Physical Test Methods Sub-Group

Technical Report

13th Collaborative Study (2020) 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 objectives of the PTM Sub-Group, 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 fulfill accreditation requirements.

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 Test Coordination Group for further processing and evaluation.

Once received, the data set was inspected for obvious inconsistencies, e.g. wrong units of measurement, such as reporting weight in g instead of mg, or reporting circumference instead of diameter. 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 2020 and laboratories were asked to report the results until end of September 2020.

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 the owner of the respective brand and the filter rods were manufactured by Cerdia GmbH, at the time of production named Solvay Acetow GmbH. 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.

With the exception of the 10th Collaborative Study (2017), where 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 two to three years it is attempted to provide samples that have similar properties as the samples used in past 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	7,2	440	
	F2	Cellulose Acetate Filter Rod	126	5,4	500	
	F3	Cellulose Acetate Filter Rod	126	7,8	290	
	F4	Cellulose Acetate Filter Rod	126	7,8	510	
	F5	Cellulose Acetate Filter Rod	126	7,8	730	
	ID	**Product Description**	**Length mm**	**Diameter mm**	**Open Draw Res. mmWG**	**Filter Ventilation %**
Cigarettes	C1	Lark Ultra One AC 100	98	7,8	82	80
	C2	Marlboro Gold 100	98	7,8	90	53
	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)

Cigarettes

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

A replicate measurement, 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, i.e. in total 2000 individual measurements.

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 weight no ISO standards or CORESTA Recommended Methods exist, but CORESTA Guide No. 6 had to be considered.

1.4 Study Participants

In total 34 sample sets were distributed to 24 laboratories, as listed in Table 2. A code was assigned to each laboratory by a member of the Test Coordination Group, 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. Despite thorough preparations to fulfill all formal and legal requirements some laboratories did not receive the sample sets, as they were withheld in customs. 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. In total 26 data sets were received for statistical analysis.

Minor deviations from the protocol were noted. One laboratory provided only three instead of five replicates and one laboratory did not provide individual weight data, but rather the average of individual measurements. Both deviations did not substantially affect the statistical analysis and the data sets were thus included in the analysis. Laboratory 21 reported that cigarette samples C1 had wrinkles on the tobacco rod. Nevertheless these samples were measured and as shown below did not lead to outlying results.

Table 2 – List of participants

Participant Name	Sets	Country
Altria Client Services	1	USA
ASL Analytic Service Laboratory GmbH	1	Germany
Bejing Omerica Technology Co.	3	China
Cerdia GmbH	2	Germany
China National Tobacco Quality Supervision & Test Center	1	China
C.I.T.M.P.S.A.	1	Uruguay
Enthalpy Analytical, LCC	1	USA
Essentra	1	United Kingdom
Global Laboratory Services	1	USA
Imperial Tobacco	2	Ukraine
Imperial Tobacco Poland	2	Poland
ITC Limited	1	India
Japan Tobacco	2	Japan

Participant Name	Sets	Country
Papierfabrik Wattens GmbH & Co KG	1	Austria
Philip Morris Brasil	1	Brazil
Philip Morris México Productos y Servicios S. de R.L.	2	Mexico
Philsa, Philip Morris Saband Sigara ve Tutunculuk A.S.	1	Turkey
Prudence Development and Management Corporation	3	Philippines
PT Hinjaya Mandala Sampoerna	1	Indonesia
Reemtsma Cigarettenfabriken Hamburg	1	Germany
Sodim	1	France
SWM	1	France
Tabacalera del Este S.A.	2	Paraguay
Tabaqueira E.I.T.	1	Portugal

2. STATISTICAL EVALUATION

2.1 Raw Data Treatment

The 26 data sets were first screened for inconsistencies and after any corrections, if needed, the data were prepared for statistical analysis. 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 3 and for cigarettes in Tables 4a and b. The number (N) of data sets is also given.

