Physical Test Methods Sub-Group

Technical Report

16ᵗʰ Collaborative Study (2023) on Physical Parameters of Cigarettes and Filter Rods

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1. INTRODUCTION

1.1 Purpose and Scope

The Physical Test Methods (PTM) Sub-Group of CORESTA carries out a normally annual inter-laboratory study on physical parameters of cigarettes and filter rods. This collaborative study allows to monitor the repeatability and reproducibility of the test methods used and further allows the laboratories to assess their performance when measuring certain physical parameters of cigarettes and filter rods, such as weight, diameter, pressure drop, draw resistance and ventilation. This collaborative study contributes to the PTM Sub-Group's objectives which require to organise, conduct and report on routine inter-laboratory studies in order to maintain CORESTA Recommended Methods, to assess inter-laboratory consistency and to enable continual improvement of participating laboratories.

In addition to monitoring the performance of the test methods, the results from this study allow each laboratory to evaluate its proficiency in comparison to other laboratories, to derive actions for improvement and to fulfil accreditation requirements.

For the determination of repeatability and reproducibility this study followed ISO 5725-2, the laboratory performance was assessed in accordance with ISO 13528. This study conforms to the principles described in ISO 17043:2010 *Conformity assessment — General requirements for proficiency testing*; however, CORESTA is not an accredited proficiency testing provider and does not adhere to certain aspects of ISO 17043.

All results will be presented in anonymized form.

1.2 Study Protocol

The test protocol used for this collaborative study is given in Appendix A and will be briefly summarized below.

The protocol contained information on the products to be tested, the preparation of samples, set-up and calibration of instruments and the procedure for carrying out the measurements. The study participants were required to provide data to identify their laboratory, data on the instruments and calibration methods used and all measurement results obtained. The data were collected in an Excel-sheet and sent to the Study Coordination Group for further processing and evaluation.

Once received, the data set was inspected for obvious inconsistencies, for example, simple typographical errors, wrong units of measurement, reporting weight in g instead of mg, reporting circumference instead of diameter or reporting total ventilation instead of filter ventilation. In cooperation with the respective laboratory such inconsistencies were corrected as far as possible and the data sets of all laboratories were anonymized, compiled to a single large data set and then used for statistical analysis.

The distribution of sample materials, the protocol and the data collection sheet started in July 2023 and laboratories were asked to report the results until end of September 2023. This deadline was later extended until end of October 2023 upon request by two laboratories which experienced issues with sample shipment.

Compared to previous inter-laboratory studies on physical parameters carried out until and including 2016 the protocol was modified in several aspects for the 10th Collaborative Study on Physical Parameters in 2017. This modified protocol also applied to the present collaborative study.

1.3 Products and Measurements

For the collaborative study cigarettes and filter rods with the main properties according to Table 1 were used. The values in Table 1 do not necessarily represent actual measured values but just serve as an indication of the general characteristics of the product. In Table 1 the pressure drop (PD) is given as the fully encapsulated pressure drop for filter rods and the open draw resistance of cigarettes.

The cigarettes were manufactured by Japan Tobacco (C1, C2) and Philip Morris Products SA (C3, C4, C5) and the filter rods were provided by Cerdia GmbH (F1, F2) and Philip Morris Products SA (F3, F4, F5). The products were not pre-selected with respect to any parameter such as weight or pressure drop and are therefore subject to typical product variability.

Except for the 10th Collaborative Study (2017), for which only three cigarette samples and five filter rod samples were available, this study was carried out with the normally used set of five cigarette samples and five filter rod samples. Even though the cigarettes and filter rods change every three to five years, every attempt is made to provide samples that have similar properties as the samples used in past studies. In particular, the samples used in this 16th Collaborative Study have also been used in the 14th and 15th collaborative studies.

Table 1 – Characteristics of the tested products

	ID	Product Description	Length mm	Diameter mm	PD mmWG	
Filter Rods	F1	Cellulose Acetate Filter Rod	126	5,4	500	
	F2	Cellulose Acetate Filter Rod	120	7,4	800	
	F3	Cellulose Acetate Filter Rod	126	7,7	280	
	F4	Cellulose Acetate Filter Rod	126	7,6	410	
	F5	Cellulose Acetate Filter Rod	126	7,7	480	

	ID	Product Description	Length mm	Diameter mm	Open Draw Res. mmWG	Filter Ventilation %
Cigarettes	C1	Pianissimo Precia Dia's Menthol	98	5,4	170	54
	C2	Pianissimo Aria Menthol	98	7,1	90	83
	C3	Parliament Aqua Blue AC 100	98	7,8	125	40
	C4	Marlboro Flavor Mix	83	7,8	82	34
	C5	Marlboro Vibe Beyond Menthol KS	83	7,8	92	55

For each product a single batch was produced and one randomly selected sample set was prepared for each laboratory and each replicate measurement. Each sample set consisted of 10 filter rods or cigarettes and as there were five replicate measurements each laboratory received at least 5×10 test pieces per product.

The laboratories were asked to determine the following physical parameters.

Filter Rods

- Weight (mg)
- Diameter (mm)
- Fully Encapsulated Pressure Drop (PD) (mmWG)

<u>Cigarettes</u>

- Weight (mg)
- Diameter (mm)
- Open Draw Resistance (mmWG)
- Closed Draw Resistance (mmWG)
- Degree of Filter Ventilation (FV) (%)

A replicate determination, consisting of the average of 10 individual measurements, had to be carried out for all products and all physical parameters on each of five different days of testing, using a new sample set on each day of measurement.

Thus, a laboratory completing the full set of measurements had to conduct 5 (filter rods) × 5 (days) × 3 (parameters) × 10 (individual measurements) = 750 measurements on filter rods and 5 (cigarettes) × 5 (days) × 5 (parameters) × 10 (individual measurements) = 1250 measurements on cigarettes. In total these are 2000 individual measurements per laboratory.

For the measurements the laboratories had to follow the respective ISO standards, such as ISO 6565 for the determination of pressure drop, open and closed draw resistance, ISO 9512 for the determination of the degree of filter ventilation and ISO 2971 for diameter. For the determination of weight neither ISO standards nor CORESTA Recommended Methods exist, but CORESTA Guide No. 6 had to be considered.

1.4 Study Participants

In total more than 40 sample sets were distributed to 28 laboratories and within the extended deadline 28 result sets were received from the 24 laboratories listed in Table 2. A member of the Study Coordination group assigned a code to each result set received in time, thus the order of laboratories in Table 2 does not match the order of the laboratories in other tables. Upon their request some laboratories received only cigarettes or only filters. Also, not all laboratories were able to measure all types of products, for example, some measured only cigarettes or were not able to measure filter rods with small diameters.

Minor deviations from the protocol were noted, for example, related to conditioning or calibration, but these data sets were accepted. Lab 6 reported that a pack of cigarettes C4 was damaged, but the lab was still able to make measurements and reported results, which fit well with the other laboratories. Lab 24 appeared to have calculated the weight of filters from the total weight of an aggregate of several filters instead of averaging individual measurements. This was also considered to be acceptable.

Table 2 – List of participants

Participant Name	Sets	Country
ASL Analytic Service Laboratory	1	Germany
British American Tobacco Bangladesh	1	Bangladesh
British American Tobacco Brazil	1	Brazil
British American Tobacco Indonesia	1	Indonesia
British American Tobacco Poland	2	Poland
British American Tobacco Romania	1	Romania
Cerulean	1	United Kingdom

Participant Name	Sets	Country
Godfrey Phillips India Ltd.	1	India
Imperial Tobacco Polska	2	Poland
ITC Ltd.	1	India
Japan Tobacco Inc.	2	Japan
Japan Tobacco International	1	Germany
Körber Technologies Instruments	1	France
KT International	1	Bulgaria
Labstat	1	Canada
Montepaz	1	Uruguay
Papierfabrik Wattens GmbH & Co KG	1	Austria
Philip Morris Czech Republic	1	Czech Republic
Philip Morris Mexico	1	Mexico
Philip Morris Poland	1	Poland
Philip Morris Turkey	2	Turkey
PT Hanjaya Mandala Sampoerna	1	Indonesia
R.J. Reynolds Tobacco Company	1	USA
SWM Le Mans	1	France

2. STATISTICAL EVALUATION

2.1 Raw Data Treatment

The 28 data sets were first screened for inconsistencies and after any corrections, if needed, the data were prepared for statistical analysis. As an initial step outlier testing by Grubbs' test on the ten individual measurements reported by each lab per parameter, product and day of measurement was carried out. Individual values that qualified as outliers were removed from further calculations, i.e. the determination of global mean values and standard deviations as well as the determination of z-scores. The mean values of the replicates as originally submitted, are shown in Appendix B.1 for filter rods and in Appendices B.2a and B.2b for cigarettes. The standard deviations of the replicates, as originally submitted, are shown in Appendix C.1 for filter rods and in Appendices C.2a and C.2b for cigarettes.

Tables 3a and 3b, for filters and cigarettes, respectively, show the values that were eliminated in this first round of outlier testing. The values are identified by a code of the form LxDy-z, wherein x is the number of the laboratory as used in all tables and diagrams, y is the day of measurement and z is the number of the individual value.

Table 3a – Outliers found by Grubbs' test on individual values for filters

ID	Weight	Diameter	Pressure Drop
F1	L1D1-7 L6D1-9 L6D5-2 L17D1-1 L17D3-8	L1D3-9 L2D3-8 L15D3-7 L28D4-6	L6D5-7 L17D1-1
F2	None	None	L10D4-2
F3	L2D4-10 L10D4-7	None	L20D3-2
F4	L17D4-2 L25D3-7	L20D2-2	L13D3-1
F5	None	L2D3-1 L14D4-6	None

Table 3b – Outliers found by Grubbs' test on individual values for cigarettes

ID	Weight	Diameter	Open Draw Resistance	Closed Draw Resistance	Filter Ventilation
C1	None	L1D1-10 L18D2-10 L25D5-10	None	None	L28D1-10
C2	L13D5-9 L19D2-7	L3D1-7	None	L10D5-7	L8D5-2 L18D2-1 L24D1-3 L24D3-1
C3	L12D2-8 L27D2-1	L19D5-8	L7D2-8 L22D2-3 L22D4-9	L22D2-3	L4D1-4 L5D4-7 L12D3-3 L21D3-1 L22D2-3 L22D4-9
C4	L1D4-9	L4D4-1	L1D4-1 L19D5-9	L27D3-6	L1D4-1 L7D5-3 L23D4-8
C5	L22D1-7 L28D4-6	L18D1-1	L2D4-8	L3D5-7 L7D2-10	L1D5-7 L15D2-10

After this first round of outlier elimination, the average over the nominally ten values obtained on each day, per product, per laboratory and parameter was calculated to obtain the five replicate values for further calculations. The five replicate values, after this outlier elimination, are shown in Appendix B.3 for filter rods and in Appendices B.4a and B.4b for cigarettes. The standard deviations of the replicates, after this outlier elimination, are shown in Appendix C.3 for filter rods and in Appendices C.4a and C.4b for cigarettes. Mean values (MV) over all laboratories and replicates, the average within-laboratory standard deviation (SDw), that is, the standard deviation of a single replicate averaged over all laboratories and the between-laboratory standard deviation (SDb), that is, the standard deviation of the mean values obtained by all laboratories, are provided for filter rods in Table 4 and for cigarettes in Tables 5a and 5b. The number (N) of data sets is also given.

Table 4 – Summary data for filter rods over all labs and days, outliers included

ID	Weight				Diameter				Pressure Drop			
	MV	SDb	SDw	N	MV	SDb	SDw	N	MV	SDb	SDw	N
	mg	mg	mg		mm	mm	mm		mmWG	mmWG	mmWG	
F1	429,256	2,03	3,15	20	5,366	0,007	0,005	19	514,0	12,27	6,15	18
F2	922,759	2,40	1,66	20	7,328	0,012	0,006	19	816,1	19,48	5,52	18
F3	806,473	2,72	3,07	22	7,653	0,008	0,005	21	278,3	5,57	2,85	20
F4	884,398	2,45	2,14	22	7,644	0,008	0,004	21	403,3	20,74	2,83	20
F5	766,520	1,72	2,86	22	7,669	0,007	0,003	21	459,8	12,25	3,67	20

Table 5a – Summary data for cigarettes over all labs and days, outliers included

ID	Weight				Diameter				Open Draw Resistance			
	MV	SDb	SDw	N	MV	SDb	SDw	N	MV	SDb	SDw	N
	mg	mg	mg		mm	mm	mm		mmWG	mmWG	mmWG	
C1	538,162	3,74	3,69	24	5,402	0,021	0,014	23	167,05	3,11	2,06	23
C2	770,759	5,26	5,24	24	7,157	0,013	0,006	23	89,28	1,58	1,42	24
C3	1063,794	8,36	7,56	24	7,828	0,018	0,008	23	125,89	2,44	1,77	24
C4	778,051	5,61	7,31	24	7,785	0,013	0,008	23	82,15	1,52	1,24	24
C5	838,991	6,25	7,41	24	7,823	0,010	0,008	23	92,53	1,22	1,24	24

Table 5b – Summary data for cigarettes over all labs and days, outliers included

	Closed Draw Resistance				Filter Ventilation			
	MV	SDb	SDw	N	MV	SDb	SDw	N
	mmWG	mmWG	mmWG		%	%	%	
C1	343,6	9,84	7,15	20	55,85	1,08	0,59	23
C2	250,1	4,97	4,17	21	82,97	0,67	0,49	24
C3	180,4	3,49	2,49	21	38,77	0,98	0,57	24
C4	110,4	2,10	1,92	21	33,98	1,20	0,58	24
C5	155,2	2,11	2,26	21	53,50	1,12	0,50	24

2.2 Outlier Analysis and Removal

Repeatability and reproducibility data were determined following ISO 5725-2, whereby outlier testing according to Cochran's test and Grubbs' test was used. First, for each laboratory the maximum and the minimum of the five replicates was checked for being an outlier according to Grubbs' test ("within-laboratory Grubbs' test"). Any outliers that were detected were removed from the data set, but the other replicates remained for further calculations.

Second, the standard deviations of each laboratory's results were compared to the total standard deviation by Cochran's test to detect any laboratories that had an unusually high standard deviation. If an outlier was detected this data set was removed from further analysis.

In a third step Grubbs' test ("between-laboratory Grubbs' test") was used to check if the mean value of a laboratory was exceptionally high or low compared to the other laboratories. All outliers were removed. These two outlier tests are generally repeated as often as is necessary until no further outliers appear. In the present case one iteration was sufficient and the number of outliers was low so that there was no danger of removing too many data sets.

After elimination of outliers, global statistics, in particular mean values and standard deviations, were calculated and the repeatability and reproducibility statistics were determined.

In order to evaluate laboratory proficiency in the form of z-scores, as described in ISO 13528:2015, a 'true' value and standard deviation need to be assigned to each product and each physical parameter, which form the basis for the calculation of z-scores. In contrast to other types of studies, where the 'true' value is known or can be easily assigned, such values are not available in this study. Consequently, the 'true' mean value and standard deviation were determined as the global average and standard deviation obtained by the above outlier elimination procedure used for the determination of repeatability and reproducibility. The z-scores were then calculated for all laboratories, which reported data, based on their originally reported data set, after elimination of outliers in the individual ten-value data sets, irrespective of whether their results were excluded in the calculation of the global mean value and standard deviation.

The laboratories which were excluded are listed for each product and parameter for the filter rods in Table 6a and for cigarettes in Table 6b. The outliers are coded in the following manner. LxxC means that laboratory xx was excluded by Cochran's test (C). Likewise LxxGWL means that the lowest value of laboratory xx qualified as outlier by the within-laboratory Grubbs' test (GW), and analogously LxxGWH for the highest values. In a similar manner the outliers detected by the between-laboratory Grubbs' (GB) test are coded as LxxGBL and LxxGBH, respectively.

Outliers were found for laboratories 2, 3, 4, 7, 11, 17, 19, 20, 24, 25 and 28 and no outliers were contained in the data sets of laboratories 1, 5, 6, 8, 9, 10, 12, 13, 14, 15, 16, 18, 21, 22, 23, 26 and 27.

For diameter measurements it has to be noted that the within-laboratory variability is very low and therefore a single value being higher or lower by 0,01 mm might already be sufficient to qualify this value as an outlier. Thus, outliers in diameter might not necessarily be an immediate reason for concern.

Table 6a – Laboratories which were excluded as outliers by Cochran's test (C) or Grubbs' test based on within-laboratory data (GW) and between-laboratory data (GB) for filters

ID	Weight	Diameter	Pressure Drop
F1	None	L24GWH L2C	L7GBL
F2	None	None	L7GBL
F3	L25GBH	None	L7GBL
F4	None	L20C	L7GBL
F5	None	L25GWL	L7GBL

Table 6b – Laboratories which were excluded as outliers by Cochran's test (C) or Grubbs' test based on within-laboratory data (GW) and between-laboratory data (GB) for cigarettes

ID	Weight	Diameter	Open Draw Resistance	Closed Draw Resistance	Filter Ventilation
C1	L28GWL	None	None	L19C	None
C2	None	None	None	None	None
C3	None	L17GBL L19GBL	None	L11GWH L17C	None
C4	None	None	None	None	L20GBH
C5	L3GWH L4C L28GWL	None	None	None	L20GBH

The remaining data sets were then used to calculate a global mean and standard deviation.

2.3 Robust Mean Values and Standard Deviations

After the removal of outliers, robust mean values and between-laboratory standard deviations were calculated using ISO 5725-2 sections 7.4.4 and 7.4.5, respectively. The results for the filter rods are given in Table 7 and for cigarettes in Tables 8a and 8b. In all tables the number of laboratories is denoted by N.

Table 7 – Robust mean values (MV), between-laboratory standard deviations (SDb) and within-laboratory standard deviation (SDw) for filter rods

	Weight				Diameter				Pressure Drop			
ID	MV	SDb	SDw	N	MV	SDb	SDw	N	MV	SDb	SDw	N
	mg	mg	mg		mm	mm	Mm		mmWG	mmWG	mmWG	
F1	429,256	2,03	3,15	20	5,365	0,007	0,004	18	516,5	6,02	6,05	17
F2	922,759	2,40	1,66	20	7,328	0,012	0,006	19	820,1	9,46	5,31	17
F3	806,067	1,99	3,12	21	7,653	0,008	0,005	21	279,4	2,85	2,69	19
F4	884,398	2,45	2,14	22	7,643	0,008	0,004	20	407,8	3,79	2,87	19
F5	766,520	1,72	2,86	22	7,669	0,007	0,003	21	462,4	4,70	3,70	19

Table 8a – Robust mean values (MV), between-laboratory standard deviations (SDb) and within-laboratory standard deviation (SDw) for cigarettes

	Weight				Diameter				Open Draw Resistance			
ID	MV	SDb	SDw	N	MV	SDb	SDw	N	MV	SDb	Sdw	N
	mg	mg	mg		mm	mm	mm		mmWG	mmWG	mmWG	
C1	538,218	3,76	3,64	24	5,402	0,021	0,014	23	167,05	3,11	2,06	23
C2	770,759	5,26	5,24	24	7,157	0,013	0,006	23	89,28	1,58	1,42	24
C3	1063,794	8,36	7,56	24	7,832	0,011	0,007	21	125,89	2,44	1,77	24
C4	778,051	5,61	7,31	24	7,785	0,013	0,008	23	82,15	1,52	1,24	24
C5	839,026	6,30	6,09	23	7,823	0,010	0,008	23	92,53	1,22	1,24	24

Table 8b – Robust mean values (MV), between-laboratory standard deviations (SDb) and within-laboratory standard deviation (SDw) for cigarettes

	Closed Draw Resistance				Filter Ventilation			
	MV	SDb	SDw	N	MV	SDb	SDw	N
	mmWG	mmWG	mmWG		%	%	%	
C1	343,2	9,98	6,42	19	55,85	1,08	0,59	23
C2	250,1	4,97	4,17	21	82,97	0,67	0,49	24
C3	180,8	2,93	2,19	20	38,77	0,98	0,57	24
C4	110,4	2,10	1,92	21	33,78	0,72	0,55	23
C5	155,2	2,11	2,26	21	53,34	0,79	0,46	23

2.4   Evaluation of Repeatability and Reproducibility

Based on the robust mean value and the between-laboratory and within-laboratory standard deviations, repeatability and reproducibility statistics were calculated according to ISO 5725-2. The results are given first for filter rods in Tables 9a and 9b and then for cigarettes in Tables 10a to 10c. The tables show the standard deviation (SD), the limit and the coefficient of variation (CoV) relative to the global mean value for repeatability and reproducibility.

Table 9a – Repeatability and reproducibility statistics for filter rod weight and diameter

	Weight						Diameter					
	Repeatability			Reproducibility			Repeatability			Reproducibility		
ID	SD	Limit	CoV	SD	Limit	CoV	SD	Limit	CoV	SD	Limit	CoV
	mg	mg	%	mg	mg	%	mm	mm	%	mm	mm	%
F1	3,15	8,92	0,73	3,48	9,83	0,81	0,004	0,011	0,071	0,007	0,021	0,139
F2	1,66	4,69	0,18	2,82	7,99	0,31	0,006	0,017	0,082	0,013	0,036	0,173
F3	3,12	8,84	0,39	3,43	9,71	0,43	0,005	0,013	0,061	0,009	0,025	0,117
F4	2,14	6,06	0,24	3,11	8,79	0,35	0,004	0,011	0,051	0,008	0,024	0,110
F5	2,86	8,10	0,37	3,08	8,72	0,40	0,003	0,009	0,043	0,008	0,021	0,098

Table 9b – Repeatability and reproducibility statistics for filter rod pressure drop

	Pressure Drop					
	Repeatability			Reproducibility		
ID	SD	Limit	CoV	SD	Limit	CoV
	mmWG	mmWG	%	mmWG	mmWG	%
F1	6,05	17,11	1,17	8,09	22,89	1,57
F2	5,31	15,02	0,65	10,59	29,94	1,29
F3	2,69	7,62	0,96	3,73	10,55	1,33
F4	2,87	8,11	0,70	4,57	12,93	1,12
F5	3,70	10,46	0,80	5,75	16,25	1,24

Table 10a – Repeatability and reproducibility statistics for cigarette weight and diameter

ID	Weight						Diameter					
	Repeatability			Reproducibility			Repeatability			Reproducibility		
	SD	Limit	CoV	SD	Limit	CoV	SD	Limit	CoV	SD	Limit	CoV
	mg	mg	%	mg	mg	%	mm	mm	%	mm	mm	%
C1	3,64	10,28	0,68	4,97	14,05	0,92	0,014	0,041	0,268	0,025	0,070	0,457
C2	5,24	14,81	0,68	7,04	19,92	0,91	0,006	0,017	0,082	0,014	0,041	0,201
C3	7,56	21,37	0,71	10,75	30,40	1,01	0,007	0,019	0,086	0,013	0,036	0,163
C4	7,31	20,68	0,94	8,62	24,37	1,11	0,008	0,022	0,101	0,015	0,041	0,188
C5	6,09	17,23	0,73	8,33	23,56	0,99	0,008	0,024	0,108	0,013	0,036	0,164

Table 10b – Repeatability and reproducibility statistics for cigarette draw resistance

ID	Open Draw Resistance						Closed Draw Resistance					
	Repeatability			Reproducibility			Repeatability			Reproducibility		
	SD	Limit	CoV	SD	Limit	CoV	SD	Limit	CoV	SD	Limit	CoV
	mmWG		%	mmWG		%	mmWG		%	mmWG		%
C1	2,06	5,84	1,24	3,62	10,24	2,17	6,42	18,17	1,87	11,52	32,58	3,36
C2	1,42	4,03	1,59	2,03	5,74	2,27	4,17	11,80	1,67	6,21	17,57	2,48
C3	1,77	5,00	1,40	2,91	8,22	2,31	2,19	6,19	1,21	3,52	9,97	1,95
C4	1,24	3,51	1,51	1,88	5,33	2,29	1,92	5,42	1,74	2,71	7,66	2,45
C5	1,24	3,51	1,34	1,65	4,66	1,78	2,26	6,39	1,46	2,92	8,27	1,88

Table 10c – Repeatability and reproducibility statistics for the degree of filter ventilation

ID	Degree of Filter Ventilation					
	Repeatability			Reproducibility		
	SD	Limit	CoV	SD	Limit	CoV
	%	%	%	%	%	%
C1	0,59	1,67	1,06	1,21	3,41	2,16
C2	0,49	1,38	0,59	0,80	2,26	0,96
C3	0,57	1,62	1,48	1,10	3,12	2,85
C4	0,55	1,55	1,62	0,87	2,46	2,58
C5	0,46	1,31	0,87	0,89	2,53	1,68

2.5 Evaluation of Laboratory Performance (z-Scores)

Based on the robust mean value and the between-laboratory standard deviation the z-scores were calculated as described in ISO 13528:2015. For the calculation of z-scores the data sets were used as reported after elimination of outliers in the individual ten-value data sets by Grubbs' test. The results are given first for filter rods in Table 11 and then for cigarettes in Tables 12a and 12b. In the tables, fields marked in orange are z-scores with $2<|z|<3$ and red fields are those with $|z|\geq3$.

