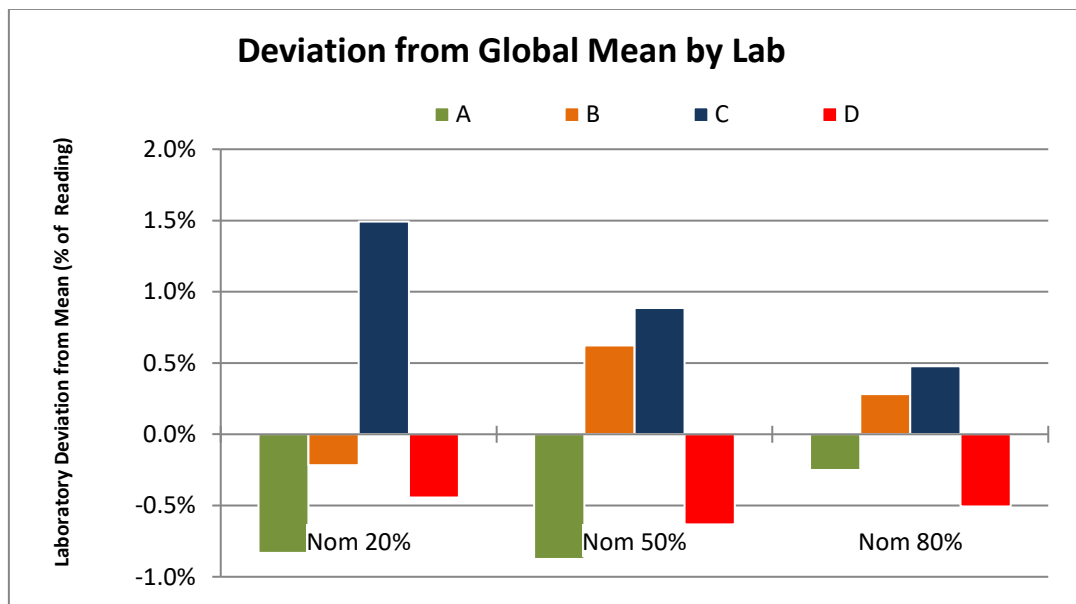


Figure 2: Deviation from Global Mean by Lab for Each Sample (relative %)

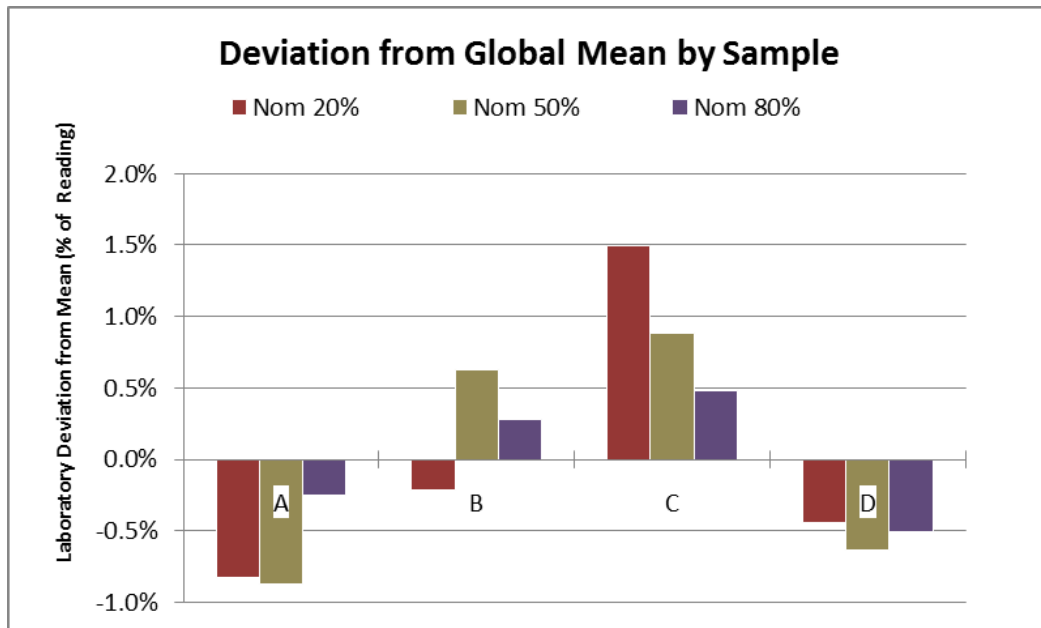


Figure 3: Deviation from Global Mean by Sample for Each Lab (relative %)

3.3 Re-check of Standards

The ventilation values of the standards were re-checked by the originating laboratory after the circulation was complete. The differences were random and all were less than $\pm 0.3\%$ absolute ventilation, thus it is concluded that there was no systematic change to the value of the standards during circulation.