Table 3 – Summary data for filter rods over all labs and days, outliers included

	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	746,155	5,55	7,79	24	7,151	0,041	0,060	23	425,6	28,15	14,36	22
F2	440,803	1,92	1,97	23	5,353	0,004	0,005	22	494,6	12,44	7,53	20
F3	825,246	3,59	4,85	25	7,804	0,007	0,011	24	289,2	6,46	3,24	23
F4	853,769	2,62	1,89	25	7,796	0,006	0,005	24	506,5	13,90	4,17	23
F5	860,993	4,36	4,58	25	7,794	0,006	0,005	24	718,6	31,09	5,90	23

Table 4a – Summary data for cigarettes over all labs and days, outliers included

	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	933,691	7,03	6,49	23	7,792	0,010	0,007	22	81,73	1,29	1,07	23
C2	963,441	6,41	5,43	23	7,826	0,008	0,005	22	88,22	1,12	1,11	23
C3	1085,605	6,97	6,73	23	7,808	0,006	0,006	22	127,16	6,17	1,98	23
C4	789,167	5,75	5,84	23	7,780	0,007	0,007	22	82,34	1,44	1,50	23
C5	855,032	6,41	5,52	23	7,822	0,007	0,008	22	92,32	1,15	0,99	23

Table 4b – 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	213,0	3,55	4,00	21	79,26	0,83	0,39	23
C2	144,5	2,66	1,73	21	53,01	0,89	0,52	23
C3	182,6	3,14	2,30	21	39,02	1,01	0,87	22
C4	111,6	2,37	1,81	21	34,09	0,72	0,77	23
C5	156,9	2,73	1,88	21	54,31	1,68	3,14	23

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 two iterations were 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 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 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 and cigarettes in Table 5. 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 1, 2, 4, 6, 7, 9, 10, 11, 15, 16, 18, 20, 21, 22, 24 and 26.

Table 5 – 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)

ID	Weight	Diameter	Pressure Drop	Open Draw Resistance	Closed Draw Resistance	Filter Ventilation
F1	L26C, L26GBH	L22GBH, L26GBH	L11GBL, L22GBL, L26C, L26GBL	not applicable		
F2	L20GWH	none	L9C, L11GWH, L20GBL			
F3	L18C	L22GWL, L26GWL	L20GBL, L26C			
F4	none	L10GWL	L6GBL, L11GWH, L20C, L20CGBL, L22GBL			
F5	L18C, L18GBL	none	L20GWL, L20GBL, L22GBL			
C1	none	none	not applicable	L18GWH	none	none
C2	none	none		none	L11GWH	none
C3	L20GWH	L2C, L15GWH		L11GBH, L20GWL, L24C	none	L24C, L24GBH
C4	none	none		none	L7C	L1C, L4GWL, L15C, L15GBH
C5	none	none		L18GWH	none	L6C, L6GBH, L16GWH, L21GWL

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. The results for the filter rods are given in Table 6 and for cigarettes in Tables 7a and 7b. In all tables the number of laboratories is denoted by N.

Table 6 – 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	745,212	3,13	3,61	23	7,140	0,006	0,006	21	435,2	9,75	5,84	19
F2	440,784	1,92	1,96	23	5,353	0,004	0,005	22	497,6	5,49	6,76	18
F3	824,892	3,19	2,48	24	7,805	0,007	0,005	23	290,1	3,65	2,56	21
F4	853,769	2,62	1,89	25	7,796	0,006	0,004	24	511,2	3,74	3,17	20
F5	861,715	2,50	2,82	24	7,794	0,006	0,005	24	727,7	8,17	5,13	21

Table 7a – 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	933,691	7,03	6,49	23	7,792	0,010	0,007	22	81,72	1,29	1,07	23
C2	963,441	6,41	5,43	23	7,826	0,008	0,005	22	88,22	1,12	1,11	23
C3	1085,502	6,94	6,63	23	7,808	0,006	0,005	21	126,13	1,82	1,55	21
C4	789,167	5,75	5,84	23	7,780	0,007	0,007	22	82,34	1,44	1,50	23
C5	855,032	6,41	5,52	23	7,822	0,007	0,008	22	92,29	1,16	0,96	23

Table 7b – 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	213,0	3,55	4,00	21	79,26	0,83	0,39	23
C2	144,5	2,66	1,73	21	53,01	0,89	0,52	23
C3	182,6	3,14	2,30	21	38,86	0,69	0,62	21
C4	111,6	2,43	1,63	20	33,97	0,59	0,55	21
C5	156,9	2,73	1,88	21	53,87	0,75	0,48	22