Table 11 – Z-Scores for all laboratories on the measurement of weight, diameter and pressure drop of filter rods

ID	Weight					Diameter					Pressure Drop				
	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
1	0,60	1,25	2,76	1,79	1,08	1,28	1,59	1,00	1,40	0,44					
2	-2,53	-0,09	1,78	0,13	-1,43	0,43	0,90	0,55	0,34	0,02					
3															
4															
5															
6	-0,22	-1,26	-0,41	-0,58	-0,62	-0,63	-0,79	-0,49	-0,54	0,03	-0,94	-0,82	-1,39	-1,20	-2,13
7	0,47	0,12	0,26	-0,79	-0,38						-7,61	-7,70	-7,59	-24,10	-10,82
8															
9	0,97	0,07	-0,59	0,66	-0,77	-1,11	-1,76	-2,42	-1,81	-2,22	0,64	1,75	-0,36	0,45	-0,08
10	0,03	0,30	1,03	1,29	1,51	0,40	2,16	1,32	0,29	1,12	1,09	-0,28	0,22	0,58	0,20
11	0,76	0,29	-0,03	0,36	0,73	0,03	0,32	0,04	0,23	0,31	1,22	0,02	-0,06	0,67	0,40
12			-1,44	-0,08	0,12			0,22	-0,43	-0,15			-0,35	-0,50	0,23
13	0,31	-0,07	0,22	-1,18	0,41	0,71	-0,19	0,25	0,53	0,49	-0,33	-0,48	0,05	-0,75	0,64
14	0,40	0,23	0,66	0,41	0,71	0,18	-0,16	0,38	-0,54	0,46	-0,08	0,35	-0,56	-0,07	-0,74
15	-0,16	-0,12	-0,09	0,21	-1,04	-0,92	0,05	-0,21	0,04	-0,12	0,26	0,86	0,82	2,28	1,37
16			-1,28	-1,61	-0,62			0,00	-0,15	0,41			-1,02	-0,94	-0,83
17	-0,03	-1,26	-0,32	-0,71	-1,49	-1,03	-1,97	-1,74	-1,63	-2,45	-2,75	-2,05	-2,31	-2,07	-1,86
18	-1,53	-1,25	0,60	-1,05	0,91	-0,81	0,09	-0,44	-0,40	0,02	0,20	0,53	2,07	1,12	1,21
19															
20	-0,64	0,35	-0,94	0,02	-0,16	-1,12	-0,29	-0,39	1,21	0,10	1,31	-0,32	0,61	1,26	0,84
21	-0,32	1,06	-0,29	0,84	0,12	1,15	0,09	-0,16	-0,37	-0,55	0,08	-0,16	-0,09	-0,79	-0,59
22	0,24	-0,30	-0,42	0,33	-1,43	-0,38	-0,28	0,00	0,16	0,21	-0,80	-0,99	-0,08	0,25	-0,53
23															
24	0,27	-0,57	-0,23	0,49	0,28	0,33	-0,75	-0,13	0,59	0,02	-0,84	1,80	-0,64	-0,59	-0,47
25	1,27	2,94	4,49	2,10	2,03	2,65	0,55	2,25	2,71	1,89	0,12	-0,19	0,13	-0,35	-0,39
26	0,30	-0,66	0,11	-0,64	-0,16	-0,74	-0,52	-1,09	-0,97	-0,76	0,10	-0,83	0,70	-0,23	0,44
27	1,57	0,25	-0,04	-0,32	1,17	-0,17	0,96	0,94	0,87	0,80	-0,30	-0,39	0,77	0,41	0,84
28		-1,27	-1,31	-1,67	-0,97	0,27	0,01	0,12	-0,32	-0,46	1,03	1,17	1,49	0,47	1,46

Table 12a – Z-Scores for all laboratories on the measurement of weight, diameter and open draw resistance for cigarettes

ID	Weight					Diameter					Open Draw Resistance				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	-0,02	-0,06	1,08	2,31	0,96	0,72	1,35	1,12	1,16	1,54	0,10	1,14	0,64	0,39	0,35
2	-0,24	-0,02	-0,10	0,07	-0,90	1,12	1,38	0,09	0,94	0,22	-0,02	0,04	-1,05	-0,96	-0,07
3	-0,47	0,05	-0,45	-0,02	0,10	-0,47	0,50	0,32	0,34	0,60	-0,25	-1,60	-0,51	0,27	-0,16
4	0,17	0,63	0,28	-1,47	-0,18	-0,49	0,25	0,07	-0,64	0,80	-0,71	0,55	-0,63	-0,58	-0,06
5	-0,63	-0,17	-0,48	-0,05	0,08	0,90	1,82	-0,15	0,39	-0,22	-0,22	-0,33	-1,72	-2,00	-1,23
6	-0,46	-0,52	-0,39	-0,83	-0,68	-0,38	0,25	-1,35	-0,11	-0,26	-0,99	-0,27	-0,35	-1,19	-0,55
7	-0,28	0,09	-0,32	0,87	0,50						0,11	0,06	0,09	0,09	0,16
8	-2,03	-2,25	-1,13	-1,75	-1,56	-1,15	-1,31	-0,38	-0,25	-1,03	1,33	0,76	1,00	1,17	1,44
9															
10	0,31	0,22	0,66	-0,51	-0,33	1,28	1,36	1,15	0,96	1,09	1,09	0,38	-0,19	0,60	0,42
11	-0,68	0,33	-0,22	-0,01	-0,33	-0,03	-0,31	-0,14	-0,62	0,03	2,14	0,87	0,34	0,57	0,45
12	-0,95	0,16	0,41	-0,13	0,23	-0,96	0,80	-1,64	0,00	0,19	-0,50	0,77	0,64	0,00	-0,73
13	-1,19	-1,07	-0,39	-0,95	-0,01	-1,09	-0,97	-0,43	0,23	-0,49	-0,65	0,82	-0,70	-0,52	-0,75
14															
15	0,23	0,71	0,79	0,06	0,07	-0,08	-1,16	0,82	0,31	-0,05	-1,38	-1,80	-0,31	-1,13	-1,92
16															
17	-0,62	-1,58	-1,85	0,10	-0,15	-0,53	-1,70	-3,23	-1,08	-2,16	-1,34	-0,80	-2,23	-2,41	-1,49
18	-1,09	-1,32	-0,92	-0,58	-1,14	-0,67	-1,10	0,09	-0,98	-0,11	0,46	0,40	0,33	1,28	1,70
19	-0,74	-0,56	-0,81	-0,52	-1,27	2,42	0,39	-5,48	-2,97	-2,09	-0,74	-0,64	-0,26	-0,80	-0,98
20	1,43	0,72	0,83	0,91	0,93	0,24	-0,98	-1,24	-0,35	-0,29	1,61	1,58	2,08	0,69	1,85
21	1,94	1,32	1,35	1,35	1,78	1,53	1,02	-1,25	0,05	-0,74	0,33	-1,57	2,10	0,38	-0,09
22	-0,15	-0,52	-1,09	-1,28	-1,78	-0,03	0,42	-0,33	0,15	0,30	-0,13	1,34	-0,55	0,63	0,06
23	0,94	1,46	0,97	1,05	0,35	0,75	-0,23	1,26	2,45	2,31	-1,92	1,16	0,53	0,08	0,57
24	1,85	1,49	0,42	1,35	1,22	-0,06	-0,94	0,82	0,00	-0,34	0,22	-1,21	-0,43	1,11	-0,63
25	1,17	1,64	2,21	0,92	1,72	-0,24	0,21	1,95	0,20	0,82	1,02	-0,43	0,90	1,17	1,06
26															
27	1,09	0,32	0,88	0,14	1,28	-1,03	-0,52	-1,44	-0,55	-0,21		-1,31	-0,07	0,33	-0,77
28	0,05	-1,07	-1,72	-1,06	-1,02	-1,75	-0,55	0,66	0,34	0,10	0,43	0,09	0,35	0,84	1,37

Table 12b – Z-Scores for all laboratories on the measurement of closed draw resistance and degree of filter ventilation for cigarettes

ID	Closed Draw Resistance					Degree of Filter Ventilation				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	-0,44	-0,14	0,87	0,49	-0,04	-0,06	-0,11	0,52	0,85	0,54
2	-0,17	-0,15	-0,77	-0,18	-0,03	0,24	0,73	1,22	2,35	1,35
3	-0,02	-0,92	-0,67	0,38	0,03	1,04	1,63	1,22	1,76	2,13
4	0,17	-0,10	-0,17	-0,58	-0,29	0,21	-0,40	0,70	0,07	-0,07
5	0,28	-0,27	-0,75	-1,83	-0,73	0,36	0,56	0,85	0,55	0,61
6	-0,39	-0,02	0,03	-0,91	-0,16	0,71	1,43	0,46	0,68	1,20
7	-0,12	-0,01	0,11	0,44	-0,19	-1,73	-0,96	-1,03	-0,73	-1,15
8						0,35	-1,87	-0,98	-0,99	-1,58
9										
10	0,84	0,72	0,06	0,57	-0,03	-1,07	-0,19	-0,56	-1,02	-1,30
11	2,13	1,74	0,66	0,37	1,20	-0,56	-0,33	-0,06	-0,81	0,28
12	1,01	0,59	0,59	0,25	-0,61	0,56	-0,79	-0,75	0,04	-0,38
13	-0,71	-0,99	-0,47	-0,66	-0,56	0,24	0,01	-0,18	-0,99	-0,35
14										
15	-0,39	-0,34	-0,17	-0,45	-0,61	0,21	1,05	1,00	0,64	1,22
16										
17	-1,09	-1,65	-3,08	-2,71	-1,28	-0,81	-0,79	-0,44	-1,11	-0,62
18						-1,11	-1,50	-0,77	-1,44	-1,66
19	0,70	-2,03	-2,93	-0,92	-1,86	0,71	-1,64	-0,13	0,14	-0,69
20	0,74	2,38	2,03	1,35	2,60	2,28	1,12	2,13	6,61	5,03
21	0,64	1,21	1,08	0,85	0,38	-0,60	0,71	-1,77	-0,81	-0,30
22	0,17	0,10	-0,67	0,79	-1,24	1,06	-0,15	1,46	1,51	0,42
23	-2,83	0,07	1,01	0,36	1,11	-2,33	-0,71	-0,42	-0,35	-0,21
24						-0,10	0,52	0,43	-0,21	0,50
25	0,52	-0,01	0,64	1,18	0,74	-0,35	0,22	-0,52	0,13	-0,65
26										
27		-0,28	-0,32	0,36	0,43		1,65	-1,56	0,50	1,18
28	-0,35	0,09	0,14	0,84	1,14	0,77	-0,20	-0,85	-0,76	-0,48

3. DATA INTERPRETATION

3.1 Repeatability and Reproducibility

The results for repeatability and reproducibility, Tables 9a and 9b and Tables 10a to 10c, do not show any exceptional values and are in line with the values reported in the respective ISO standards (ISO 2971, ISO 6565, ISO 9512). It has to be taken into account that the testing of physical parameters as carried out in this study is considered as "destructive" so that each individual measurement has to be performed on a different filter rod or cigarette. Consequently, repeatability and reproducibility data also include the product variability.

Nevertheless the coefficients of variation of repeatability and reproducibility for the measurement of diameter and weight are generally below 1 %, which is satisfactory for practical purposes.

As expected, the weight variability of cigarettes is higher than of filter rods, therefore the repeatability coefficient of variation is higher by a factor of about 2 for cigarettes compared to filter rods. The reproducibility of the measurement of flow parameters like pressure drop, draw resistances and degree of filter ventilation is also higher for cigarettes by a factor of about 2 compared to filter rods. The higher variability of cigarettes can partially be attributed to the higher number of components of a cigarette, such as tobacco, filter, tipping paper, plug wrap and cigarette paper, compared to a filter. Also conditioning of the samples may have a stronger influence on cigarettes.

The reproducibility coefficient of variation for flow parameters is in the low percent range, which is acceptable for routine measurements.

The coefficients of variation for repeatability and reproducibility are rather stable over the entire product range tested in this study, which indicates that the repeatability standard deviation increases approximately proportional to the mean value of the respective parameter.

In summary, the results are within expectations and do not suggest the immediate need for a revision of the concerned methods.

3.2 Laboratory Performance

As described in ISO 13528:2015, in normal circumstances about 95 % of all z-scores will be in the range between -2 and 2. Occasionally, absolute z-scores equal to or greater than 2 may be expected at a rate of about 5 %, while absolute z-scores equal to or greater than 3 will occur only at a rate of about 0,3 %.

Thus for absolute z-scores between 2 and 3 it is up to the laboratory to decide if these exceptional values are of importance and require any corrective action or review of the laboratory procedures. For absolute z-scores of 3 or higher it is strongly recommended that the laboratory investigates the reasons for the deviation and derives appropriate actions from these investigations.

In the present study, for filter rods 25 of 302 determinations, i.e. 8,3 %, resulted in absolute z-scores of 2 or higher and 6 of 302 determinations, i.e. 2,0 %, in absolute z-scores of 3 or higher. For the cigarettes 33 of 577 determinations (5,7 %) provided absolute z-scores of 2 or higher and 5 determinations (0,9 %) had absolute z-scores of 3 or higher.

Comparing these rates of occurrence of absolute z-scores between 2 and 3 with the expected rates it can be concluded that the present study found, at least for filters, an unusually high

number of z-scores with absolute values above 2 and 3. For cigarettes the proportion of absolute z-scores above 2 and 3, respectively, is approximately within the expected range.

For the filters, it can be seen in Table 11 that laboratory 7 consistently obtained z-scores less than -3 when measuring the pressure drop. The reasons for this deviation should be investigated and may, for example, be related to using the wrong samples, errors during calibration or in the instrument setup.

Laboratory 25 achieved a series of high z-scores for filter weight and diameter. It is recommended to investigate potential reasons for these deviations.

Laboratory 17 obtained rather low values for filter pressure drop resulting in several z-scores below -2 and also the diameter values appear to be consistently low, although only one of the z-scores is below -2.

For the cigarettes, laboratory 17 measured low open draw resistances, with two z-scores being less than -2, low diameters, including a z-score less than -3 and also low closed draw resistances. As similar trends were also observed for filters, it is recommended to investigate the reasons.

Laboratory 19 had highly variable results for cigarette diameter, with one z-score being greater than 2 and several z-scores less than -2. Also the closed pressure drop was generally lower than in other laboratories. This also suggests a need for reviewing the laboratory procedures or the instrument setup.

Laboratory 20 measured high cigarette filter ventilation levels with two z-scores greater than 3 and also high closed draw resistances with several z-scores above 2.

Further laboratories that reported suspicious results are laboratory 8 with low cigarette weight values and laboratory 23 with high cigarette diameters.

Extreme z-scores are generally concentrated in a few laboratories, particularly laboratories 7, 17, 19, 20 and 25 which account for 38 (66 %) of the total 58 z-scores with absolute values greater than 2, while the remaining z-scores with high absolute values are more randomly distributed and may not be an immediate reason for concern.

In total 11 of the 28 participating laboratories did not obtain any z-scores with an absolute value greater than 2, thus their results fit rather well to each other and to the 'true' value for all physical parameters tested in this study. These laboratories are 4, 5, 12, 13, 14, 16, 22, 24, 26, 27 and 28.

3.3   Comparison with Historical Data

One of the purposes of this study is to assess laboratory performance so that over time a steady improvement can be achieved. The following historical assessment by comparing data from the 7th to 9th Proficiency Test on Physical Parameters (2014, 2015, 2016) and the 10th to 16th Collaborative Study on Physical Parameters (2017 to 2023) is an attempt to investigate, if such an improvement can be observed.
The results of this analysis have to be interpreted very cautiously as different laboratories have taken part in the ten inter-laboratory studies and as the tested products differed in the studies. Also, as the data are anonymized the performance of individual laboratories cannot be assessed. Instead, an average robust coefficient of variation is calculated over all products in a category by the ratio of the robust standard deviation and the robust global mean value and expressed as a percentage. As the robust standard deviation is calculated from the between-laboratory standard deviations it may be expected that the robust coefficient of variation decreases over time as the laboratories improve and the differences between the laboratories become smaller.

The results of this analysis are provided for information only and are not based on any specific statistical test or analysis.

Table 13 – Historical development of a robust coefficient of variation for parameters measured on filter rods

Parameter	Robust Coefficient of Variation									
	%									
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Weight	0,239	0,392	0,421	0,332	0,300	0,290	0,368	0,418	0,337	0,296
Diameter	0,070	0,063	0,089	0,080	0,084	0,085	0,079	0,075	0,086	0,115
Pressure Drop	2,710	1,715	1,357	1,105	1,124	0,914	1,291	1,402	1,037	1,056

Table 14 – Historical development of a robust coefficient of variation for parameters measured on cigarettes

Parameter	Robust Coefficient of Variation									
	%									
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Weight	0,528	0,852	0,817	0,721	0,625	0,647	0,707	0,708	0,655	0,728
Diameter	0,126	0,104	0,103	0,172	0,150	0,132	0,100	0,172	0,184	0,203
Open Draw Res.	2,104	1,476	1,370	1,632	1,354	1,029	1,459	1,595	1,610	1,748
Closed Draw Res.	2,403	2,732	2,305	1,984	1,673	1,289	1,829	2,380	1,655	1,955
Deg. of Vent.	2,785	2,211	2,524	1,347	1,432	1,860	1,527	1,813	1,710	1,780

First it has to be noted that the measurement of weight, diameter, pressure drop, draw resistance and the degree of filter ventilation is based on mature measurement methods so that no substantial change from year to year can be expected. The variability of the measurement of filter rods is generally lower than for cigarettes, which is likely to be due to the higher homogeneity of filter rods and their higher resistance to mechanical damage during transport and handling.

The observed variation for pressure drop, draw resistance and degree of filter ventilation is in good agreement with the variability reported in ISO 6565 and ISO 9512, respectively. This supports the conclusion that the laboratories are properly applying these standards. As the methods have not changed from 2014 to 2023 the observed changes may mostly be attributable to differences in the test pieces and to the laboratories that have taken part in the collaborative studies.

Since 2017 this inter-laboratory study has been carried out as a collaborative study by making the test methods mandatory. Therefore, it is possible to also compare an average coefficient of variation for repeatability and reproducibility from 2017 to 2023. Tables 15a and 15b show these parameters for the filter rods and Tables 16a and 16b for the cigarettes.

Table 15a – Historical development of repeatability coefficient of variation for parameters measured on filter rods

Parameter	Repeatability Coefficient of Variation						
	%						
	2017	2018	2019	2020	2021	2022	2023
Weight	0,292	0,338	0,321	0,356	0,405	0,312	0,384
Diameter	0,071	0,073	0,069	0,072	0,077	0,070	0,062
Pressure Drop	0,820	0,826	0,861	0,981	0,930	0,896	0,857

Table 15b – Historical development of reproducibility coefficient of variation for parameters measured on filter rods

Parameter	Reproducibility Coefficient of Variation						
	%						
	2017	2018	2019	2020	2021	2022	2023
Weight	0,422	0,428	0,408	0,489	0,554	0,440	0,459
Diameter	0,102	0,105	0,106	0,102	0,102	0,107	0,128
Pressure Drop	1,336	1,382	1,203	1,575	1,634	1,323	1,311

Table 16a – Historical development of repeatability coefficient of variation for parameters measured on cigarettes

Parameter	Repeatability Coefficient of Variation						
	%						
	2017	2018	2019	2020	2021	2022	2023
Weight	0,733	0,628	0,663	0,651	0,721	0,692	0,746
Diameter	0,088	0,097	0,106	0,081	0,129	0,136	0,129
Open Draw Resistance	1,477	1,430	1,471	1,333	1,520	1,604	1,417
Closed Draw Resistance	2,087	1,842	1,573	1,398	2,249	1,768	1,589
Degree of Filter Ventilation	1,037	1,438	1,348	1,113	1,345	1,302	1,123

Table 16b – Historical development of reproducibility coefficient of variation for parameters measured on cigarettes

Parameter	Reproducibility Coefficient of Variation						
	%						
	2017	2018	2019	2020	2021	2022	2023
Weight	0,973	0,856	0,880	0,916	0,962	0,905	0,989
Diameter	0,190	0,175	0,165	0,124	0,210	0,224	0,234
Open Draw Resistance	2,100	1,874	1,695	1,886	2,101	2,162	2,164
Closed Draw Resistance	2,767	2,372	1,913	2,226	3,143	2,332	2,425
Degree of Filter Ventilation	1,640	1,986	2,239	1,834	2,181	2,073	2,045

For the filter rods and for the cigarettes no substantial changes in these parameters could be observed from 2017 to 2023, but it is noteworthy that reproducibility parameters of cigarette and filter diameter in this collaborative study are generally high. This may be attributed to the sample materials used in these studies and somewhat agrees with the findings in the 15th Collaborative Study. Development of these parameters will of course be monitored in future studies.

For cigarettes with the exception of diameter, which has very low variability, the reproducibility coefficient of variation is about 30 % to 80 % higher than the repeatability coefficient of variation for all parameters and this ratio remains stable from 2017 to 2023, so that no specific changes have occurred, which would require further investigation.

Overall, there seem to be only small changes and no specific trends in these variation parameters so that the results do not suggest an immediate need for revision of any of the concerned methods. Also, the variability is sufficiently low for all practical purposes.

4.   REFERENCES

- ISO 3402:1999, Tobacco and tobacco products – Atmosphere for conditioning and testing
- CORESTA Guide 6:2009, A User Guideline for the Use of Balances for Cigarettes and Cigarette Related Products
- ISO 2971:2013, Cigarettes and filter rods – Determination of nominal diameter -- Method using a non-contact optical measuring apparatus
- ISO 6565:2015, Tobacco and tobacco products – Draw resistance of cigarettes and pressure drop of filter rods – Standard conditions and measurement
- ISO 9512:2019, Cigarettes – Determination of ventilation – Definitions and measurement principles
- ISO 5725-2:2019, Accuracy (trueness and precision) of measurement methods and results - Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method
- ISO/IEC 17043:2010, Conformity assessment – General requirements for proficiency testing.
- ISO 13528:2020, Statistical methods for use in proficiency testing by interlaboratory comparison

5. APPENDICES

APPENDIX A – Protocol

The protocol is reproduced in its original form. Minor typographical errors were corrected and e-mail addresses were removed.

Protocol for the 16th Collaborative Study (2023) on Physical Parameters

1. Preparation of Samples

1.1 All measurements should take place in an environment according to ISO 3402 (Testing atmosphere: $(22\pm2)°C$, (60 ± 5) % rH). Give comments in case of deviation.

