Physical Test Methods Sub-Group

Technical Report

4th Round Robin Test for Multi-Capillary Ventilation Calibration Standards (2015/2016)

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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 that is open to member laboratories that have a calibration laboratory to compare their capability to calibrate standards used in physical test instrumentation. This report covers the results of the 4th ventilation (FV) standards test conducted between July 2015 and September 2016. This testing provides a baseline of ventilation instrument performance across the industry since this standard type is used in the pressure drop / 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 4th 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 % filter ventilation
- 50 % filter ventilation
- 80 % filter 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.

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. 04 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.

Note that ventilation is expressed as the percentage of the total flow that has passed along the ventilation pathway. Where ventilation values are *compared* in percentage terms this is indicated as 'relative %' or ' % of mean' in the case of coefficient of variation (CoV).

Table 2: PTM 04 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 %	18.6 %	0.08 %	0.42 %	0.2 %	0.91 %
Nom 50 %	51.0 %	0.38 %	0.75 %	0.8 %	1.66 %
Nom 80 %	78.1 %	0.53 %	0.68 %	1.2 %	1.52 %

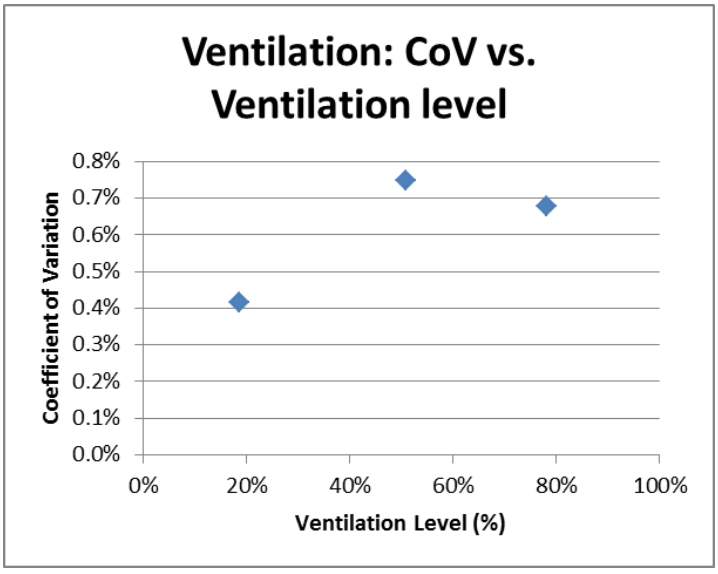

Figure 1: Ventilation CoV of Laboratory Means vs. Ventilation Level

3.2 Individual laboratory results

The individual mean values obtained by each laboratory for each FV calibration standard are shown in Table 3. The 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 per laboratory and calibration standard in Tables 5 and 6, respectively.

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

Table 3: Lab Mean by Sample (% ventilation)

	LABORATORIES			
Sample	**A**	**B**	**C**	**D**
Nom 20 %	18.60 %	18.52 %	18.69 %	18.67 %
Nom 50 %	50.75 %	51.02 %	51.52 %	50.67 %
Nom 80 %	77.82 %	78.34 %	78.72 %	77.53 %

Table 4: Deviation from Sample Mean (relative %)

	LABORATORIES			
Sample	**A**	**B**	**C**	**D**
Nom 20 %	-0.12 %	-0.54 %	0.38 %	0.28 %
Nom 50 %	-0.47 %	0.06 %	1.03 %	-0.62 %
Nom 80 %	-0.36 %	0.30 %	0.79 %	-0.73 %

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

	LABORATORIES			
Sample	**A**	**B**	**C**	**D**
Nom 20 %	0.12 %	0.05 %	0.09 %	0.01 %
Nom 50 %	0.07 %	0.03 %	0.25 %	0.03 %
Nom 80 %	0.10 %	0.04 %	0.17 %	0.11 %

Table 6: Lab CoV by Sample (relative %)

	LABORATORIES			
Sample	**A**	**B**	**C**	**D**
Nom 20 %	0.67 %	0.27 %	0.47 %	0.06 %
Nom 50 %	0.14 %	0.05 %	0.48 %	0.06 %
Nom 80 %	0.12 %	0.06 %	0.22 %	0.14 %