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 8a-b and then for cigarettes in Tables 9a-c. 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 8a – 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	3,61	10,22	0,49	4,50	12,73	0,60	0,006	0,016	0,077	0,008	0,022	0,108
F2	1,96	5,55	0,45	2,60	7,36	0,59	0,005	0,015	0,097	0,006	0,018	0,118
F3	2,48	7,02	0,30	3,88	10,99	0,47	0,005	0,015	0,067	0,008	0,023	0,103
F4	1,89	5,34	0,22	3,12	8,83	0,37	0,004	0,012	0,055	0,007	0,020	0,090
F5	2,82	7,98	0,33	3,55	10,05	0,41	0,005	0,014	0,065	0,007	0,020	0,093

Table 8b – 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	5,84	16,52	1,34	11,06	31,28	2,54
F2	6,76	19,11	1,36	8,17	23,10	1,64
F3	2,56	7,23	0,88	4,31	12,18	1,48
F4	3,17	8,97	0,62	4,69	13,27	0,92
F5	5,13	14,52	0,71	9,37	26,50	1,29

Table 9a – Repeatability and reproducibility statistics for cigarette 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	%
C1	6,49	18,35	0,69	9,11	25,78	0,98	0,007	0,019	0,085	0,012	0,033	0,151
C2	5,43	15,37	0,56	8,04	22,75	0,83	0,005	0,014	0,065	0,009	0,027	0,121
C3	6,63	18,76	0,61	9,13	25,82	0,84	0,005	0,014	0,062	0,008	0,021	0,096
C4	5,84	16,53	0,74	7,77	21,97	0,98	0,007	0,020	0,090	0,009	0,026	0,120
C5	5,52	15,61	0,65	8,09	22,88	0,95	0,008	0,023	0,102	0,010	0,029	0,132

Table 9b – Repeatability and reproducibility statistics for cigarette draw resistanc

	Open Draw Resistance						Closed Draw Resistance					
	Repeatability			Reproducibility			Repeatability			Reproducibility		
ID	SD	Limit	CoV	SD	Limit	CoV	SD	Limit	CoV	SD	Limit	CoV
	mmWG		%	mmWG		%	mmWG		%	mmWG		%
C1	1,07	3,02	1,31	1,61	4,54	1,97	4,00	11,31	1,88	5,04	14,26	2,37
C2	1,11	3,14	1,26	1,50	4,24	1,70	1,73	4,88	1,19	3,08	8,70	2,13
C3	1,55	4,40	1,23	2,29	6,47	1,81	2,30	6,50	1,26	3,75	10,61	2,05
C4	1,50	4,24	1,82	1,97	5,57	2,39	1,63	4,61	1,46	2,83	8,01	2,54
C5	0,96	2,73	1,04	1,44	4,08	1,56	1,88	5,32	1,20	3,21	9,08	2,05

Table 9c – Repeatability and reproducibility statistics for the degree of filter ventilation

	Degree of Filter Ventilation					
	Repeatability			Reproducibility		
ID	SD	Limit	CoV	SD	Limit	CoV
	%	%	%	%	%	%
C1	0,39	1,11	0,50	0,91	2,56	1,14
C2	0,52	1,46	0,97	1,00	2,83	1,89
C3	0,62	1,75	1,59	0,89	2,51	2,28
C4	0,55	1,55	1,61	0,77	2,17	2,26
C5	0,48	1,36	0,89	0,86	2,44	1,60

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 without any outlier elimination. The results are given first for filter rods and then for cigarettes. In the tables, fields marked in orange are z-scores with $2<|z|<3$ and red fields are those with $3\leq|z|$.

Table 10 – Z-Scores for all laboratories on the measurement of weight, diameter and pressure drop of filter rods