1.2 Prepare for each product – see data sheet: products - 5 separate samples (#1, #2, #3, #4, #5) of 10 filter rods / cigarettes. Sample 1 is measured on Day 1, sample 2 on Day 2, sample 3 on Day 3, sample 4 on Day 4 and sample 5 on Day 5. Inspect prepared samples visually to avoid measurements of damages samples.

1.3 Samples should be unpacked and conditioned at least 48 h (conditioning time can affect the level / results of physical parameters !) regarding ISO 3402 (conditioning atmosphere: $(22\pm1)°C$, (60 ± 3) % rH) prior to the measurement. Give comments in case of deviation.

1.4 To avoid changes in sample moisture the samples should be transferred from conditioning environment to the instrument in tightly closed plastic boxes.

2. Instrument Setup

2.1 The instrument system should be arranged to make the weight measurement first, followed by diameter or PD and ventilation (the order of these last three is normally provided by the instrument system).

2.2 Before making measurements, the instrument(s) should be set up to accept the sample being measured (e.g. for slim products - hopper adjustment, sleeves, measuring head; for filter rods - length of sleeve-holder to ensure a totally encapsulated PD measurement).

2.3 All specific instrument information should be recorded in the instrument configuration sheet.

3. Calibration of Instruments

3.1 At the beginning of each measuring day (run of all products) all instruments have to be checked for accuracy and, if necessary, recalibrated according to current ISO-standards:

3.2 PD: ISO 6565
Diameter: ISO 2971
FV: ISO 9512
Balance in regards to the instrument supplier's recommendation

Repeat calibration check after every change in the units (e.g. PD/FV unit: necessary changes caused by sample diameter and/or changes from cigarette to filter rod measurements).
If possible, do not recalibrate until all products have been measured. If this is impossible, make a note in the comments column.

3.3 PD calibration should be carried out using nominally 800 mmWG multi-capillary standards for filter PD measurements and nominally 200 mmWG multi-capillary standards for cigarette measurements

Calibration checking should use at least 2 levels of PD standards to ensure an effective linearity and leak check:

> 400 mmWG and 800 mmWG nominal for filter rods
> 200 mmWG and 400 mmWG nominal for cigarettes

Standards should be calibrated according to CRM 41 (June 2007).
If the difference between the measured and the defined value of the standard during a calibration check exceeds ±0,5 % of the defined value, recalibrate the instrument.

3.4 For all parameters (size, weight, PD, ventilation and diameter) the defined values should be noted in the instrument configuration sheet. The defined and the measured / actual values should be noted in the record sheet.

3.5 In case of the use of automatic calibration, no extra calibration according to 3.3 is necessary.

4. Making Measurements

4.1 Measure all parameters as defined in data recording sheets.

4.2 Record date and time of each measurement as defined in data recording sheet – see 5.1

4.3 Randomise the order of sample measurement in a practical order to avoid excessive measuring head changes.

4.4 Measurements should be made using the same measurement procedures as used on routine samples (daily business).

4.5 Measure one set of products in one measurement run on one instrument within a single day - see measurement scheme 4.8

4.6 Record individual readings for each sample of 10 cigarettes or filters, as defined in data recording sheet - see 5.1. If the mean value is not based on a sample size of N=10 (e.g. caused by damaging a cigarette/ filter rod during the measurement or a faulty measurement) please note the deviating N in the comments column.

4.7 Measurement Scheme:

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
	Data recording sheet DAY 1	Data recording sheet DAY 2	Data recording sheet DAY 3	Data recording sheet DAY 4	Data recording sheet DAY 5
Individual measurements per day	5*10 = 50 filters + 5*10 = 50 cigarettes	5*10 = 50 filters + 5*10 = 50 cigarettes	5*10 = 50 filters + 5*10 = 50 cigarettes	5*10 = 50 filters + 5*10 = 50 cigarettes	5*10 = 50 filters + 5*10 = 50 cigarettes
Individual measurements in total	250 filters + 250 cigarettes				

Remark: Day 1 can be different for filters and cigarettes but samples 1, 2, 3, 4 & 5 must be analysed on a different day.

5. **Recording of Results**

5.1 Record results as defined in data recording sheet:

Please use 1 sheet per day from DAY 1 to DAY 5
Do not use internal terms for Lab ID: Lab ID=company ID
Date measured: dd/mm/yyyy
Time measured: hh:mm (24 hour clock)
Individual weight: mg
Diameter (not circumference!):   mm
PD (fully encapsulated) :   mmWG
PD open :   mmWG
PD closed :   mmWG
FV :   %
And decimal-places as given with the print-out of the instrument

If no relevant information is available, please fill in: n.a.   (abbreviation for: not applicable)

Remark: It is not permitted to make any changes on the data recording sheets. Results being reported not in the correct way will be rejected from the trial!
For any additional information or remarks please use the comments column. You could also add an additional spreadsheet.

5.2   E-mail completed spreadsheets (file) to : Ph. Le Men and B. Eitzinger - latest by September 30th

Set e-mail subject line: Collaborative Study 2023 results - PTM Sub-Group
Rename the completed file: Add the company ID at the beginning of the existing file name
Acceptance of new or modified results submitted after that date is in the sole discretion of the study coordinators.
After distribution of the draft report no new or modified results will be accepted.

APPENDIX B – Data Summary (Mean Values)

Appendix B.1: Mean values of weight, diameter and pressure drop for filter rods over all laboratories (ID) as originally submitted

| ID | Weight | | | | | Diameter | | | | | Pressure Drop | | | | |
| | mg | | | | | mm | | | | | mmWG | | | | |
	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
1	430,10	925,76	811,56	888,78	768,38	5,37	7,35	7,66	7,65	7,67					
2	424,12	922,54	809,18	884,72	764,06	5,37	7,34	7,66	7,65	7,67					
3															
4															
5															
6	427,82	919,72	805,24	882,98	765,46	5,36	7,32	7,65	7,64	7,67	511,94	812,38	275,46	403,30	452,34
7	430,22	923,04	806,58	882,46	765,86						470,70	747,22	257,82	316,58	411,54
8															
9	431,22	922,92	804,90	886,02	765,20	5,36	7,31	7,63	7,63	7,65	520,32	836,66	278,40	409,56	461,96
10	429,32	923,48	807,46	887,56	769,12	5,37	7,35	7,66	7,65	7,68	523,06	815,92	280,06	410,02	463,28
11	430,80	923,46	806,00	885,28	767,78	5,37	7,33	7,65	7,65	7,67	523,84	820,30	279,26	410,38	464,24
12			803,20	884,20	766,72			7,65	7,64	7,67			278,44	405,96	463,42
13	429,88	922,60	806,50	881,50	767,22	5,37	7,33	7,65	7,65	7,67	514,54	815,58	279,56	404,74	465,38
14	430,06	923,30	807,38	885,40	767,74	5,37	7,33	7,66	7,64	7,67	516,04	823,46	277,82	407,56	458,88
15	428,94	922,48	805,88	884,90	764,74	5,36	7,33	7,65	7,64	7,67	518,04	828,28	281,76	416,46	468,80
16			803,52	880,46	765,46			7,65	7,64	7,67			276,52	404,30	458,44
17	429,26	919,72	805,42	883,12	763,96	5,36	7,31	7,64	7,63	7,65	500,80	800,68	272,86	400,02	453,62
18	426,14	919,76	807,26	881,82	768,08	5,36	7,33	7,65	7,64	7,67	517,70	825,12	285,32	412,08	468,04
19															
20	427,96	923,60	804,20	884,44	766,24	5,36	7,32	7,65	7,65	7,67	524,38	817,08	281,60	412,60	466,30
21	428,60	925,30	805,48	886,46	766,72	5,37	7,33	7,65	7,64	7,67	516,96	818,58	279,18	404,84	459,58
22	429,74	922,04	805,22	885,20	764,06	5,36	7,32	7,65	7,64	7,67	511,66	810,76	279,20	408,80	459,88
23															
24	429,80	921,40	805,60	885,60	767,00	5,37	7,32	7,65	7,65	7,67	511,44	837,16	277,62	405,60	460,16
25	431,83	929,83	815,01	889,34	770,01	5,38	7,33	7,67	7,66	7,68	517,20	818,33	279,79	406,51	460,50
26	429,86	921,18	806,28	882,84	766,24	5,36	7,32	7,64	7,64	7,66	517,10	812,28	281,42	406,96	464,42
27	432,44	923,36	805,98	883,62	768,52	5,36	7,34	7,66	7,65	7,67	514,70	816,44	281,62	409,40	466,30
28	425,72	919,70	803,46	880,32	764,86	5,37	7,33	7,65	7,64	7,67	522,68	831,20	283,66	409,62	469,22

Appendix B.2a: Mean values of weight, diameter and open draw resistance for all laboratories (ID) as originally submitted.

| | Weight | | | | | Diameter | | | | | Pressure Drop | | | | |
| | mg | | | | | mm | | | | | mmWG | | | | |
ID	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	538,14	770,42	1072,80	789,90	845,10	5,42	7,17	7,84	7,80	7,84	167,38	91,08	127,46	82,38	92,96
2	537,32	770,64	1063,00	778,46	833,38	5,43	7,18	7,83	7,80	7,83	167,00	89,34	123,34	80,68	92,64
3	536,44	771,04	1060,02	777,94	839,66	5,39	7,16	7,84	7,79	7,83	166,28	86,76	124,64	82,56	92,34
4	538,86	774,08	1066,10	769,82	837,86	5,39	7,16	7,83	7,78	7,83	164,84	90,16	124,36	81,26	92,46
5	535,86	769,88	1059,80	777,76	839,55	5,42	7,18	7,83	7,79	7,82	166,36	88,76	121,69	79,10	91,04
6	536,50	768,02	1060,52	773,42	834,74	5,39	7,16	7,82	7,78	7,82	163,96	88,86	125,04	80,34	91,86
7	537,16	771,24	1061,12	782,92	842,16						167,40	89,38	125,48	82,28	92,72
8	530,60	758,92	1054,38	768,22	829,18	5,38	7,14	7,83	7,78	7,81	171,20	90,48	128,34	83,92	94,28
9															
10	539,40	771,92	1069,28	775,20	836,94	5,43	7,17	7,84	7,80	7,83	170,46	89,88	125,44	83,06	93,04
11	535,66	772,48	1061,98	777,98	836,94	5,40	7,15	7,83	7,78	7,82	173,72	90,66	126,72	83,02	93,08
12	534,64	771,62	1067,98	777,34	840,46	5,38	7,17	7,81	7,78	7,83	165,50	90,50	127,46	82,14	91,64
13	533,76	766,06	1060,52	772,74	838,96	5,38	7,14	7,83	7,79	7,82	165,02	90,58	124,18	81,36	91,62
14															
15	539,10	774,50	1070,36	778,36	839,48	5,40	7,14	7,84	7,79	7,82	162,74	86,44	125,14	80,42	90,20
16															
17	535,90	762,44	1048,32	778,64	838,06	5,39	7,13	7,80	7,77	7,80	162,88	88,02	120,46	78,48	90,72
18	534,14	763,84	1056,12	774,80	831,82	5,39	7,14	7,83	7,77	7,82	168,50	89,92	126,70	84,10	94,60
19	535,44	766,92	1057,02	775,16	831,02	5,45	7,16	7,77	7,75	7,80	164,74	88,28	125,26	80,69	91,34
20	543,58	774,54	1070,70	783,18	844,88	5,41	7,14	7,82	7,78	7,82	172,08	91,78	130,96	83,20	94,78
21	545,50	777,72	1075,12	785,62	850,26	5,43	7,17	7,82	7,79	7,82	168,08	86,80	131,02	82,72	92,42
22	537,66	768,00	1054,66	770,88	828,54	5,40	7,16	7,83	7,79	7,83	166,66	91,40	122,38	83,10	92,60
23	541,74	778,44	1071,94	783,96	841,24	5,42	7,15	7,85	7,82	7,85	161,08	91,12	127,18	82,26	93,22
24	545,18	778,62	1067,34	785,64	846,72	5,40	7,14	7,84	7,78	7,82	167,74	87,38	124,84	83,84	91,76
25	542,60	779,37	1082,25	783,20	849,86	5,40	7,16	7,85	7,79	7,83	170,22	88,60	128,08	83,92	93,82
26															
27	542,30	772,42	1071,48	778,86	847,08	5,38	7,15	7,82	7,78	7,82		87,22	125,72	82,64	91,60
28	538,40	765,12	1049,38	772,12	831,68	5,37	7,15	7,84	7,79	7,82	168,38	89,42	126,74	83,42	94,20

Appendix B.2b: Mean values of closed draw resistance and degree of filter ventilation of cigarettes for all laboratories (ID) as originally submitted.

ID	Closed Draw Resistance mg					Degree of Filter Ventilation %				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	338,78	249,42	183,32	111,44	155,14	55,79	82,90	39,28	34,61	53,90
2	341,52	249,38	178,52	110,04	155,16	56,11	83,46	39,96	35,48	54,40
3	342,98	245,54	178,80	111,20	155,60	56,98	84,06	39,96	35,05	55,02
4	344,90	249,58	180,26	109,20	154,62	56,08	82,70	39,61	33,84	53,28
5	345,98	248,78	178,56	106,58	153,68	56,24	83,34	39,74	34,18	53,82
6	339,30	250,00	180,86	108,50	154,88	56,62	83,93	39,22	34,28	54,29
7	342,04	250,06	181,10	111,34	155,22	53,97	82,33	37,77	33,18	52,42
8						56,23	81,62	37,81	33,07	52,09
9										
10	351,62	254,56	180,96	111,60	155,16	54,70	82,85	38,22	33,05	52,30
11	364,50	258,72	182,70	111,18	157,76	55,24	82,75	38,72	33,20	53,56
12	353,28	253,02	182,50	110,94	153,94	56,46	82,44	37,85	33,82	53,04
13	336,12	245,20	179,38	109,02	154,04	56,11	82,98	38,59	33,07	53,06
14										
15	339,28	248,42	180,28	109,46	153,94	56,08	83,68	39,75	34,24	54,35
16										
17	332,34	241,90	171,74	104,72	152,52	54,97	82,45	38,34	32,99	52,84
18						54,65	81,89	38,02	32,75	52,02
19	350,16	240,02	172,20	108,47	151,30	56,62	81,88	38,64	33,89	52,79
20	350,62	261,90	186,72	113,24	160,73	58,32	83,72	40,86	38,54	57,32
21	349,60	256,12	183,94	112,20	156,02	55,20	83,44	36,94	33,20	53,10
22	344,94	250,60	178,24	112,06	152,60	57,01	82,87	41,15	34,87	53,67
23	314,98	250,46	183,72	111,16	157,58	53,33	82,50	38,36	33,45	53,17
24						55,74	83,13	39,19	33,63	53,73
25	348,38	250,06	182,64	112,88	156,78	55,48	83,12	38,26	33,88	52,82
26										
27		248,70	179,84	111,34	156,14		84,08	37,25	34,15	54,27
28	339,70	250,54	181,18	112,18	157,64	56,56	82,84	37,94	33,24	52,95

Appendix B.3: Mean values of weight, diameter and pressure drop for filter rods over all laboratories (ID) after outlier testing by Grubbs' test on individual values. Values that have been affected are highlighted.

ID	Weight					Diameter					Pressure Drop				
	mg					mm					mmWG				
	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
1	430,47	925,76	811,56	888,78	768,38	5,37	7,35	7,66	7,65	7,67					
2	424,12	922,54	809,61	884,72	764,06	5,37	7,34	7,66	7,65	7,67					
3															
4															
5															
6	428,81	919,72	805,24	882,98	765,46	5,36	7,32	7,65	7,64	7,67	510,87	812,38	275,46	403,30	452,34
7	430,22	923,04	806,58	882,46	765,86						470,70	747,22	257,82	316,58	411,54
8															
9	431,22	922,92	804,90	886,02	765,20	5,36	7,31	7,63	7,63	7,65	520,32	836,66	278,40	409,56	461,96
10	429,32	923,48	808,12	887,56	769,12	5,37	7,35	7,66	7,65	7,68	523,06	817,44	280,06	410,02	463,28
11	430,80	923,46	806,00	885,28	767,78	5,37	7,33	7,65	7,65	7,67	523,84	820,30	279,26	410,38	464,24
12			803,20	884,20	766,72			7,65	7,64	7,67			278,44	405,96	463,42
13	429,88	922,60	806,50	881,50	767,22	5,37	7,33	7,65	7,65	7,67	514,54	815,58	279,56	405,02	465,38
14	430,06	923,30	807,38	885,40	767,74	5,37	7,33	7,66	7,64	7,67	516,04	823,46	277,82	407,56	458,88
15	428,94	922,48	805,88	884,90	764,74	5,36	7,33	7,65	7,64	7,67	518,04	828,28	281,76	416,46	468,80
16			803,52	880,46	765,46			7,65	7,64	7,67			276,52	404,30	458,44
17	429,19	919,72	805,42	882,66	763,96	5,36	7,31	7,64	7,63	7,65	499,94	800,68	272,86	400,02	453,62
18	426,14	919,76	807,26	881,82	768,08	5,36	7,33	7,65	7,64	7,67	517,70	825,12	285,32	412,08	468,04
19															
20	427,96	923,60	804,20	884,44	766,24	5,36	7,32	7,65	7,65	7,67	524,38	817,08	281,16	412,60	466,30
21	428,60	925,30	805,48	886,46	766,72	5,37	7,33	7,65	7,64	7,67	516,96	818,58	279,18	404,84	459,58
22	429,74	922,04	805,22	885,20	764,06	5,36	7,32	7,65	7,64	7,67	511,66	810,76	279,20	408,80	459,88
23															
24	429,80	921,40	805,60	885,60	767,00	5,37	7,32	7,65	7,65	7,67	511,44	837,16	277,62	405,60	460,16
25	431,83	929,83	815,01	889,53	770,01	5,38	7,33	7,67	7,66	7,68	517,20	818,33	279,79	406,51	460,50
26	429,86	921,18	806,28	882,84	766,24	5,36	7,32	7,64	7,64	7,66	517,10	812,28	281,42	406,96	464,42
27	432,44	923,36	805,98	883,62	768,52	5,36	7,34	7,66	7,65	7,67	514,70	816,44	281,62	409,40	466,30
28	425,72	919,70	803,46	880,32	764,86	5,37	7,33	7,65	7,64	7,67	522,68	831,20	283,66	409,62	469,22

Appendix B.4a: Mean values of weight, diameter and open draw resistance for all laboratories (ID) after outlier testing by Grubbs' test on individual values. Values that have been affected are highlighted.

ID	Weight					Diameter					Open Draw Resistance				
	mg					mm					mmWG				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	538,14	770,42	1072,80	791,01	845,10	5,42	7,17	7,84	7,80	7,84	167,38	91,08	127,46	82,73	92,96
2	537,32	770,64	1063,00	778,46	833,38	5,43	7,18	7,83	7,80	7,83	167,00	89,34	123,34	80,68	92,45
3	536,44	771,04	1060,02	777,94	839,66	5,39	7,16	7,84	7,79	7,83	166,28	86,76	124,64	82,56	92,34
4	538,86	774,08	1066,10	769,82	837,86	5,39	7,16	7,83	7,78	7,83	164,84	90,16	124,36	81,26	92,46
5	535,86	769,88	1059,80	777,76	839,55	5,42	7,18	7,83	7,79	7,82	166,36	88,76	121,69	79,10	91,04
6	536,50	768,02	1060,52	773,42	834,74	5,39	7,16	7,82	7,78	7,82	163,96	88,86	125,04	80,34	91,86
7	537,16	771,24	1061,12	782,92	842,16						167,40	89,38	126,10	82,28	92,72
8	530,60	758,92	1054,38	768,22	829,18	5,38	7,14	7,83	7,78	7,81	171,20	90,48	128,34	83,92	94,28
9															
10	539,40	771,92	1069,28	775,20	836,94	5,43	7,17	7,84	7,80	7,83	170,46	89,88	125,44	83,06	93,04
11	535,66	772,48	1061,98	777,98	836,94	5,40	7,15	7,83	7,78	7,82	173,72	90,66	126,72	83,02	93,08
12	534,64	771,62	1067,20	777,34	840,46	5,38	7,17	7,81	7,78	7,83	165,50	90,50	127,46	82,14	91,64
13	533,76	765,13	1060,52	772,74	838,96	5,38	7,14	7,83	7,79	7,82	165,02	90,58	124,18	81,36	91,62
14															
15	539,10	774,50	1070,36	778,36	839,48	5,40	7,14	7,84	7,79	7,82	162,74	86,44	125,14	80,42	90,20
16															
17	535,90	762,44	1048,32	778,64	838,06	5,39	7,13	7,80	7,77	7,80	162,88	88,02	120,46	78,48	90,72
18	534,14	763,84	1056,12	774,80	831,82	5,39	7,14	7,83	7,77	7,82	168,50	89,92	126,70	84,10	94,60
19	535,44	767,82	1057,02	775,16	831,02	5,45	7,16	7,77	7,75	7,80	164,74	88,28	125,26	80,93	91,34
20	543,58	774,54	1070,70	783,18	844,88	5,41	7,14	7,82	7,78	7,82	172,08	91,78	130,96	83,20	94,78
21	545,50	777,72	1075,12	785,62	850,26	5,43	7,17	7,82	7,79	7,82	168,08	86,80	131,02	82,72	92,42
22	537,66	768,00	1054,66	770,88	827,82	5,40	7,16	7,83	7,79	7,83	166,66	91,40	124,55	83,10	92,60
23	541,74	778,44	1071,94	783,96	841,24	5,42	7,15	7,85	7,82	7,85	161,08	91,12	127,18	82,26	93,22
24	545,18	778,62	1067,34	785,64	846,72	5,40	7,14	7,84	7,78	7,82	167,74	87,38	124,84	83,84	91,76
25	542,60	779,37	1082,25	783,20	849,86	5,40	7,16	7,85	7,79	7,83	170,22	88,60	128,08	83,92	93,82
26															
27	542,30	772,42	1071,14	778,86	847,08	5,38	7,15	7,82	7,78	7,82		87,22	125,72	82,64	91,60
28	538,40	765,12	1049,38	772,12	832,61	5,37	7,15	7,84	7,79	7,82	168,38	89,42	126,74	83,42	94,20

Appendix B.4b: Mean values of closed draw resistance and degree of filter ventilation of cigarettes for all laboratories (ID) after outlier testing by Grubbs' test on individual values. Values that have been affected are highlighted.

ID	Closed Draw Resistance mg C1	C2	C3	C4	C5	Degree of Filter Ventilation % C1	C2	C3	C4	C5
1	338,78	249,42	183,32	111,44	155,14	55,79	82,90	39,28	34,39	53,76
2	341,52	249,38	178,52	110,04	155,16	56,11	83,46	39,96	35,48	54,40
3	342,98	245,54	178,80	111,20	155,28	56,98	84,06	39,96	35,05	55,02
4	344,90	249,58	180,26	109,20	154,62	56,08	82,70	39,46	33,84	53,28
5	345,98	248,78	178,56	106,58	153,68	56,24	83,34	39,60	34,18	53,82
6	339,30	250,00	180,86	108,50	154,88	56,62	83,93	39,22	34,28	54,29
7	342,04	250,06	181,10	111,34	154,83	53,97	82,33	37,77	33,26	52,42
8						56,23	81,72	37,81	33,07	52,09
9										
10	351,62	253,69	180,96	111,60	155,16	54,70	82,85	38,22	33,05	52,30
11	364,50	258,72	182,70	111,18	157,76	55,24	82,75	38,72	33,20	53,56
12	353,28	253,02	182,50	110,94	153,94	56,46	82,44	38,04	33,82	53,04
13	336,12	245,20	179,38	109,02	154,04	56,11	82,98	38,59	33,07	53,06
14										
15	339,28	248,42	180,28	109,46	153,94	56,08	83,68	39,75	34,24	54,31
16										
17	332,34	241,90	171,74	104,72	152,52	54,97	82,45	38,34	32,99	52,84
18						54,65	81,97	38,02	32,75	52,02
19	350,16	240,02	172,20	108,47	151,30	56,62	81,88	38,64	33,89	52,79
20	350,62	261,90	186,72	113,24	160,73	58,32	83,72	40,86	38,54	57,32
21	349,60	256,12	183,94	112,20	156,02	55,20	83,44	37,04	33,20	53,10
22	344,94	250,60	178,80	112,06	152,60	57,01	82,87	40,20	34,87	53,67
23	314,98	250,46	183,72	111,16	157,58	53,33	82,50	38,36	33,54	53,17
24						55,74	83,32	39,19	33,63	53,73
25	348,38	250,06	182,64	112,88	156,78	55,48	83,12	38,26	33,88	52,82
26										
27		248,70	179,84	111,17	156,14		84,08	37,25	34,15	54,27
28	339,70	250,54	181,18	112,18	157,64	56,68	82,84	37,94	33,24	52,95

APPENDIX C – Data Summary (Standard Deviations)

Appendix C.1: Standard deviations of weight, diameter and pressure drop for filter rods over all laboratories (ID) as originally submitted.