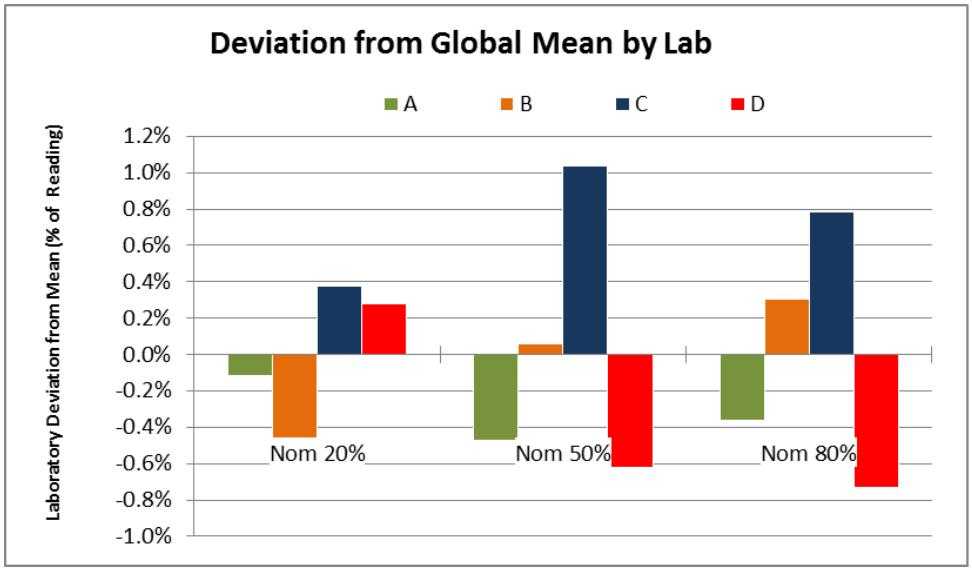

Figure 2: Deviation from Global Mean by Lab (relative %)

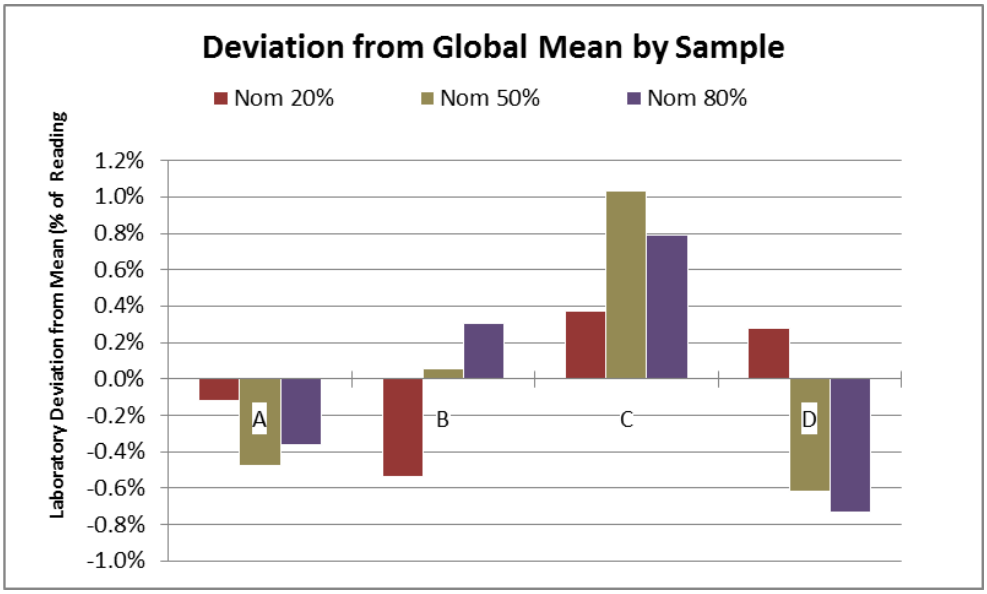

Figure 3: Deviation from Global Mean by Sample (relative %)