	Weight					Diameter					Pressure Drop				
ID	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
1	-0,43	0,69	1,05	0,72	-0,25	-0,80	1,94	0,49	0,68	0,99					
2			0,97	-0,26	-1,25			1,19	1,83	0,62			0,79	0,81	0,59
3	-0,54		-1,58	-1,48	-0,37	1,01		-0,44	-0,93	0,53	0,22		-0,69	-0,79	0,27
4	-0,98	-1,53	-1,45	-1,08	-2,14	-0,63	-0,67	-1,17	-0,64	-1,70	0,19	-0,41	-0,64	-1,01	-0,57
5	0,81	1,29	1,79	1,41	1,05	1,29	1,57	1,37	1,04	0,77	1,18	-0,05	1,32	1,24	0,70
6	0,68	2,28	0,61	0,84	1,37	-1,88	-0,79	-1,28	-1,45	-1,60	-2,52		-2,97	-6,13	-2,68
7	-0,31	-0,56	0,00	-0,55	-0,96	-0,84	-0,57	0,49	-0,33	0,33	0,28	0,06	0,14	0,23	0,40
8	-1,21	-1,66	-2,05	-1,89	-1,19	-1,28	-1,59	-1,80	-2,29	-1,87	0,47	-0,10	0,05	0,98	1,07
9	-0,95	-0,10	-0,74	-0,85	-0,18	0,27	0,31	-0,37	-1,15	-0,10	-0,26	-2,32	-1,57	-2,74	-1,35
10	0,08	-0,56	0,13	0,48	-0,64	0,83	0,70	0,90	0,07	0,18	0,29	1,11	0,83	1,30	0,99
11	0,71	0,89	0,35	-0,10	1,02	-1,12	-0,98	-0,10	0,23	-0,49	-10,60	1,63	1,66	0,11	0,72
12	0,52	1,52	1,35	1,03	0,96	-0,10	-1,04	0,21	-0,12	-0,53	0,14	0,44	0,25	0,11	0,56
13	0,73	0,90	0,75	1,63	1,23	0,26	0,20	-0,18	0,10	0,10	0,84	0,36	-0,91	-0,70	-0,20
14	0,56	0,15	0,34	0,36	0,29	0,82	0,09	0,39	0,75	0,83	0,11	-2,65	0,45	-1,45	-2,03
15	-0,43	0,08	0,17	-0,40	-0,68	1,07	1,21	1,24	0,72	1,02	-0,06	1,23	-0,16	-0,34	-0,02
16															
17	1,74	-0,04	0,04	0,83	0,48	1,35	0,64	0,36	1,31	0,73	0,68	0,19	0,40	0,76	0,11
18	-1,76	-1,22	2,77	-2,01	-7,21	-1,52	-1,36	-2,15	-1,11	-1,30	-0,08	-1,28	0,06	-0,23	0,96
19	-0,32	-0,06	-0,19	-0,82	0,15	0,50	0,84	-0,05	0,03	0,31	0,78	1,28	0,54	0,84	0,90
20	-0,64	-0,11	-1,16	0,41	1,33						-2,74	-8,99	-6,93	-14,67	-11,82
21	0,70	0,24	0,43	0,64	0,01	1,10	-0,48	0,02	-0,02	-0,43	0,56	0,25	0,35	0,84	0,57
22	2,48	-0,56	0,13	0,68	-0,12	12,32	-0,72	-1,76	-0,32	0,28	-7,15	-0,49	-0,33	-8,29	-13,68
23	-1,35	-1,47	-1,53	-1,13	-1,81	-0,86	-0,68	-1,36	-1,17	-1,84	-0,19	-0,89	-0,03	-0,32	-0,56
24	0,14	0,21	-0,39	0,64	0,87	0,26	-0,58	0,29	1,01	1,32					
25	-0,22	-0,70	1,11	0,37	-0,07	0,26	1,36	1,45	0,72	1,01	0,12	-0,22	0,45	0,11	-0,18
26	7,23	0,56	-0,14	0,54	0,91	31,37	0,59	-1,63	0,17	0,83	-3,85	-0,29	1,46	0,37	-0,25

Table 11a – Z-Scores for all laboratories on the measurement of weight, diameter and open draw resistance for cigarettes