ID	Weight					Diameter					Pressure Drop				
	mg					mm					mmWG				
	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
1	2,56	2,28	2,55	1,97	2,28	0,007	0,004	0,004	0,003	0,003					
2	6,48	0,82	1,65	1,51	3,36	0,012	0,008	0,003	0,005	0,004					
3															
4															
5															
6	1,71	1,27	1,54	2,68	3,88	0,003	0,005	0,006	0,004	0,002	5,58	5,07	2,14	2,64	2,60
7	2,31	0,49	1,56	1,51	4,11						7,68	8,37	4,94	1,87	3,09
8															
9	2,02	1,51	3,36	3,56	2,96	0,002	0,002	0,005	0,005	0,003	9,70	6,50	3,33	5,17	2,97
10	1,91	2,03	4,17	0,92	3,23	0,002	0,005	0,006	0,002	0,006	2,79	7,21	3,93	2,08	4,18
11	0,34	1,93	2,03	1,97	2,95	0,003	0,006	0,003	0,004	0,003	0,82	7,37	2,80	3,68	4,65
12			4,58	0,35	2,12			0,007	0,004	0,002			3,11	1,81	4,39
13	0,80	1,85	3,18	0,97	4,26	0,002	0,010	0,003	0,003	0,004	5,31	4,61	3,26	3,90	4,59
14	4,53	1,96	4,79	2,41	2,85	0,004	0,005	0,004	0,004	0,004	6,45	4,47	3,68	3,53	4,28
15	2,47	1,76	6,32	1,66	3,05	0,008	0,004	0,008	0,005	0,004	6,30	3,20	3,80	2,44	4,64
16			3,22	2,01	2,20			0,004	0,002	0,003			2,21	2,04	3,38
17	2,41	2,22	2,43	2,95	3,63	0,005	0,006	0,005	0,005	0,007	7,42	8,46	1,68	3,93	3,61
18	6,14	2,48	0,92	3,16	3,10	0,003	0,010	0,004	0,002	0,002	12,22	8,10	1,59	2,30	2,95
19															
20	4,00	0,93	3,08	2,32	3,89	0,004	0,005	0,003	0,009	0,002	8,76	7,68	3,44	5,08	1,43
21	1,19	0,70	2,27	2,36	2,92	0,002	0,005	0,003	0,005	0,005	3,28	3,54	1,87	2,53	5,73
22	2,02	1,50	3,50	2,87	1,18	0,002	0,003	0,006	0,005	0,003	7,30	5,05	2,68	1,53	2,43
23															
24	5,54	1,95	0,89	2,88	1,58	0,001	0,005	0,002	0,004	0,003	1,18	5,25	0,51	1,58	5,61
25	1,29	0,68	1,54	0,84	1,31	0,002	0,009	0,007	0,005	0,006	1,24	2,26	1,32	1,16	1,67
26	0,11	0,26	0,63	0,24	0,19	0,001	0,003	0,001	0,001	0,001	0,23	0,20	0,22	0,27	0,43
27	1,54	1,68	0,40	0,51	1,20	0,002	0,007	0,002	0,003	0,003	3,06	2,46	2,77	1,34	1,51
28	2,49	2,21	4,55	1,56	2,35	0,005	0,005	0,005	0,003	0,002	6,60	2,88	3,53	1,26	3,78

Appendix C.2a: Standard deviations of weight, diameter and open draw resistance for all laboratories (ID) as originally submitted.

	Weight					Diameter					Open Draw Resistance				
	mg					mm					mmWG				
ID	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	4,13	6,63	2,25	8,53	9,80	0,018	0,005	0,006	0,012	0,014	2,51	0,90	1,84	1,50	1,50
2	1,76	5,61	8,91	6,57	7,26	0,021	0,002	0,008	0,005	0,007	1,30	1,85	2,15	1,96	1,01
3	5,24	2,13	9,31	5,83	7,14	0,017	0,006	0,005	0,015	0,007	1,40	1,43	0,99	1,70	0,56
4	1,46	6,60	9,68	14,41	19,41	0,009	0,007	0,005	0,008	0,011	1,67	1,48	1,40	1,61	1,63
5	2,79	2,07	6,94	3,25	2,73	0,018	0,002	0,008	0,008	0,009	2,13	1,11	2,40	0,46	0,56
6	2,56	2,20	10,08	3,59	4,54	0,020	0,001	0,009	0,006	0,007	1,89	1,31	2,55	0,97	1,13
7	3,54	5,88	5,50	5,66	3,60						2,07	1,58	3,62	0,89	1,47
8	1,25	2,84	4,83	4,53	6,89	0,012	0,006	0,009	0,008	0,006	1,11	0,88	0,63	0,73	0,46
9															
10	2,14	8,31	5,51	7,64	6,36	0,005	0,007	0,004	0,003	0,007	2,78	1,72	0,78	1,22	1,62
11	1,68	3,02	6,31	3,79	4,63	0,014	0,005	0,009	0,008	0,006	1,57	1,08	1,46	1,20	1,87
12	3,12	6,88	5,23	7,48	6,66	0,014	0,007	0,004	0,006	0,010	2,27	1,60	3,64	1,18	1,65
13	2,78	3,82	2,91	3,38	7,39	0,011	0,006	0,003	0,010	0,006	1,76	1,95	1,30	0,72	1,36
14															
15	3,36	1,94	4,16	2,42	5,63	0,013	0,006	0,005	0,008	0,009	2,64	0,90	1,52	1,06	0,86
16															
17	7,76	10,21	11,28	10,93	10,19	0,020	0,008	0,018	0,006	0,005	1,75	0,96	1,38	1,28	1,30
18	6,38	2,86	5,66	12,31	7,29	0,023	0,009	0,013	0,010	0,009	3,58	1,03	2,17	1,52	0,87
19	4,14	4,31	7,03	8,99	3,08	0,001	0,007	0,005	0,004	0,006	3,22	1,98	1,43	1,79	0,65
20	7,00	5,34	5,62	8,90	8,15	0,018	0,005	0,004	0,006	0,002	1,50	2,42	0,91	1,69	1,13
21	2,48	8,43	12,65	6,06	5,28	0,006	0,009	0,005	0,007	0,008	2,28	1,40	0,82	1,80	1,14
22	3,81	4,14	3,81	6,25	6,07	0,015	0,009	0,008	0,007	0,009	2,49	1,62	3,96	0,62	1,74
23	2,18	2,65	7,48	3,22	7,77	0,013	0,004	0,009	0,006	0,008	0,92	1,02	1,29	1,76	1,07
24	2,43	6,11	13,48	3,80	6,22	0,008	0,005	0,008	0,007	0,016	1,90	1,76	0,89	0,42	0,95
25	0,54	0,46	1,74	1,20	0,58	0,006	0,006	0,004	0,008	0,010	0,93	0,23	0,91	0,87	0,98
26															
27	1,95	1,89	2,00	3,90	2,07	0,008	0,002	0,002	0,001	0,000		0,16	2,04	0,77	1,51
28	3,06	4,44	11,03	12,45	6,19	0,006	0,004	0,002	0,009	0,004	1,04	1,43	2,20	0,80	1,32

Appendix C.2b: Standard deviations of closed draw resistance and degree of filter ventilation of cigarettes for all laboratories (ID) as originally submitted.

ID	Closed Draw Resistance					Degree of Filter Ventilation				
	mg					%				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	5,58	6,70	1,97	1,24	3,10	0,50	0,54	0,84	0,70	0,45
2	2,66	5,13	1,23	2,15	0,55	0,64	0,26	0,95	0,90	0,69
3	2,78	2,22	2,78	1,48	1,81	0,29	0,49	0,52	0,80	0,28
4	4,91	4,27	2,56	2,76	3,32	0,30	0,63	0,67	0,38	0,51
5	5,31	3,55	1,50	0,58	1,87	0,31	0,41	0,60	1,02	0,60
6	3,57	4,72	2,97	1,87	0,99	0,48	0,71	0,57	0,37	0,52
7	7,72	6,35	2,92	0,70	1,71	0,42	0,29	0,58	0,38	0,39
8						0,35	0,35	0,23	0,17	0,36
9										
10	9,95	3,34	1,27	1,89	3,61	0,38	0,42	0,47	0,27	0,41
11	8,34	4,20	1,91	1,42	3,11	0,51	0,43	0,56	0,38	0,25
12	9,00	3,70	4,53	1,99	3,50	0,73	0,41	0,87	0,72	0,58
13	10,77	2,91	1,11	0,74	0,25	0,76	0,57	0,32	0,48	0,27
14										
15	4,14	1,51	1,60	2,04	2,04	0,72	0,37	0,23	0,41	0,62
16										
17	6,87	5,25	5,53	2,96	3,04	0,83	0,49	0,57	0,80	0,43
18						0,76	0,35	0,31	0,29	0,71
19	15,43	5,83	1,61	2,44	1,46	1,19	0,33	0,73	0,97	0,46
20	1,70	1,35	1,27	2,76	0,56	0,36	0,60	0,87	1,04	0,97
21	8,60	6,13	2,04	3,12	1,28	0,39	0,47	0,63	0,57	0,53
22	8,79	4,15	2,82	0,99	2,55	0,81	0,49	1,28	0,46	0,41
23	3,63	3,00	2,04	2,44	2,25	0,45	0,68	0,26	0,33	0,42
24						0,64	0,61	0,58	0,25	0,41
25	0,58	0,52	2,03	0,67	1,62	0,34	0,46	0,17	0,27	0,28
26										
27		0,45	1,20	1,14	1,49		0,51	0,32	0,49	0,44
28	4,01	4,05	2,44	1,28	1,52	0,31	0,60	0,54	0,30	0,34

Appendix C.3: Standard deviations of weight, diameter and pressure drop for filter rods over all laboratories (ID) after outlier testing by Grubbs' test on individual values.

ID	Weight mg F1	F2	F3	F4	F5	Diameter mm F1	F2	F3	F4	F5	Pressure Drop mmWG F1	F2	F3	F4	F5
1	2,91	2,28	2,55	1,97	2,28	0,008	0,004	0,004	0,003	0,003					
2	6,48	0,82	1,71	1,51	3,36	0,012	0,008	0,003	0,005	0,003					
3															
4															
5															
6	1,99	1,27	1,54	2,68	3,88	0,003	0,005	0,006	0,004	0,002	4,63	5,07	2,14	2,64	2,60
7	2,31	0,49	1,56	1,51	4,11						7,68	8,37	4,94	1,87	3,09
8															
9	2,02	1,51	3,36	3,56	2,96	0,002	0,002	0,005	0,005	0,003	9,70	6,50	3,33	5,17	2,97
10	1,91	2,03	3,92	0,92	3,23	0,002	0,005	0,006	0,002	0,006	2,79	4,93	3,93	2,08	4,18
11	0,34	1,93	2,03	1,97	2,95	0,003	0,006	0,003	0,004	0,003	0,82	7,37	2,80	3,68	4,65
12			4,58	0,35	2,12			0,007	0,004	0,002			3,11	1,81	4,39
13	0,80	1,85	3,18	0,97	4,26	0,002	0,010	0,003	0,003	0,004	5,31	4,61	3,26	4,03	4,59
14	4,53	1,96	4,79	2,41	2,85	0,004	0,005	0,004	0,004	0,003	6,45	4,47	3,68	3,53	4,28
15	2,47	1,76	6,32	1,66	3,05	0,008	0,004	0,008	0,005	0,004	6,30	3,20	3,80	2,44	4,64
16			3,22	2,01	2,20			0,004	0,002	0,003			2,21	2,04	3,38
17	1,98	2,22	2,43	3,57	3,63	0,005	0,006	0,005	0,005	0,007	6,55	8,46	1,68	3,93	3,61
18	6,14	2,48	0,92	3,16	3,10	0,003	0,010	0,004	0,002	0,002	12,22	8,10	1,59	2,30	2,95
19															
20	4,00	0,93	3,08	2,32	3,89	0,004	0,005	0,003	0,010	0,002	8,76	7,68	2,75	5,08	1,43
21	1,19	0,70	2,27	2,36	2,92	0,002	0,005	0,003	0,005	0,005	3,28	3,54	1,87	2,53	5,73
22	2,02	1,50	3,50	2,87	1,18	0,002	0,003	0,006	0,005	0,003	7,30	5,05	2,68	1,53	2,43
23															
24	5,54	1,95	0,89	2,88	1,58	0,001	0,005	0,002	0,004	0,003	1,18	5,25	0,51	1,58	5,61
25	1,29	0,68	1,54	1,11	1,31	0,002	0,009	0,007	0,005	0,006	1,24	2,26	1,32	1,16	1,67
26	0,11	0,26	0,63	0,24	0,19	0,001	0,003	0,001	0,001	0,001	0,23	0,20	0,22	0,27	0,43
27	1,54	1,68	0,40	0,51	1,20	0,002	0,007	0,002	0,003	0,003	3,06	2,46	2,77	1,34	1,51
28	2,49	2,21	4,55	1,56	2,35	0,004	0,005	0,005	0,003	0,002	6,60	2,88	3,53	1,26	3,78

Appendix C.4a: Standard deviations of weight, diameter and open draw resistance for all laboratories (ID) after outlier testing by Grubbs' test on individual values.

	Weight					Diameter					Open Draw Resistance				
	mg					mm					mmWG				
ID	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	4,13	6,63	2,25	8,54	9,80	0,020	0,005	0,006	0,012	0,014	2,51	0,90	1,84	0,83	1,50
2	1,76	5,61	8,91	6,57	7,26	0,021	0,002	0,008	0,005	0,007	1,30	1,85	2,15	1,96	0,92
3	5,24	2,13	9,31	5,83	7,14	0,017	0,005	0,005	0,015	0,007	1,40	1,43	0,99	1,70	0,56
4	1,46	6,60	9,68	14,41	19,41	0,009	0,007	0,005	0,011	0,011	1,67	1,48	1,40	1,61	1,63
5	2,79	2,07	6,94	3,25	2,73	0,018	0,002	0,008	0,008	0,009	2,13	1,11	2,40	0,46	0,56
6	2,56	2,20	10,08	3,59	4,54	0,020	0,001	0,009	0,006	0,007	1,89	1,31	2,55	0,97	1,13
7	3,54	5,88	5,50	5,66	3,60						2,07	1,58	2,52	0,89	1,47
8	1,25	2,84	4,83	4,53	6,89	0,012	0,006	0,009	0,008	0,006	1,11	0,88	0,63	0,73	0,46
9															
10	2,14	8,31	5,51	7,64	6,36	0,005	0,007	0,004	0,003	0,007	2,78	1,72	0,78	1,22	1,62
11	1,68	3,02	6,31	3,79	4,63	0,014	0,005	0,009	0,008	0,006	1,57	1,08	1,46	1,20	1,87
12	3,12	6,88	4,99	7,48	6,66	0,014	0,007	0,004	0,006	0,010	2,27	1,60	3,64	1,18	1,65
13	2,78	4,34	2,91	3,38	7,39	0,011	0,006	0,003	0,010	0,006	1,76	1,95	1,30	0,72	1,36
14															
15	3,36	1,94	4,16	2,42	5,63	0,013	0,006	0,005	0,008	0,009	2,64	0,90	1,52	1,06	0,86
16															
17	7,76	10,21	11,28	10,93	10,19	0,020	0,008	0,018	0,006	0,005	1,75	0,96	1,38	1,28	1,30
18	6,38	2,86	5,66	12,31	7,29	0,026	0,009	0,013	0,010	0,009	3,58	1,03	2,17	1,52	0,87
19	4,14	6,14	7,03	8,99	3,08	0,001	0,007	0,006	0,004	0,006	3,22	1,98	1,43	1,65	0,65
20	7,00	5,34	5,62	8,90	8,15	0,018	0,005	0,004	0,006	0,002	1,50	2,42	0,91	1,69	1,13
21	2,48	8,43	12,65	6,06	5,28	0,006	0,009	0,005	0,007	0,008	2,28	1,40	0,82	1,80	1,14
22	3,81	4,14	3,81	6,25	7,54	0,015	0,009	0,008	0,007	0,009	2,49	1,62	1,62	0,62	1,74
23	2,18	2,65	7,48	3,22	7,77	0,013	0,004	0,009	0,006	0,008	0,92	1,02	1,29	1,76	1,07
24	2,43	6,11	13,48	3,80	6,22	0,008	0,005	0,008	0,007	0,016	1,90	1,76	0,89	0,42	0,95
25	0,54	0,46	1,74	1,20	0,58	0,005	0,006	0,004	0,008	0,010	0,93	0,23	0,91	0,87	0,98
26															
27	1,95	1,89	1,92	3,90	2,07	0,008	0,002	0,002	0,001	0,000		0,16	2,04	0,77	1,51
28	3,06	4,44	11,03	12,45	6,37	0,006	0,004	0,002	0,009	0,004	1,04	1,43	2,20	0,80	1,32

Appendix C.4b: Standard deviations of closed draw resistance and degree of filter ventilation of cigarettes for all laboratories (ID) after outlier testing by Grubbs' test on individual values.

ID	Closed Draw Resistance mg					Degree of Filter Ventilation %				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	5,58	6,70	1,97	1,24	3,10	0,50	0,54	0,84	0,34	0,24
2	2,66	5,13	1,23	2,15	0,55	0,64	0,26	0,95	0,90	0,69
3	2,78	2,22	2,78	1,48	2,32	0,29	0,49	0,52	0,80	0,28
4	4,91	4,27	2,56	2,76	3,32	0,30	0,63	0,39	0,38	0,51
5	5,31	3,55	1,50	0,58	1,87	0,31	0,41	0,69	1,02	0,60
6	3,57	4,72	2,97	1,87	0,99	0,48	0,71	0,57	0,37	0,52
7	7,72	6,35	2,92	0,70	2,29	0,42	0,29	0,58	0,34	0,39
8						0,35	0,49	0,23	0,17	0,36
9										
10	9,95	3,13	1,27	1,89	3,61	0,38	0,42	0,47	0,27	0,41
11	8,34	4,20	1,91	1,42	3,11	0,51	0,43	0,56	0,38	0,25
12	9,00	3,70	4,53	1,99	3,50	0,73	0,41	0,90	0,72	0,58
13	10,77	2,91	1,11	0,74	0,25	0,76	0,57	0,32	0,48	0,27
14										
15	4,14	1,51	1,60	2,04	2,04	0,72	0,37	0,23	0,41	0,68
16										
17	6,87	5,25	5,53	2,96	3,04	0,83	0,49	0,57	0,80	0,43
18						0,76	0,32	0,31	0,29	0,71
19	15,43	5,83	1,61	2,44	1,46	1,19	0,33	0,73	0,97	0,46
20	1,70	1,35	1,27	2,76	0,56	0,36	0,60	0,87	1,04	0,97
21	8,60	6,13	2,04	3,12	1,28	0,39	0,47	0,72	0,57	0,53
22	8,79	4,15	2,56	0,99	2,55	0,81	0,49	0,35	0,46	0,41
23	3,63	3,00	2,04	2,44	2,25	0,45	0,68	0,26	0,25	0,42
24						0,64	0,43	0,58	0,25	0,41
25	0,58	0,52	2,03	0,67	1,62	0,34	0,46	0,17	0,27	0,28
26										
27		0,45	1,20	1,19	1,49		0,51	0,32	0,49	0,44
28	4,01	4,05	2,44	1,28	1,52	0,41	0,60	0,54	0,30	0,34

APPENDIX D – Results for Filter Rods (Diagrams)

Appendix D.1: Weights of filter rods F1-F5

F1: Weight (Mean±95% CI)

F2: Weight (Mean±95% CI)

F3: Weight (Mean±95% CI)

F4: Weight (Mean±95% CI)