3.3 Re-check of standards

The ventilation values of the standards were re-checked after the circulation was complete. The differences were random and less than ±0.3 % ventilation, thus it 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. No outliers were detected according to Mandel's *h* and *k* statistics. 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	18.62 %	51.00 %	78.10 %
Std Dev of Lab Means	0.08 %	0.37 %	0.53 %
Repeatability Std Dev (sr)	0.08 %	0.13 %	0.11 %
Reproducibility Std Dev (sR)	0.11 %	0.39 %	0.54 %

Table 8: Repeatability and Reproducibility CoV (relative%)

	Standard		
	Nom 20 %	**Nom 50 %**	**Nom 80 %**
Repeatability CoV	0.43 %	0.25 %	0.15 %
Reproducibility CoV	0.57 %	0.76 %	0.69 %

3.5 Comparison between results from the previous round robin tests

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

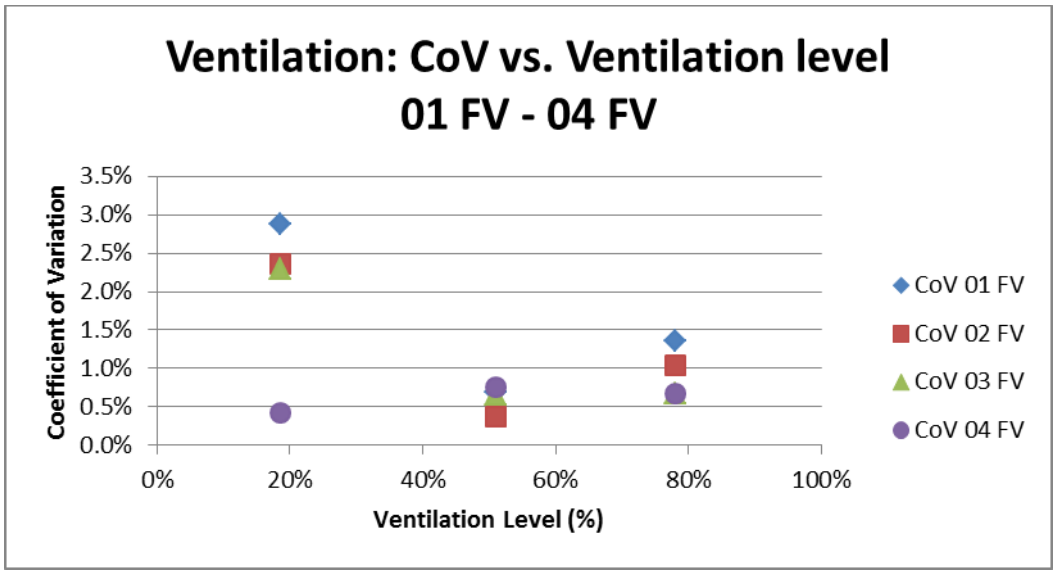

Figure 4: Ventilation – CoV of Laboratory Means vs. Ventilation Level

4. Comments on Results

The FV results of the 4th round robin test present one significant difference to the previous tests in that the CoV of the laboratory means for all three standards are <1 %, in contrast to the previous results where the low ventilation standard exhibited a CoV of >2 %, which was far higher than for the medium and high ventilation levels.

As with the 3rd test, laboratory C presented determinations that are generally higher than the other laboratories, albeit now within an overall range of <2 % of value for each standard. This difference now looks to be worthy of investigation and follow-up in future round robin tests, especially if the apparently improved inter-laboratory precision is maintained.

The inter-laboratory variation of up to 0.8 % remains several times greater than that for PD standards. This is likely to be accounted for by the additional complexity of ventilation measurement, which:

a. is based on the ratio of two flows, with the ventilation flow measurement also having to be corrected for pressure drop,
b. requires careful compensation to minimise the pressure differential between the inlets to the 'main' and ventilation flow paths, and
c. has not been studied to the same extent as PD calibration and therefore lacks a rigorous procedure to compensate a determination made at ambient conditions to the industry standard atmosphere 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 approaching 8 % exhibited for ventilation measurements in the PTM Proficiency Tests (2007 – 2011).