3.4 Repeatability and Reproducibility Estimations

Repeatability and reproducibility (r and R) estimations were calculated according to the principles of ISO 5725:1994. The data were screened using Mandel's h and k statistics and an h outlier was detected (Lab C for the 20 % standard), but this was not removed from the analysis since it was within the historical performance of the method (see Section 3.5). With the participation of just four laboratories only r and R standard deviations are presented.

Tables 7 and 8 respectively present the summary data and r and R estimations as % ventilation and the r and R CoV as relative %.

Table 7: Repeatability and Reproducibility Estimates (% ventilation)

	Standard		
	Nom 20 %	Nom 50 %	Nom 80 %
Grand Mean for All Labs	18.82 %	51.08 %	78.15 %
Std Dev of Lab Means	0.19 %	0.43 %	0.36 %
Repeatability Std Dev (sr)	0.05 %	0.04 %	0.21 %
Reproducibility Std Dev (sR)	0.20 %	0.43 %	0.40 %

Table 8: Repeatability and Reproducibility CoV (relative %)

	Standard		
	Nom 20 %	Nom 50 %	Nom 80 %
Repeatability CoV	0.26 %	0.08 %	0.26 %
Reproducibility CoV	1.05 %	0.84 %	0.52 %

3.5 Comparison Between Results from the Previous Round Robin Tests

A direct comparison between the results of the five Round Robin tests conducted to date is presented in Figure 4 in terms of the global CoV vs ventilation level for each standard.

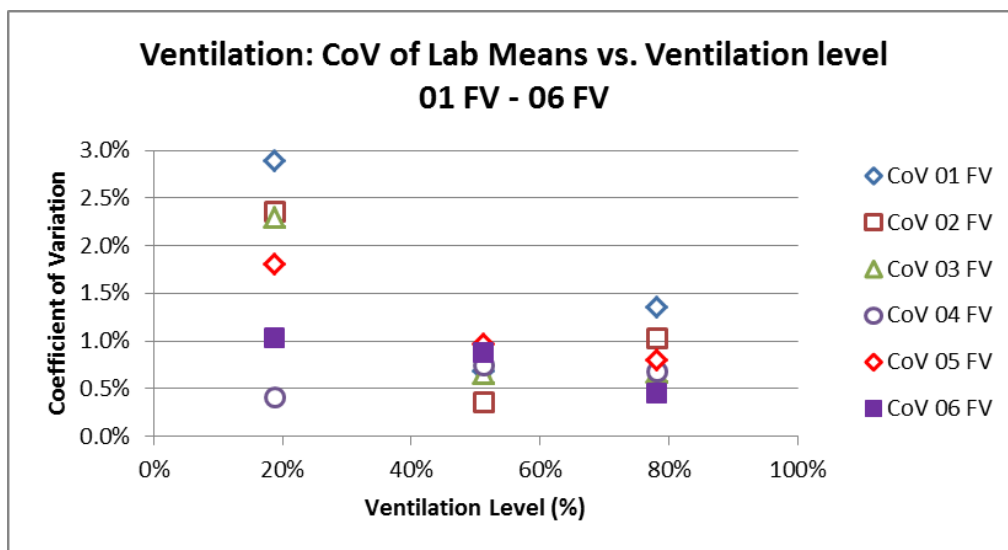


Figure 4: Ventilation – CoV of Laboratory Means vs. Ventilation Level

4. Comments on Results

The FV results of the 6th Round Robin test are broadly in line the historical performance of the method.

The inter-laboratory variation is several times greater than that for PD standards, which is of the order of 1 % for ventilation vs. 0.2 % for PD. This is likely to be accounted for by the additional complexity of ventilation measurement, which:

- is based on the ratio of two flow measurements, with the ventilation flow measurement also having to be corrected for pressure drop,
- requires careful compensation to minimise the pressure differential between the inlets to the ‘main’ and ventilation flow paths, and
- (unlike PD calibration) lacks a rigorous procedure to compensate a determination made under the ambient conditions at the time of measurement to the industry standard atmospheric conditions of 22 °C, 1013.25 hPa, 60 % RH.

The contribution to instrumental offset deriving from the calibration of ventilation standards in different laboratories is acceptable compared to the reproducibility limit of up to 3.5 % ventilation (approximately 10 % of reading) exhibited for ventilation measurements in the 11th annual PTM Collaborative Study on physical parameters of cigarettes and filters undertaken in 2018.