F5: Weight (Mean±95% CI)
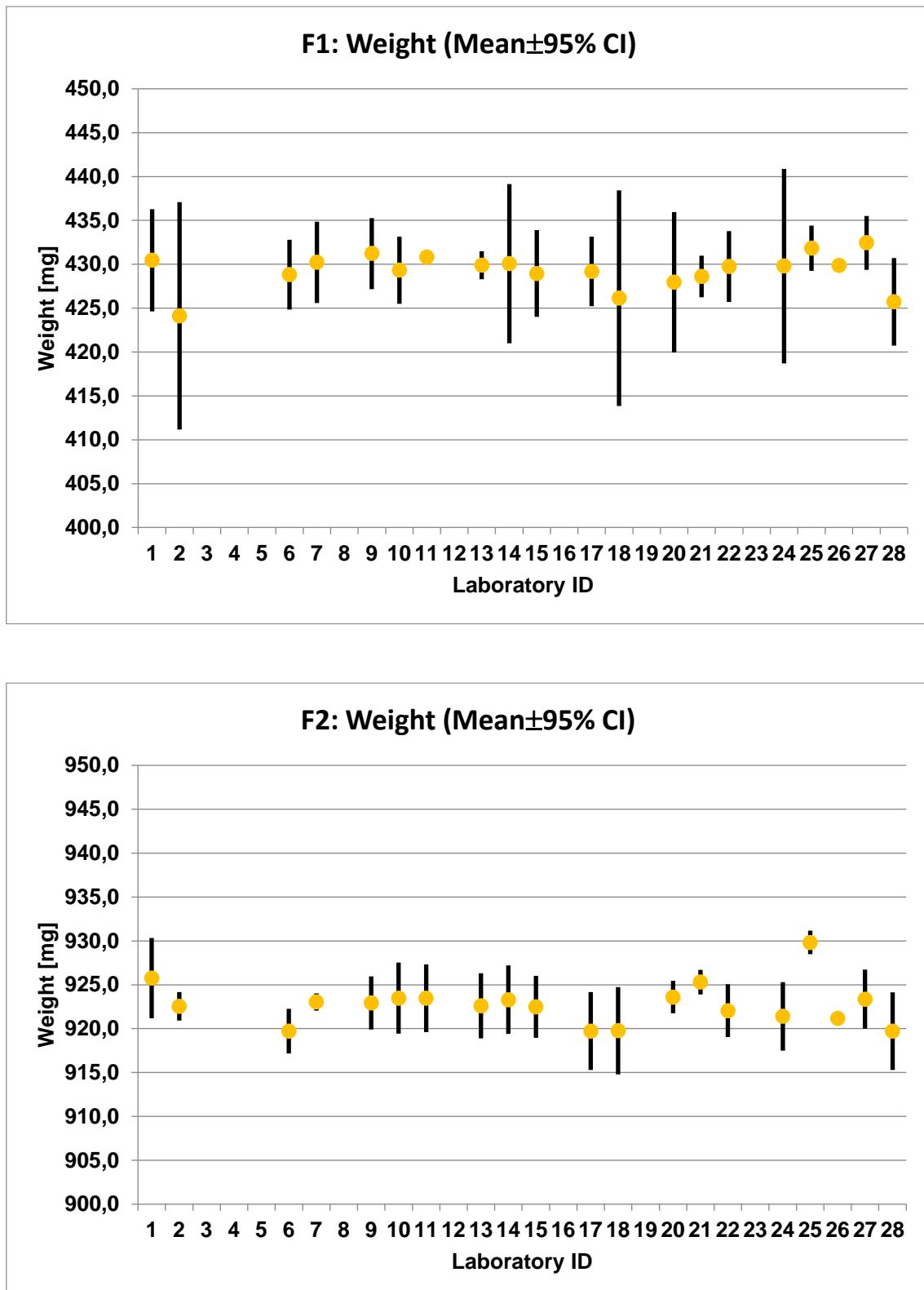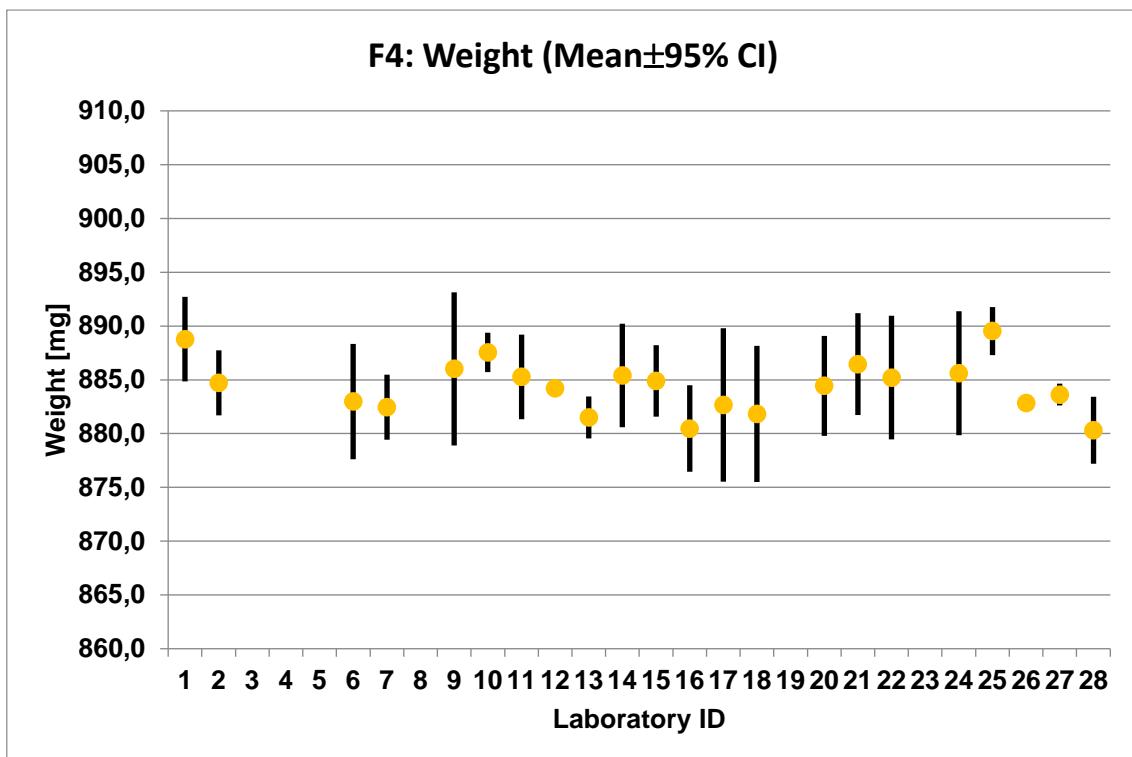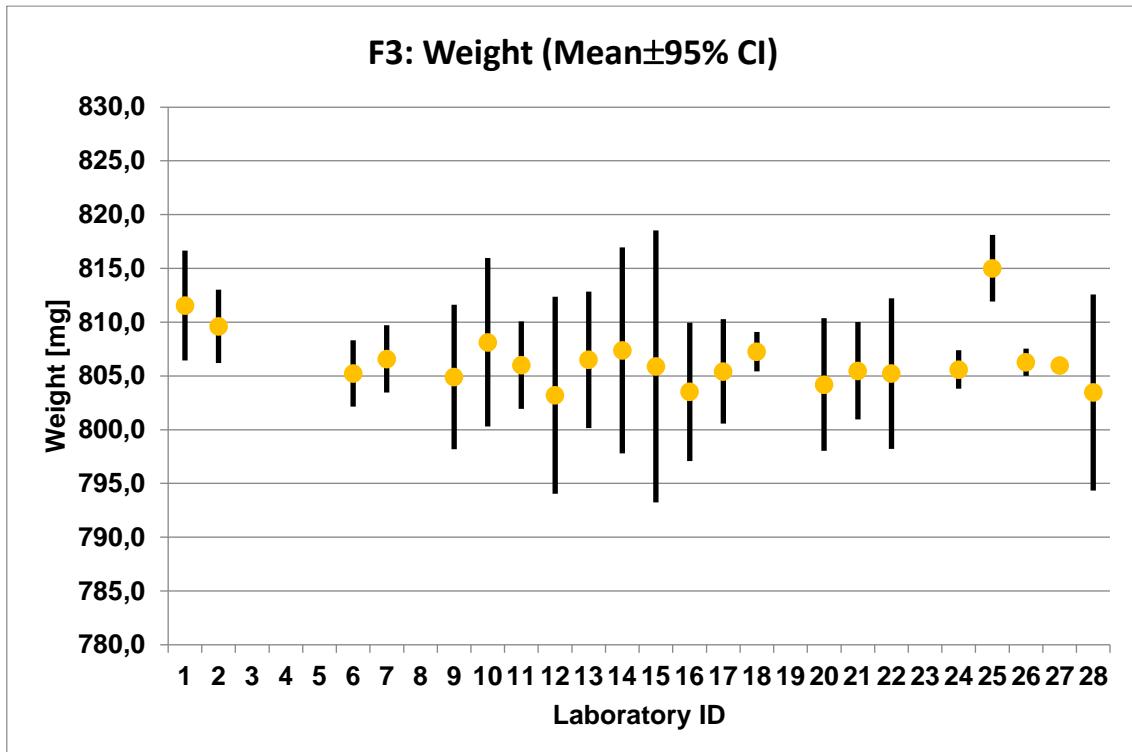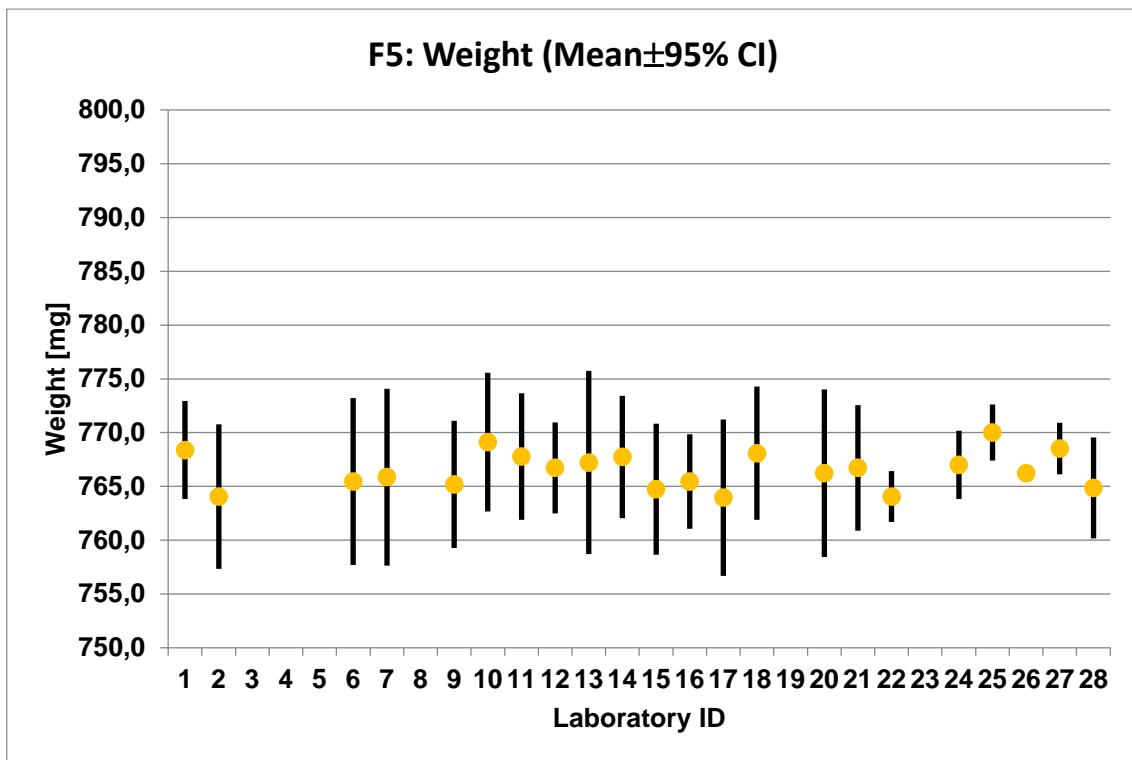
Appendix D.2: Diameters of filter rods F1-F5

F1: Diameter (Mean±95% CI)
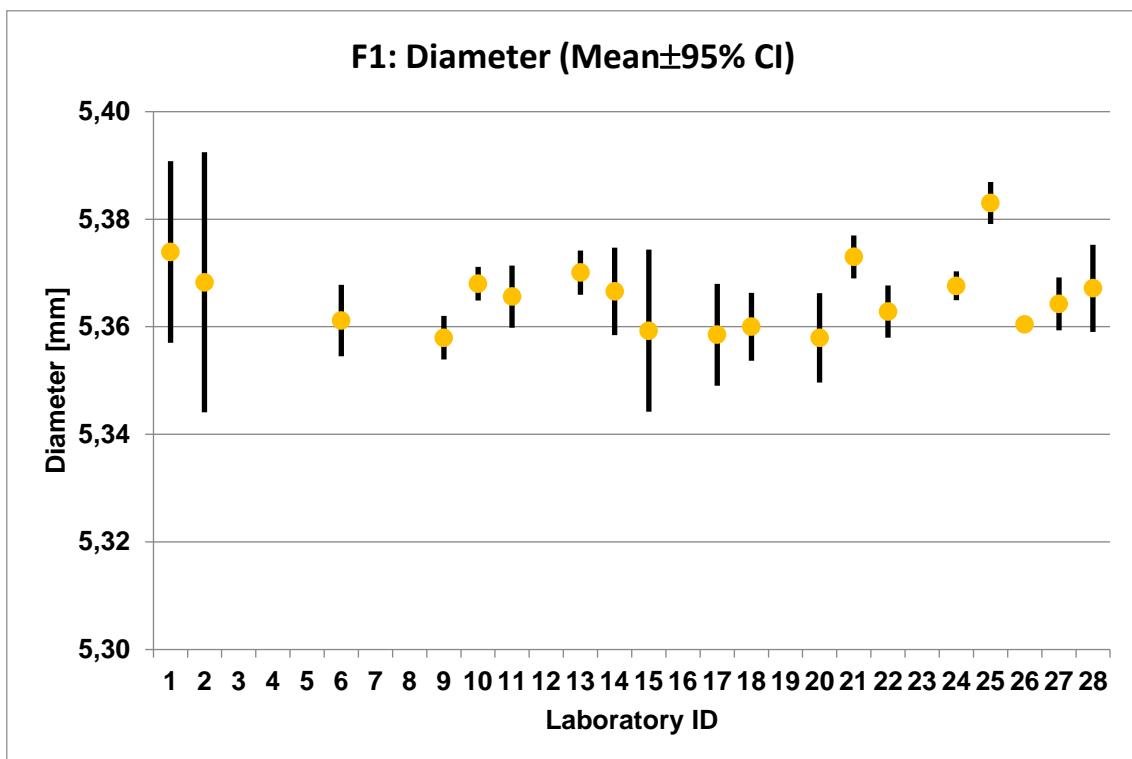
F2: Diameter (Mean±95% CI)
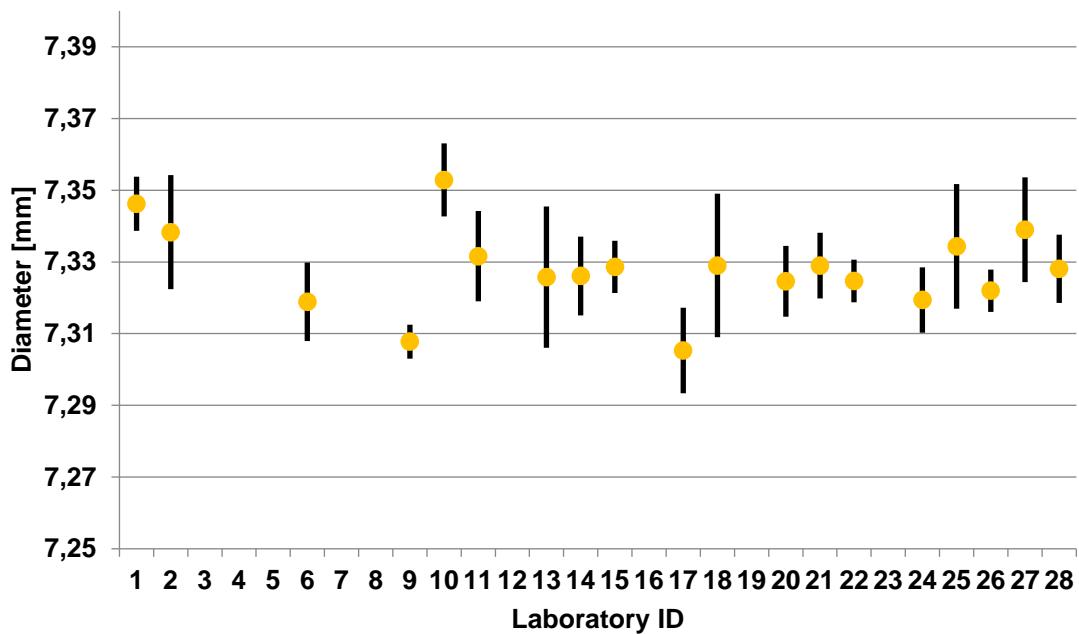
F3: Diameter (Mean±95% CI)
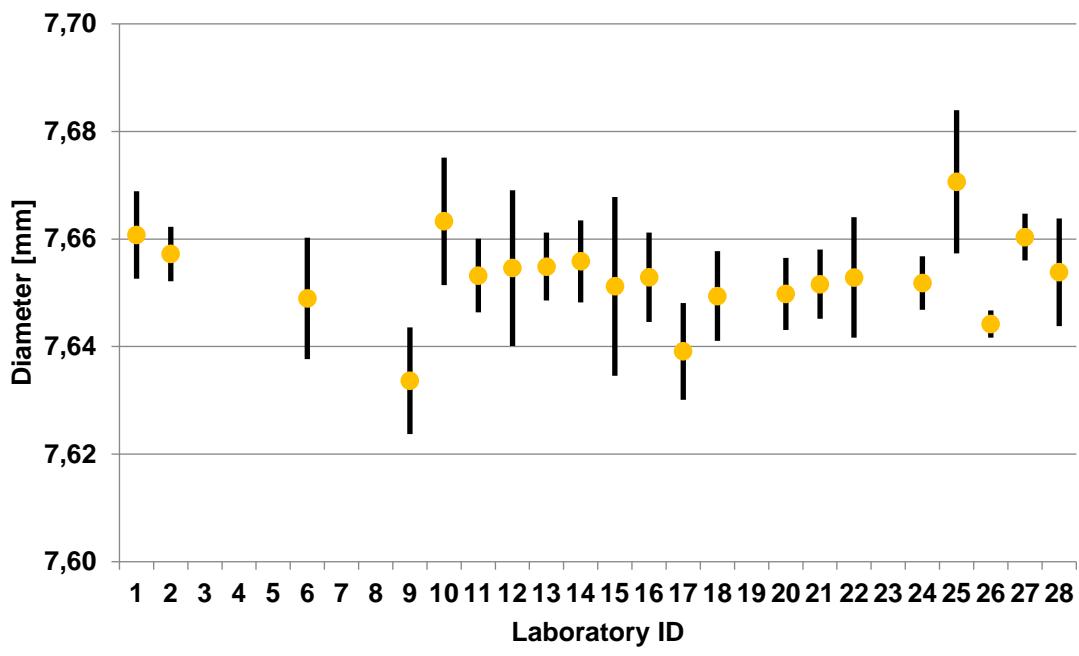
F4: Diameter (Mean±95% CI)
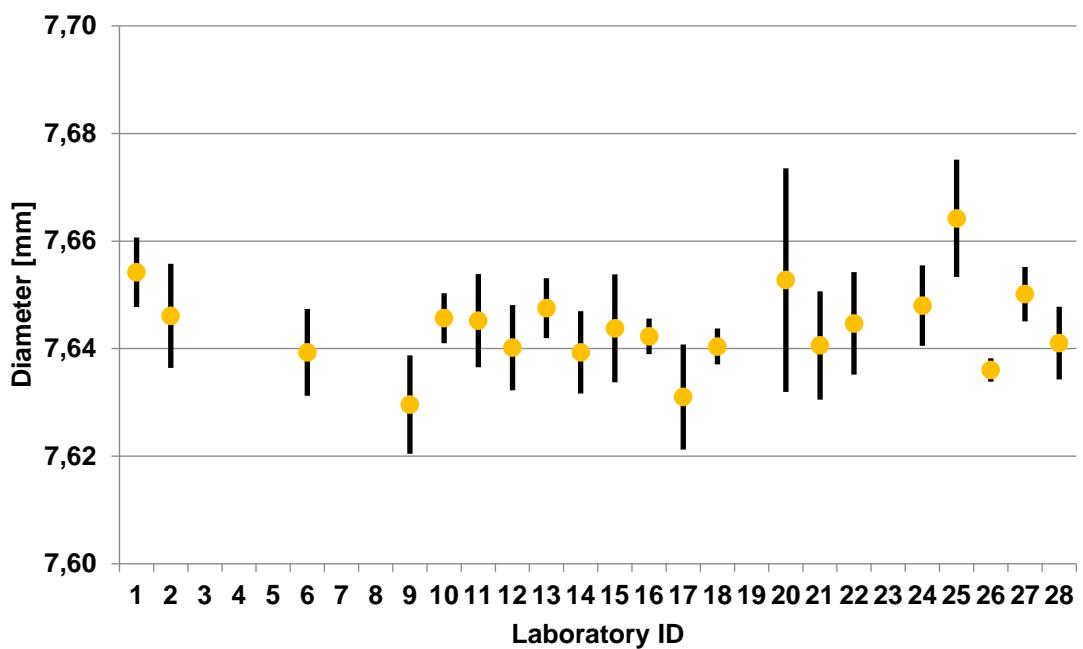
F5: Diameter (Mean±95% CI)
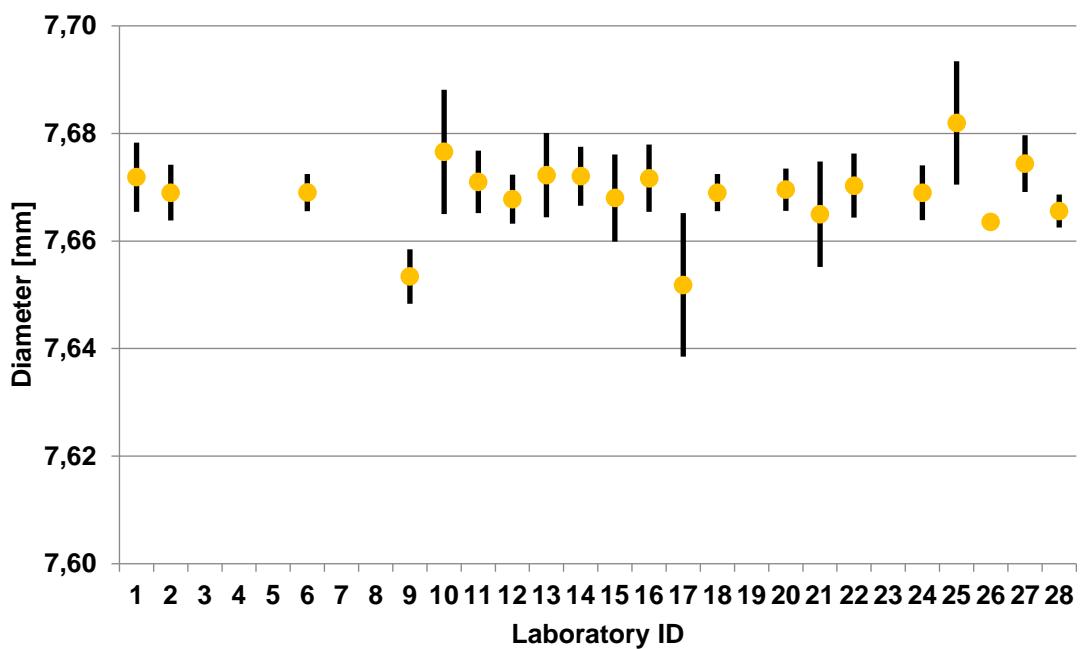
Appendix D.3: Fully encapsulated pressure drops of filter rods F1-F5

F1: Pressure Drop (Mean±95% CI)

F2: Pressure Drop (Mean±95% CI)
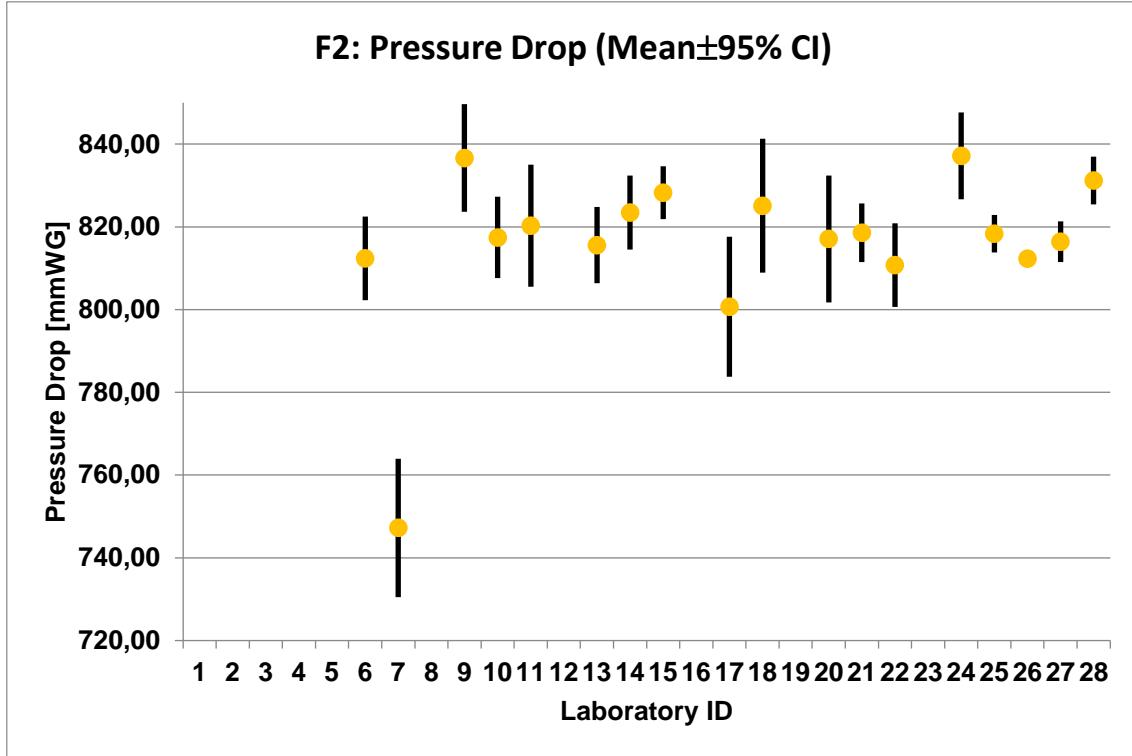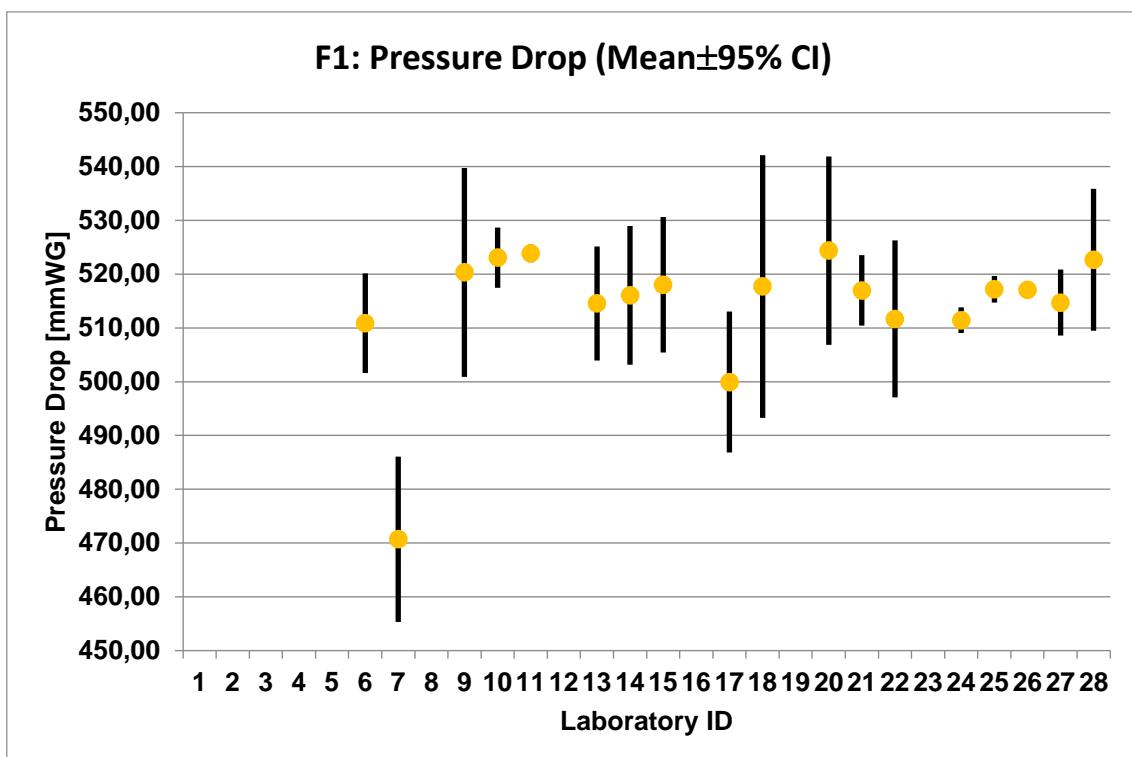
F3: Pressure Drop (Mean±95% CI)
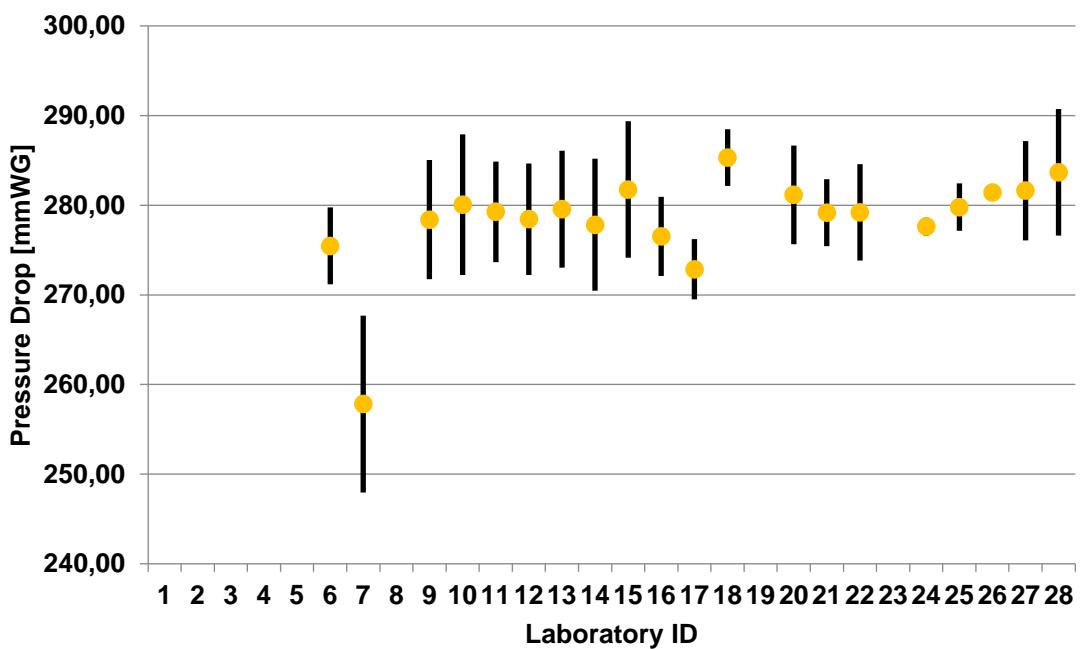
F4: Pressure Drop (Mean±95% CI)
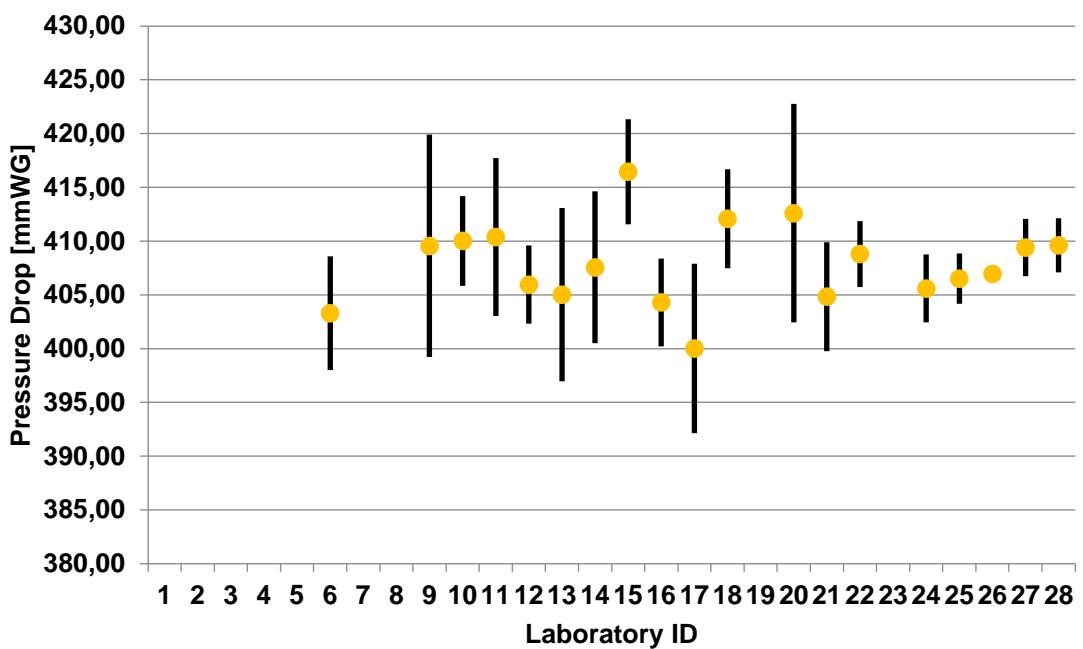
F5: Pressure Drop (Mean±95% CI)
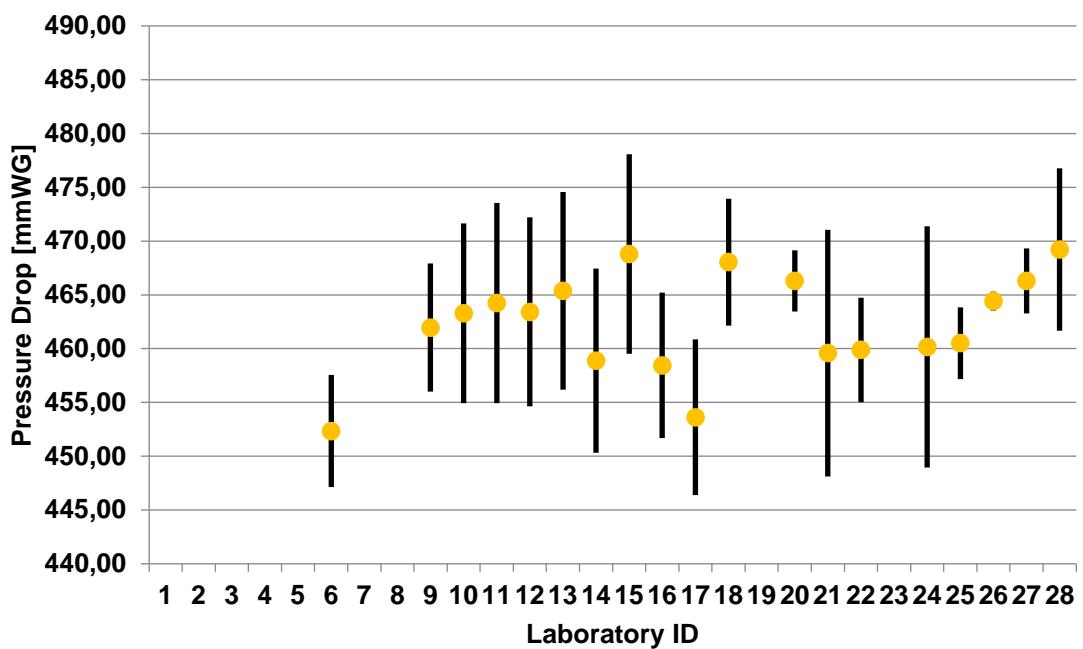
APPENDIX E – Results for Cigarettes (Diagrams)

Appendix E.1: Weights of cigarettes C1-C5

C1: Weight (Mean±95% CI)

C2: Weight (Mean±95% CI)

C3: Weight (Mean±95% CI)

C4: Weight (Mean±95% CI)

C5: Weight (Mean±95% CI)
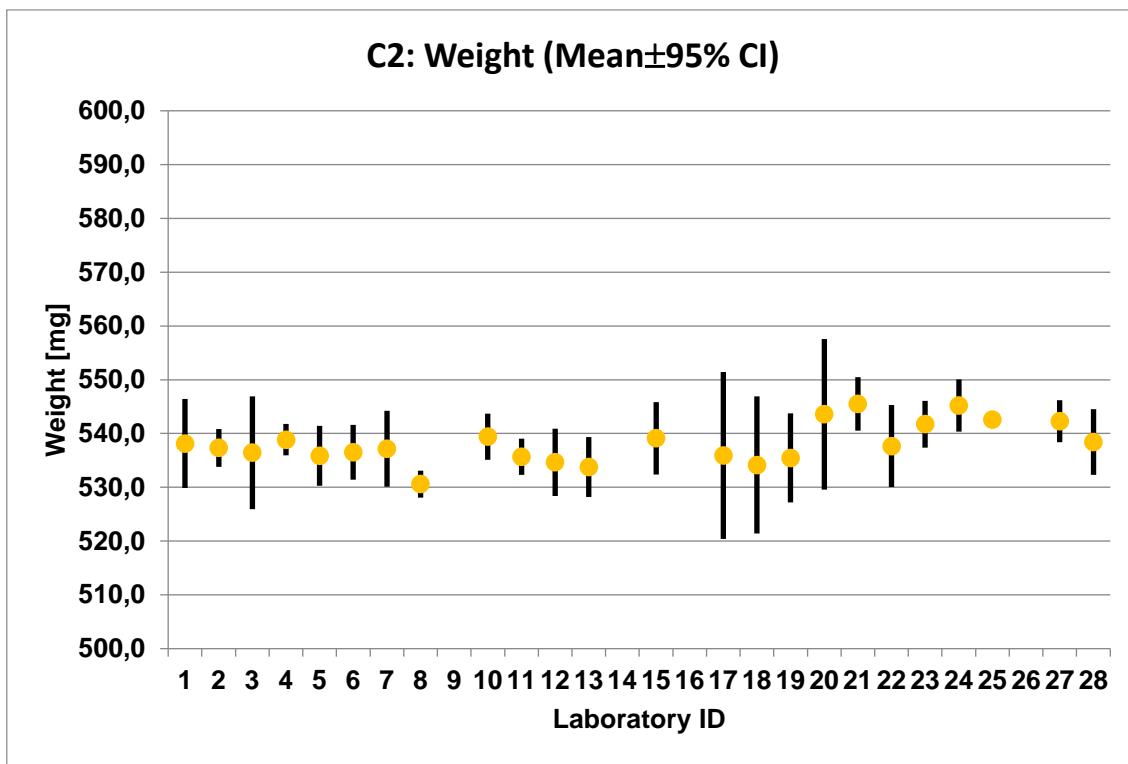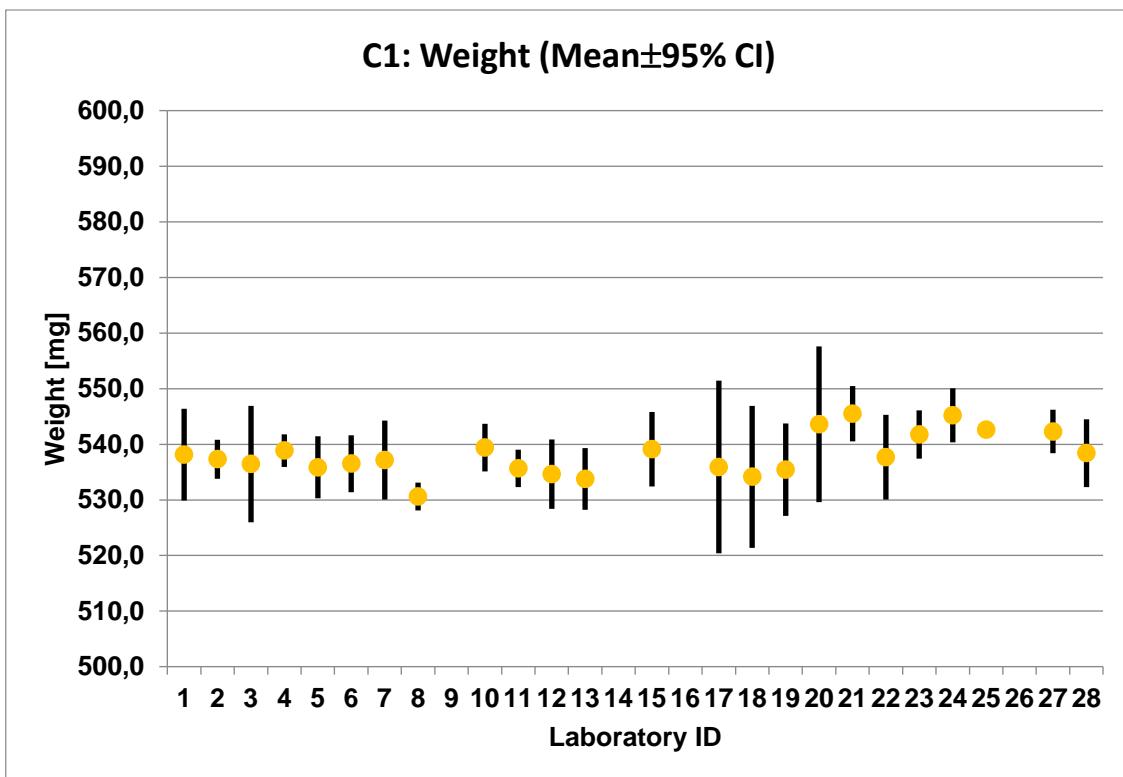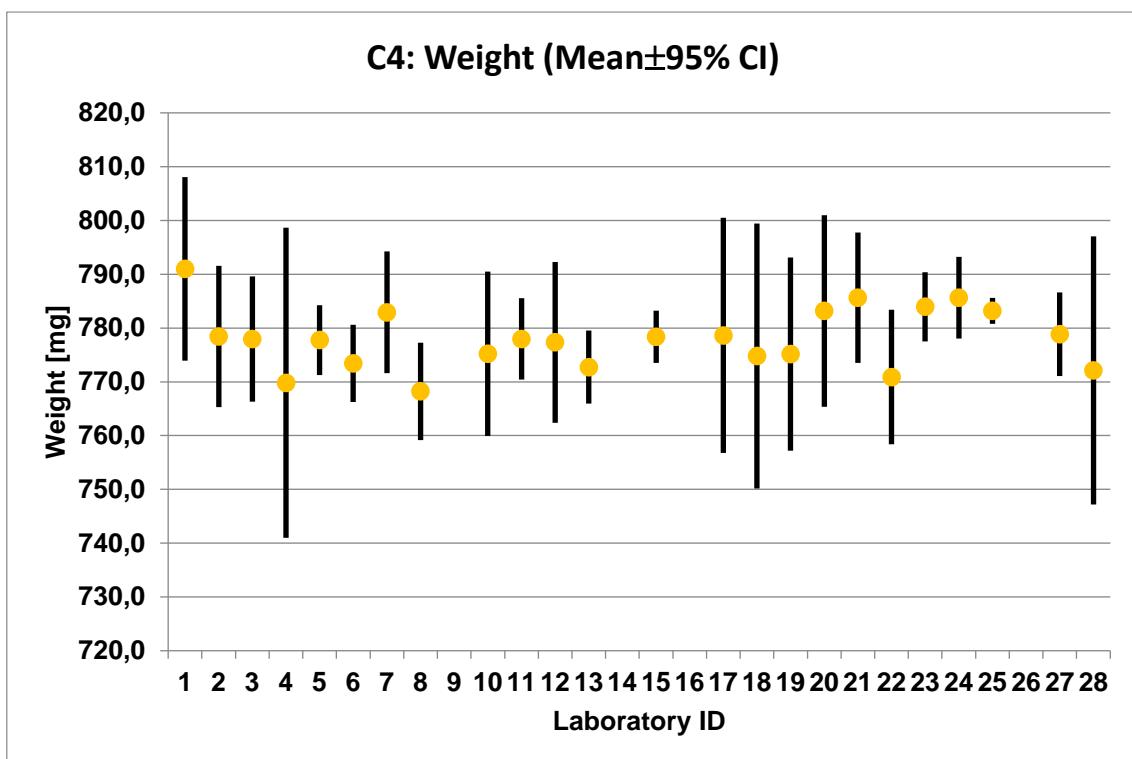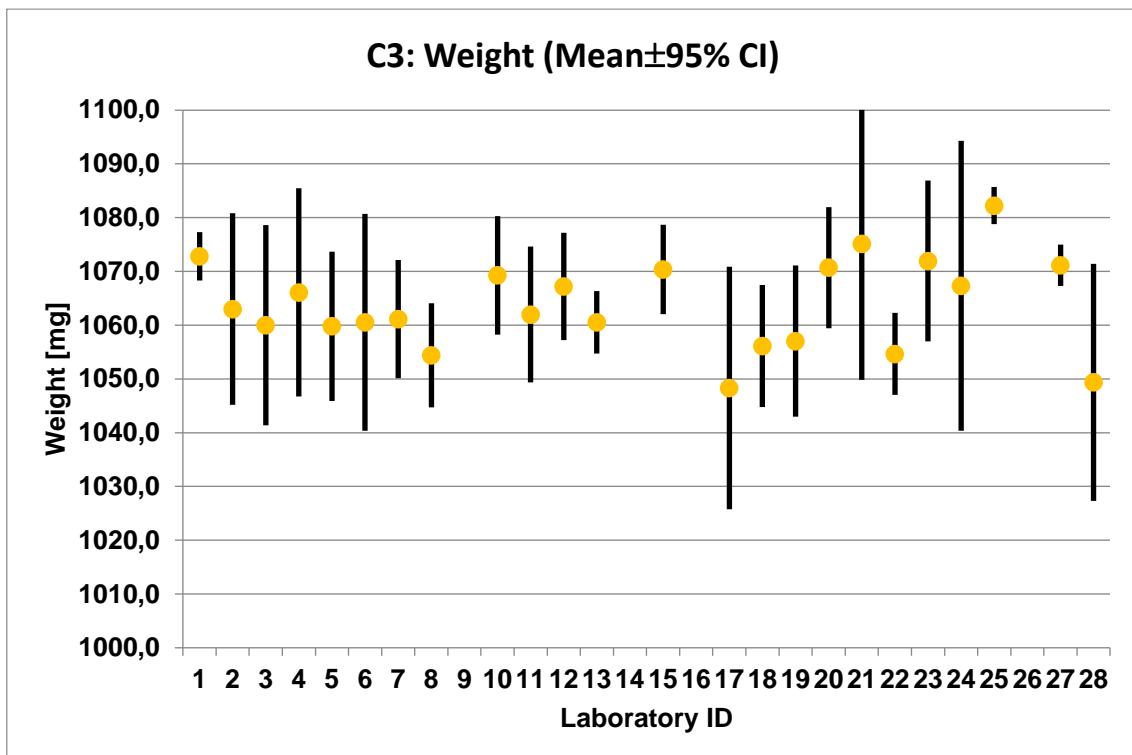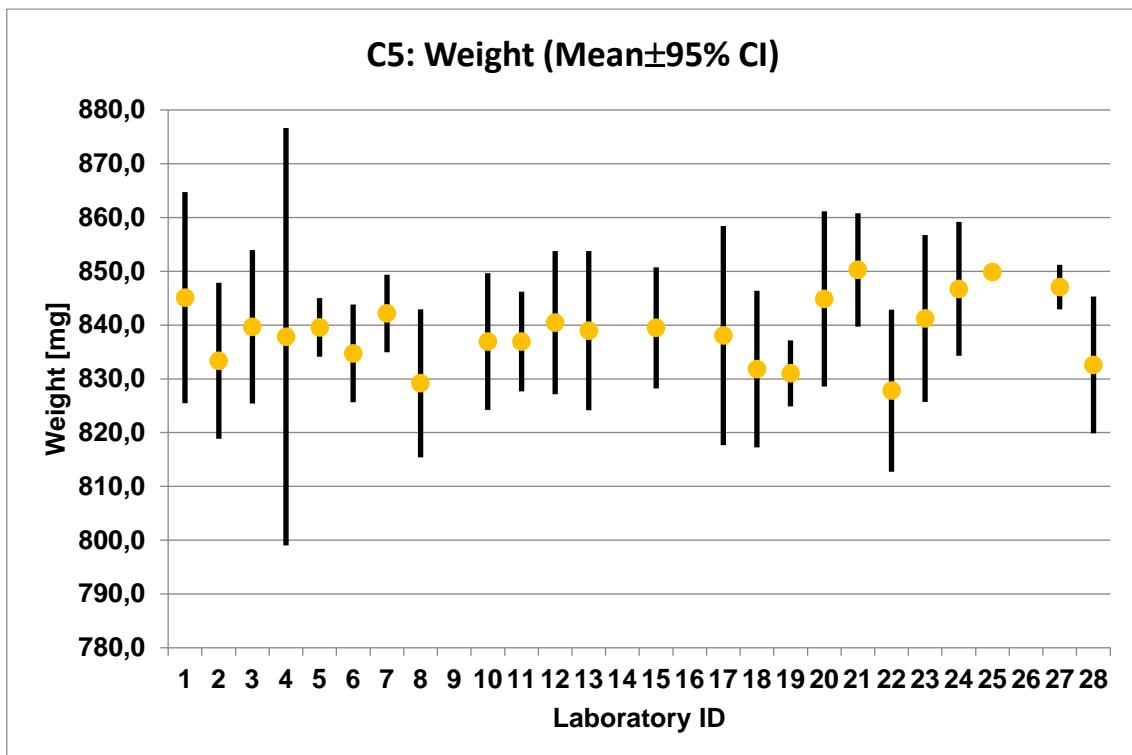
Appendix E.2: Diameters of cigarettes C1-C5

C1: Diameter (Mean±95% CI)

C2: Diameter (Mean±95% CI)

C3: Diameter (Mean±95% CI)

C4: Diameter (Mean±95% CI)

C5: Diameter (Mean±95% CI)
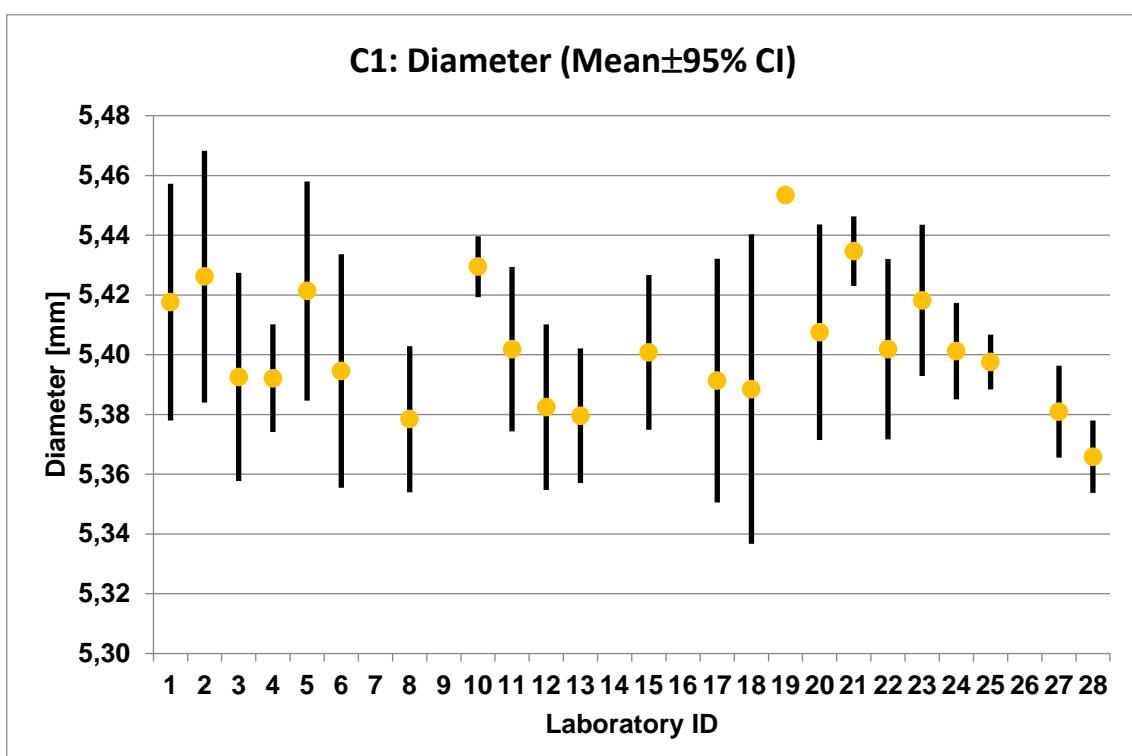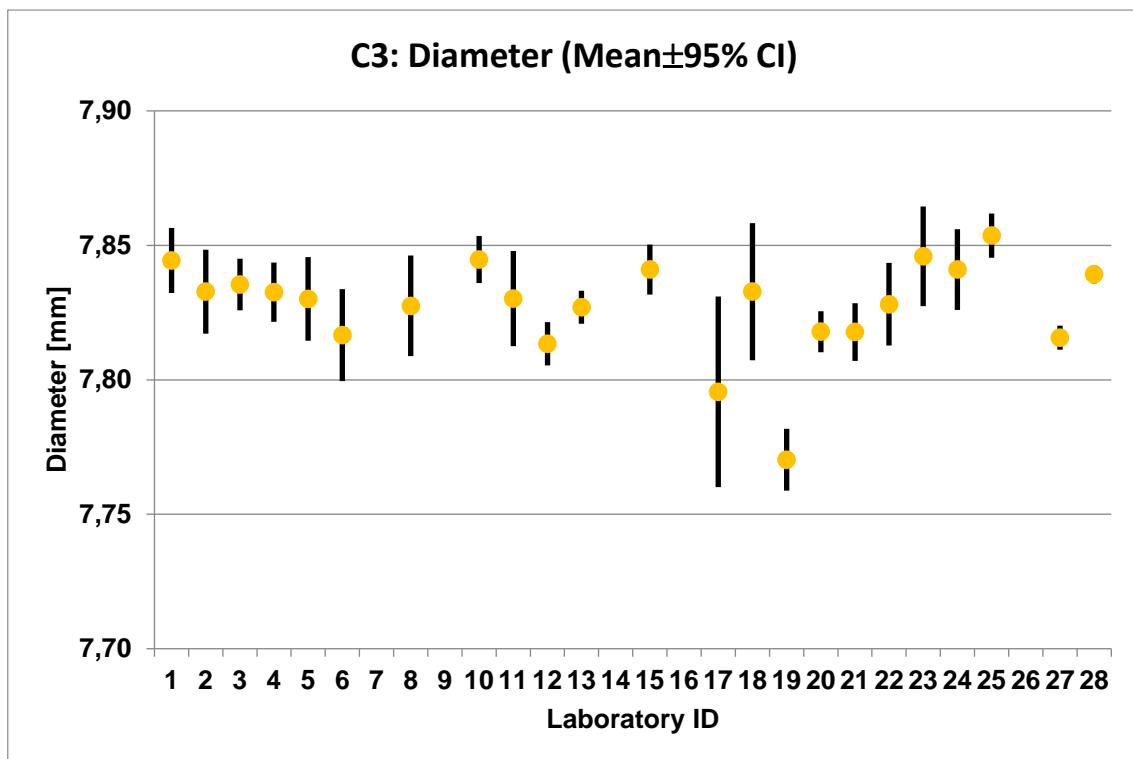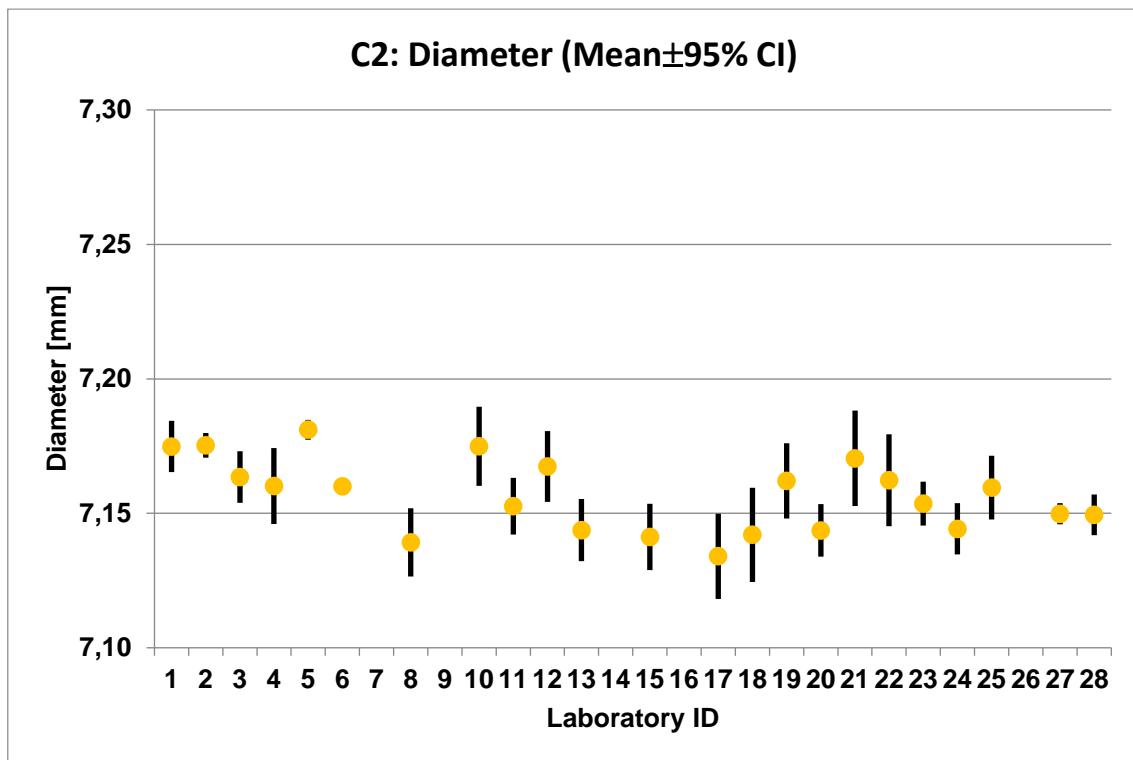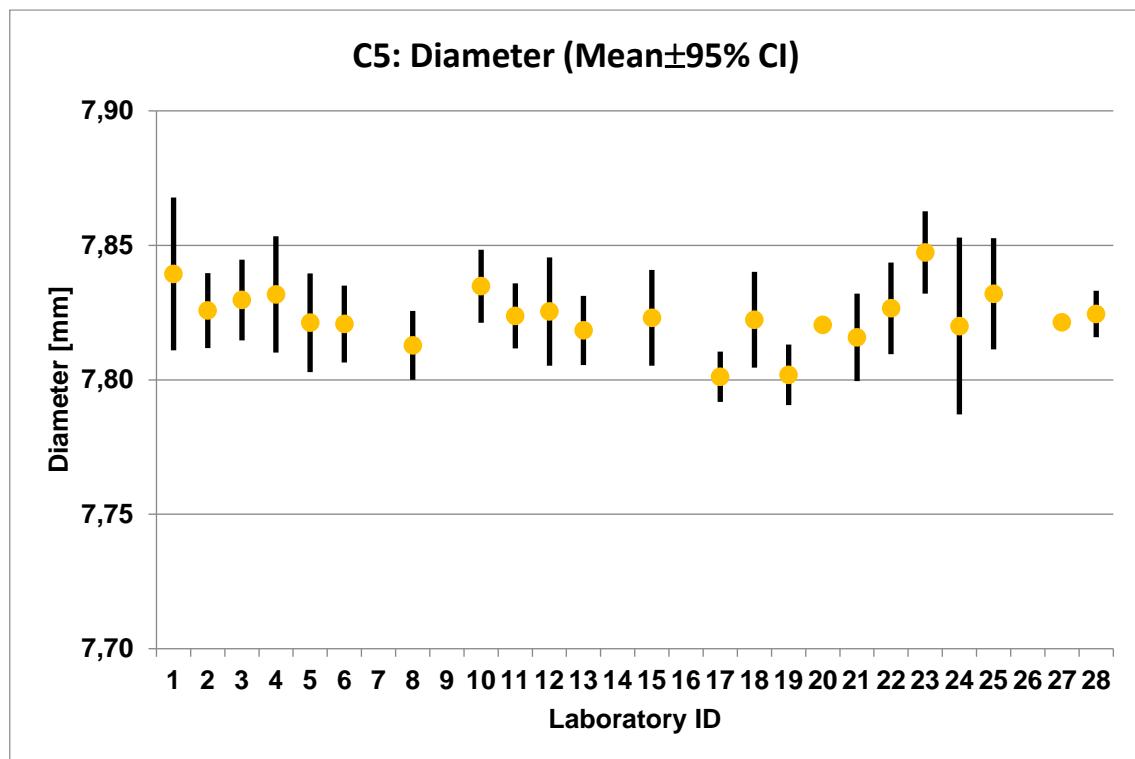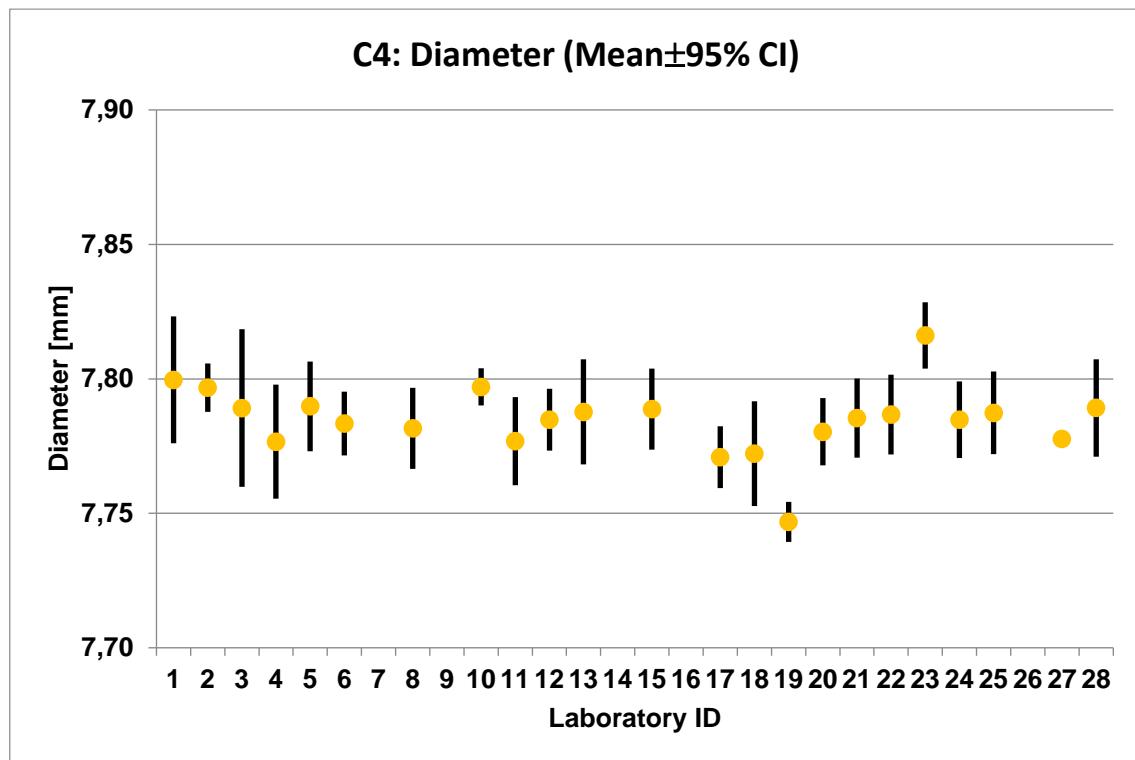
Appendix E.3: Open draw resistances of cigarettes C1-C5

C1: Open Draw Resistance (Mean±95% CI)

C2: Open Draw Resistance (Mean±95% CI)
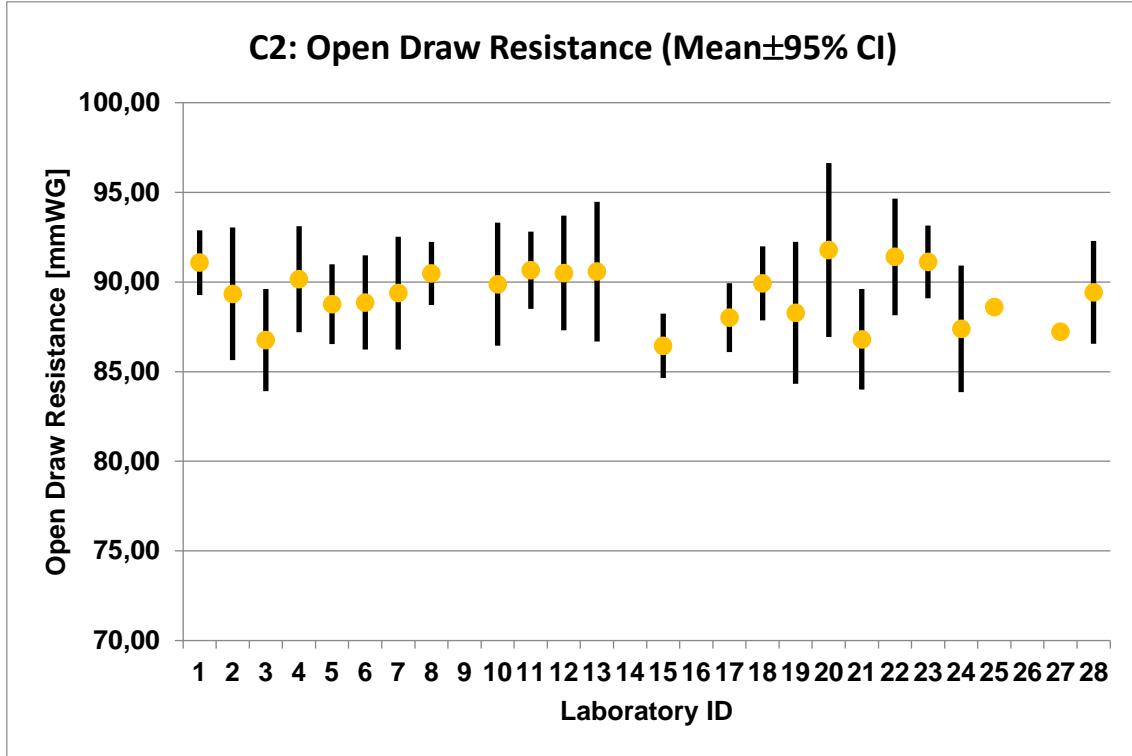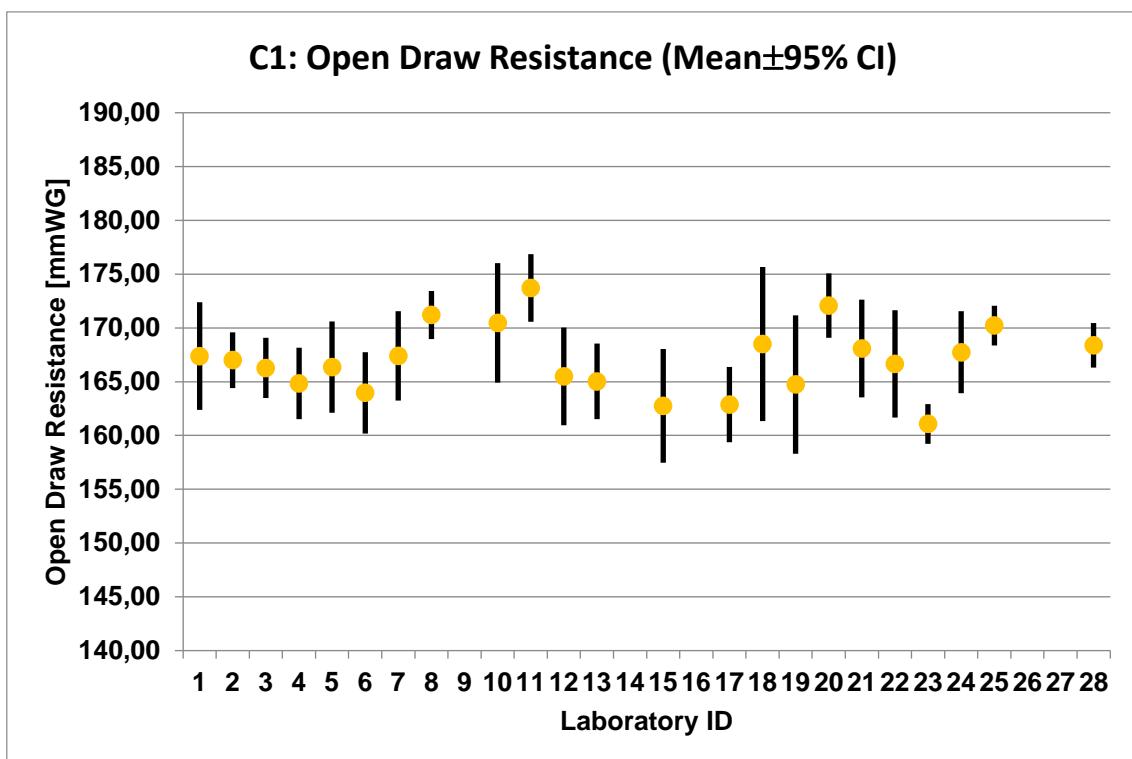
C3: Open Draw Resistance (Mean±95% CI)

C4: Open Draw Resistance (Mean±95% CI)
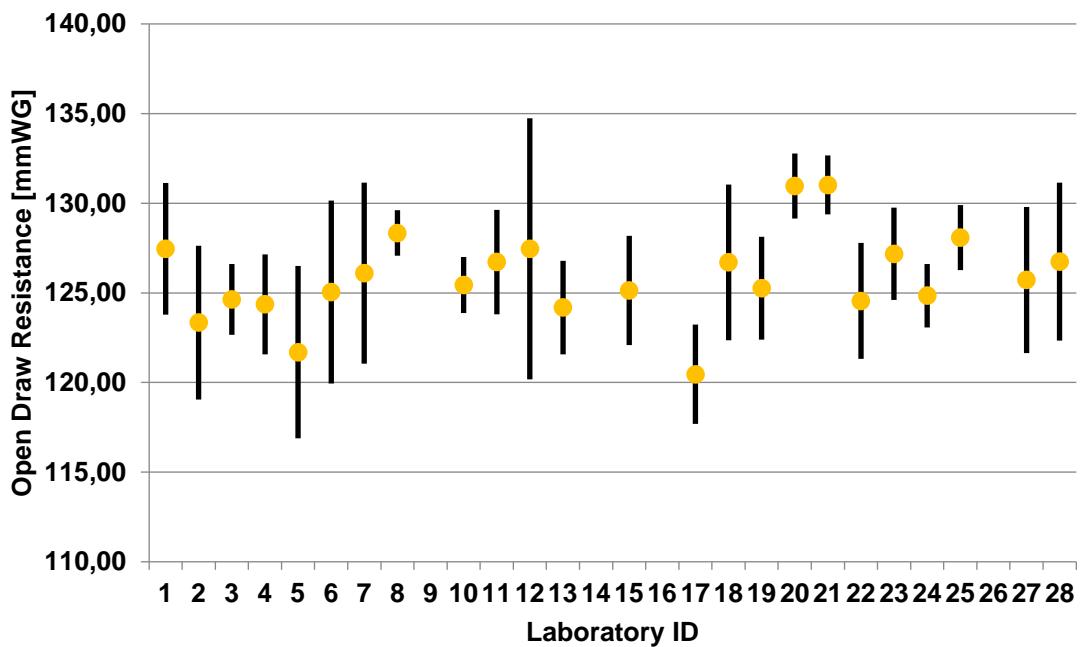
C5: Open Draw Resistance (Mean±95% CI)
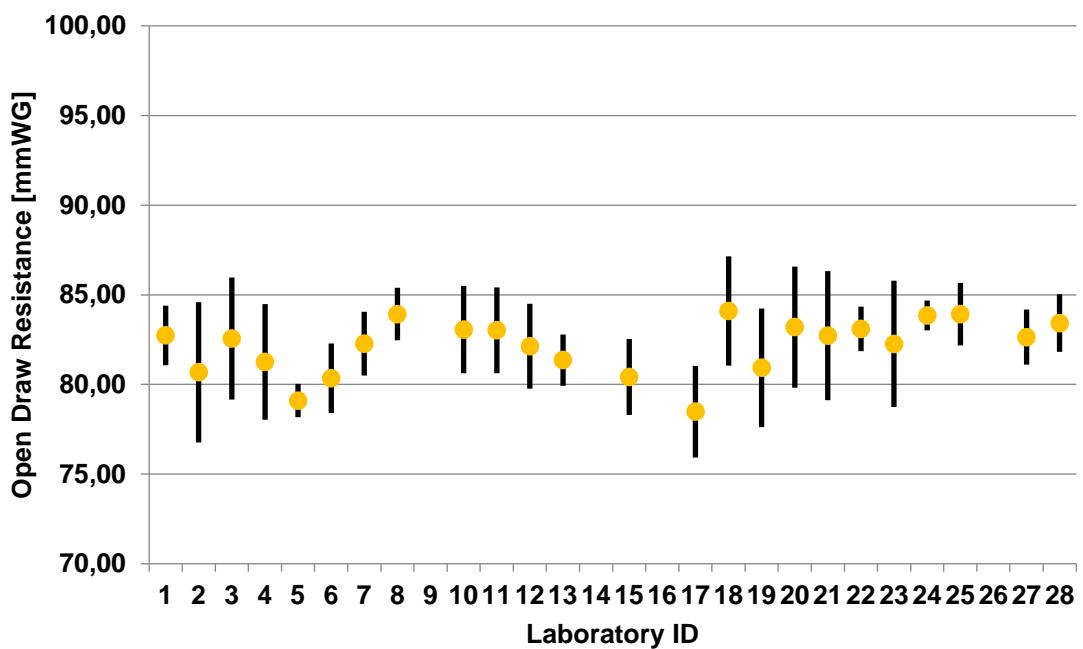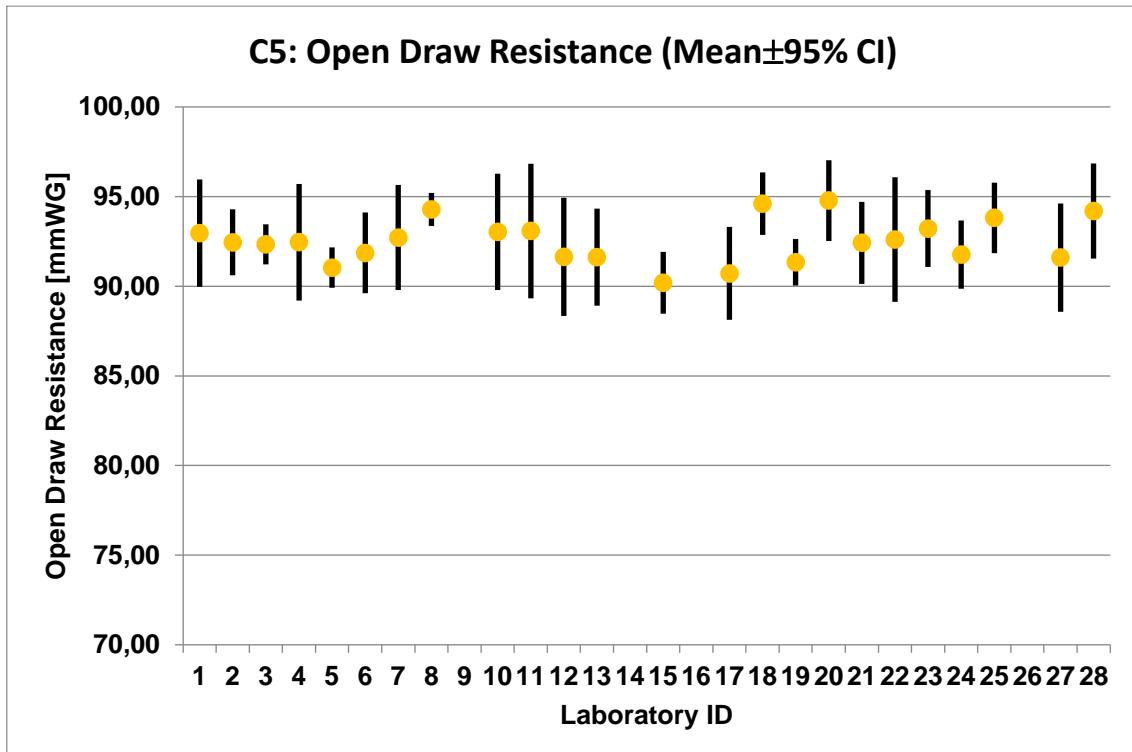
Appendix E.4: Closed draw resistances of cigarettes C1-C5

C1: Closed Draw Resistance (Mean±95% CI)
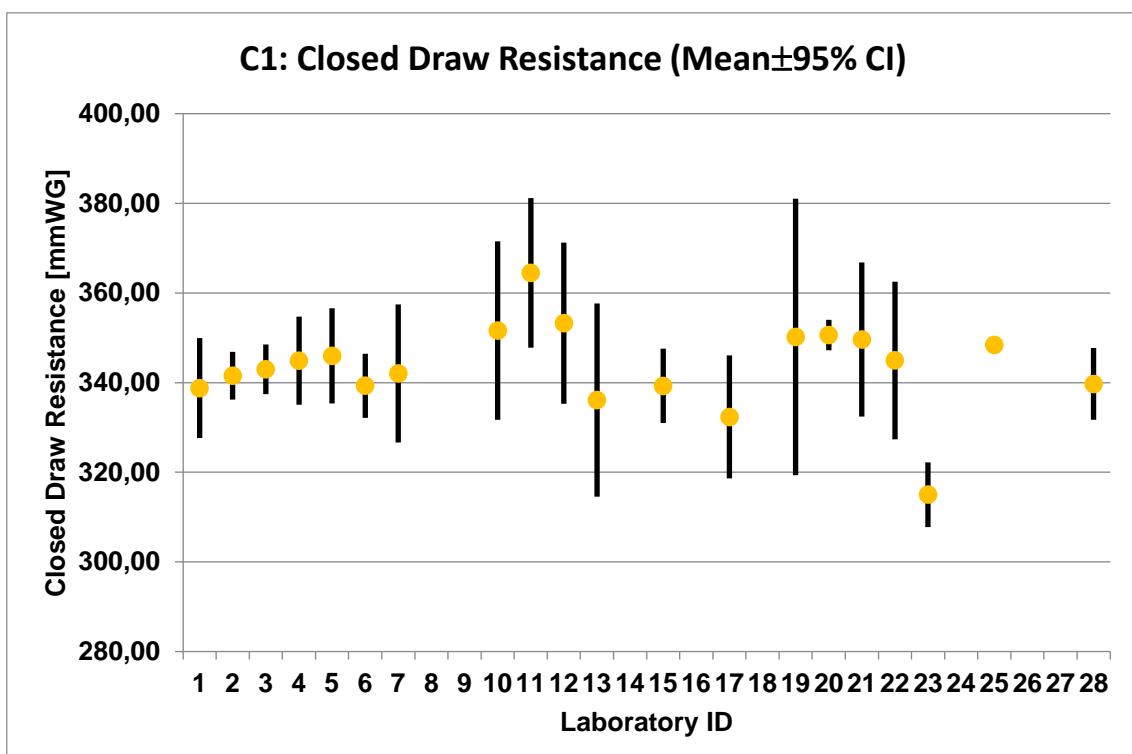
C2: Closed Draw Resistance (Mean±95% CI)
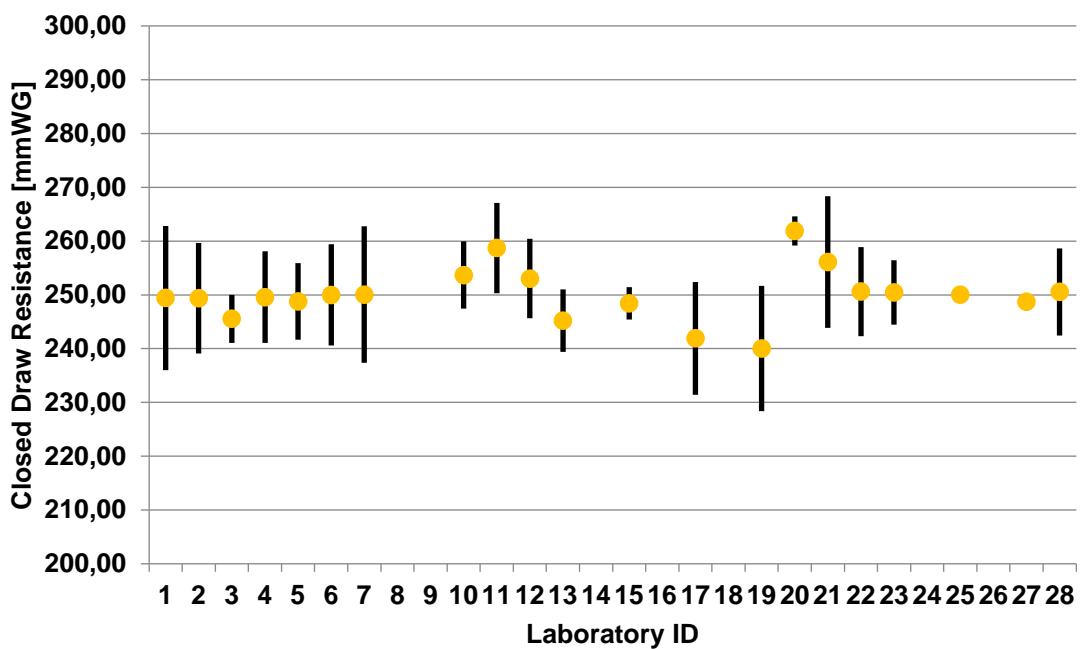
C3: Closed Draw Resistance (Mean±95% CI)
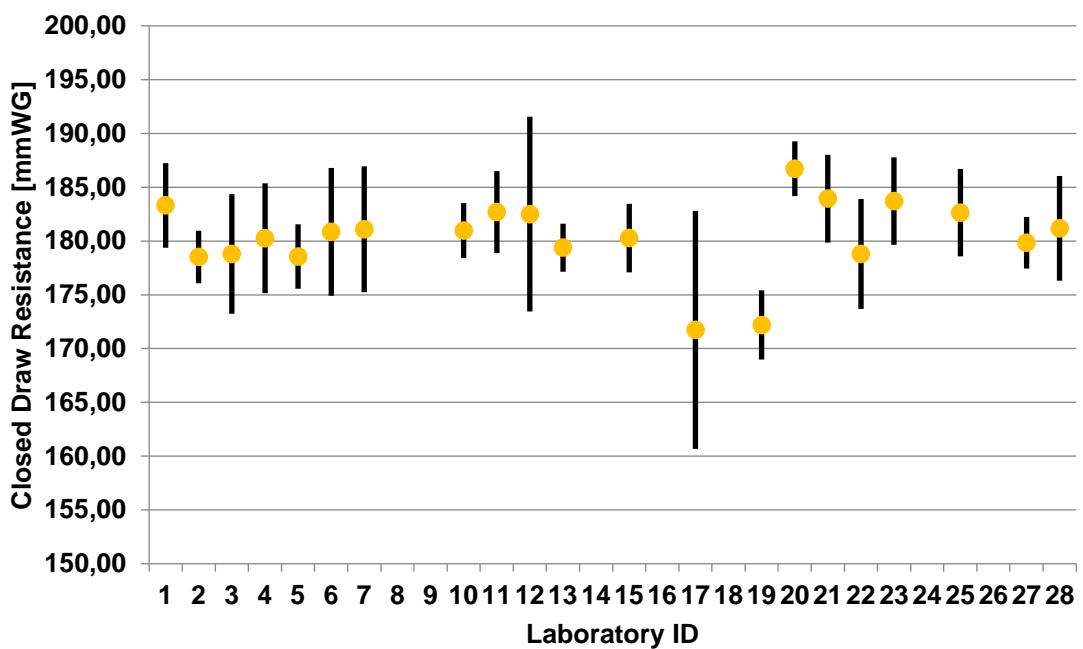
C4: Closed Draw Resistance (Mean±95% CI)
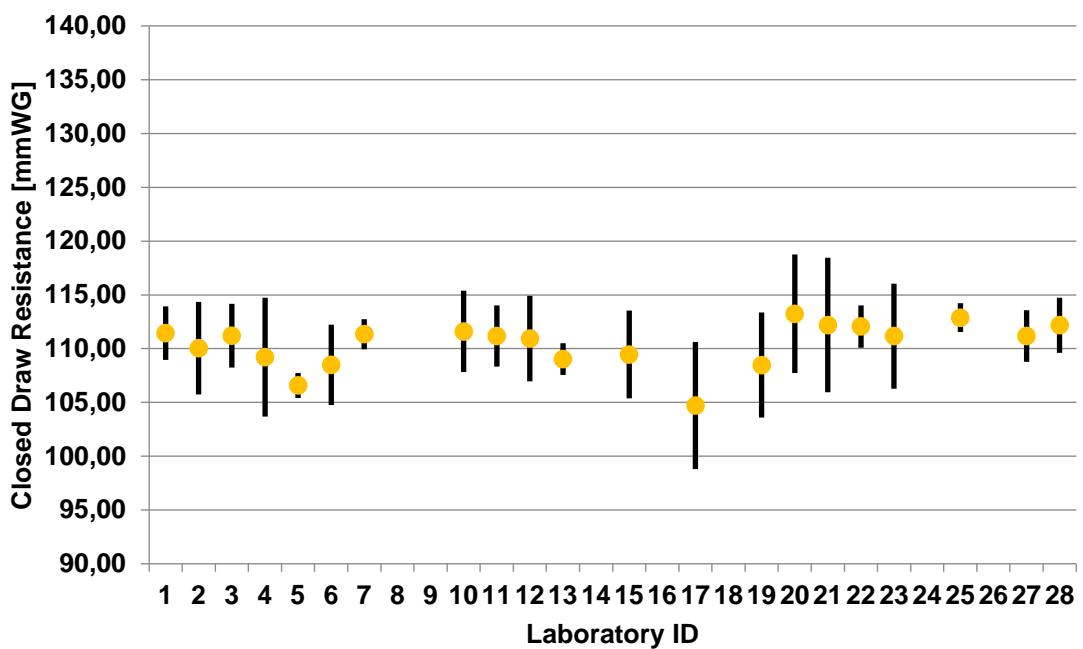
C5: Closed Draw Resistance (Mean±95% CI)
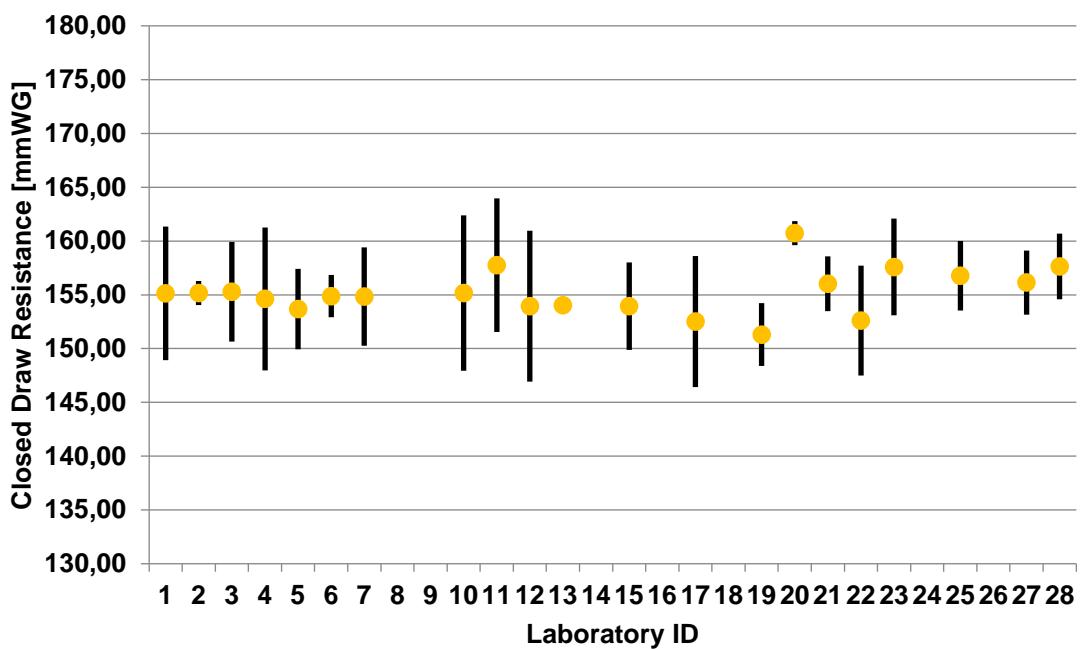
Appendix E.5: Degrees of filter ventilation of cigarettes C1-C5

C1: Degree of Filter Ventilation (Mean±95% CI)

C2: Degree of Filter Ventilation (Mean±95% CI)
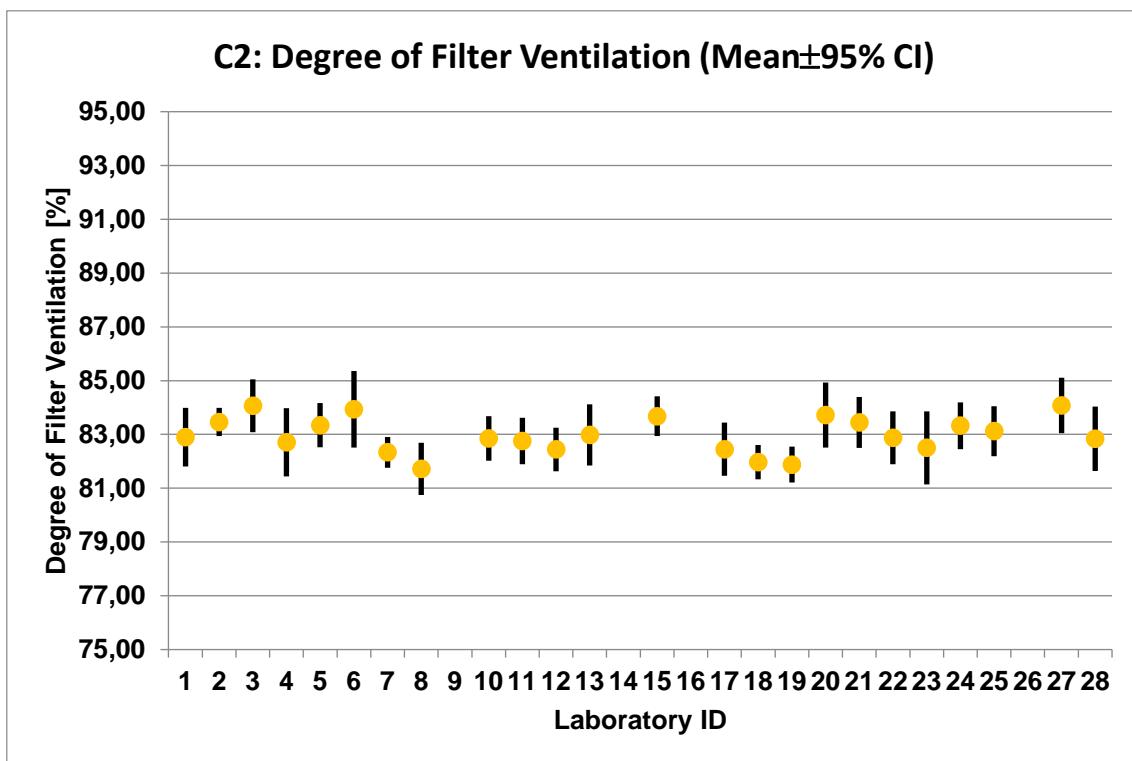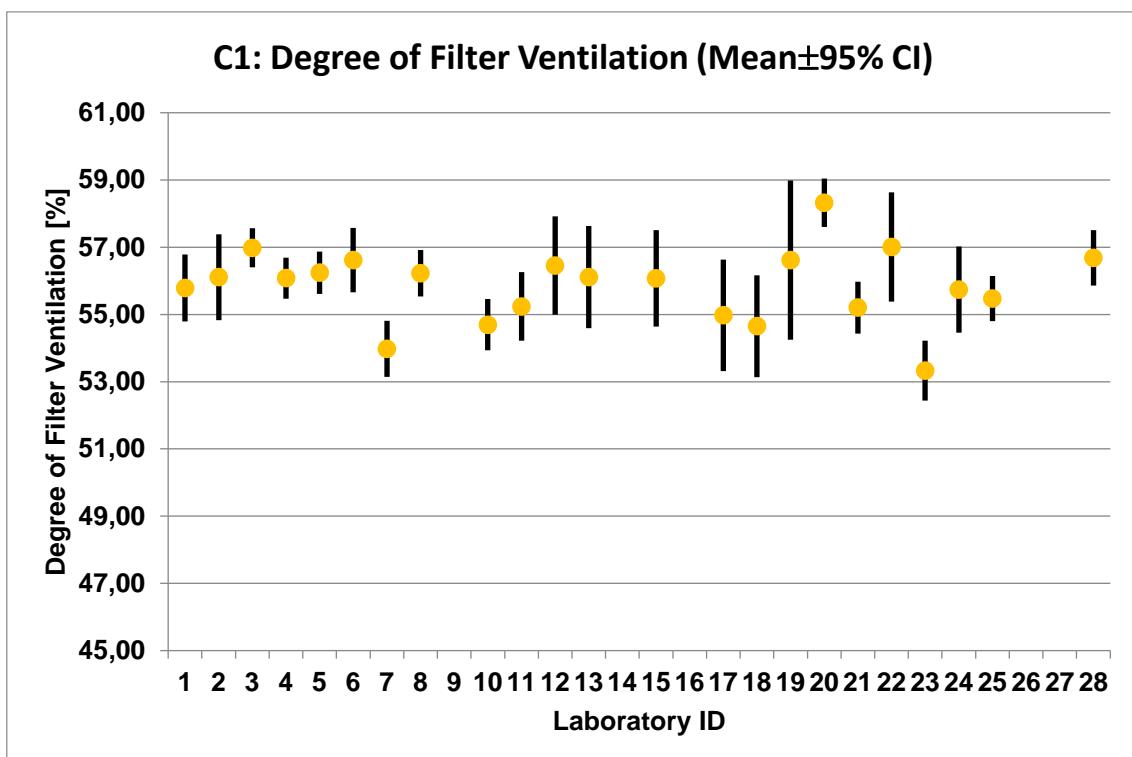
C3: Degree of Filter Ventilation (Mean±95% CI)
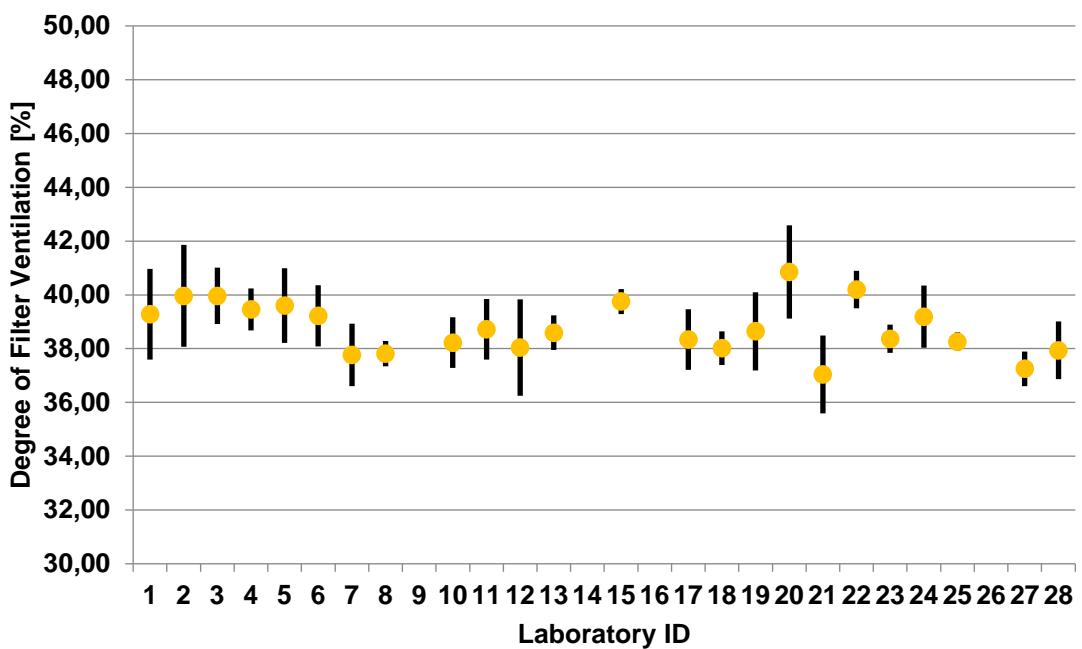
C4: Degree of Filter Ventilation (Mean±95% CI)

C5: Degree of Filter Ventilation (Mean±95% CI)