	Weight					Diameter					Open Draw Resistance				
ID	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	0,04	-0,27	-0,03	-0,56	0,00	2,07	1,95	2,41	-0,52	-0,10	0,50	0,09	-0,23	-1,45	0,44
2	-0,82	-0,60	-0,29	-0,45	-1,42	-0,06	0,34	0,14	1,69	0,95	0,33	0,57	1,77	-0,28	0,39
3	-0,42	-0,38	-0,74	-1,37	-1,03	1,72	1,39	1,29	-0,82	0,26	-0,09	-0,18	-0,95	-0,29	1,06
4	-0,95	-1,94	-1,72	-1,68	-0,32	-0,47	-1,15	-0,55	-0,68	0,55	0,45	-0,50	-0,91	-0,64	-0,08
5	0,91	1,39	0,69	0,89	1,30	0,29	0,02	-0,44	0,69	1,06	1,04	1,57	1,45	1,57	1,82
6	0,66	1,18	0,64	0,90	1,64	-0,22	-1,20	-1,31	-2,04	-1,59	-1,90	-1,83	-1,36	-1,36	-2,42
7	-1,07	-0,60	-1,02	-1,07	-0,22	0,46	0,51	0,04	-0,88	-1,04	0,68	0,46	-0,45	0,43	-0,06
8															
9	0,17	0,66	-0,50	0,46	-0,84	-1,22	0,00	-0,06	0,48	-0,31	0,78	-0,93	-0,93	-1,62	-1,26
10	0,31	0,07	0,38	1,61	0,61	0,94	0,82	0,83	1,70	2,55	0,41	0,53	-0,13	1,69	0,16
11	0,48	1,32	0,81	-0,32	-0,35	-1,29	0,20	-0,84	-0,31	0,91	-1,92	-2,07	15,40	-0,59	-0,88
12															
13	-0,01	-0,12	-0,08	1,18	1,32	-0,78	-0,30	-1,23	-0,68	-1,11	-0,21	-0,20	0,73	0,97	0,56
14	-1,07	-0,32	-0,09	0,36	0,44	-0,36	0,11	-0,16	-0,16	0,08	-1,31	-0,39	-0,57	0,65	-1,00
15	1,31	0,96	1,01	0,44	1,25	0,36	0,30	0,82	0,25	1,00	0,61	0,07	-0,32	-1,09	-0,08
16	-0,12	0,16	0,38	0,12	-0,11	-1,64	0,01	0,30	-0,24	-1,07	-1,14	-0,07	0,39	-0,68	-0,17
17	0,17	-0,11	0,84	-0,29	0,43	0,26	-0,14	-0,48	1,95	1,03	1,95	2,03	2,46	0,85	2,34
18	-1,86	-1,68	-2,28	-1,27	-1,74	0,10	-0,22	-0,84	-1,02	-0,21	-0,32	-0,16	0,02	1,11	-0,15
19	-1,48	-0,96	-1,26	-1,25	-1,77	-0,31	0,16	-0,40	-0,48	-0,08	0,90	0,73	0,42	0,82	0,54
20	0,15	0,42	0,53	0,45	0,92						0,85	-0,75	-0,99	-0,32	-0,67
21	2,01	1,50	1,42	1,64	1,12	-0,23	-1,72	-0,27	-0,47	-0,70	-1,52	-0,57	-0,64	-0,30	-0,34
22	1,17	0,87	1,09	0,14	-0,23	-0,88	-1,07	-0,72	0,09	-0,77	-0,04	1,00	-0,10	0,50	0,63
23	-1,35	-1,82	-1,21	-1,43	-0,99	-0,51	-1,56	-0,52	-0,43	-1,20	-0,40	-0,75	-0,84	-1,34	-0,60
24	0,64	-0,32	0,38	0,76	-0,30	2,06	2,08	2,34	1,29	0,41	-0,06	-0,27	-2,14	0,40	-0,18
25															
26	1,12	0,59	1,39	0,75	0,32	-0,28	-0,53	-0,12	0,58	-0,60	0,58	1,59	0,98	0,97	0,39

Table 11b – Z-Scores for all laboratories on the measurement of closed draw resistance and degree of filter ventilation for cigarettes

	Closed Draw Resistance					Degree of Filter Ventilation				
ID	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	-0,52	-0,02	-0,46	-0,94	-0,01	0,17	0,58	0,26	1,68	0,39
2	0,01	0,15	0,73	0,05	-0,04	-0,75	-0,24	-1,90	0,99	-0,50
3	-0,81	-0,74	-0,75	-0,55	-0,20	0,45	0,76	1,43	1,13	0,23
4	-0,72	-1,51	-1,04	-1,12	-1,37	-0,94	-2,24	-1,30	-1,33	-2,20
5	0,88	0,96	1,58	1,52	1,72	-1,40	-0,82	0,47	0,32	-0,51
6	-2,27	-0,69	-1,24	-1,07	-0,90	-0,39	0,19	-1,10	-0,46	6,04
7	1,23	0,03	-0,26	0,14	-0,47	0,24	-0,43	0,08	-1,10	-0,59
8										
9	-0,36	-1,05	-0,73	-1,56	-1,09	-1,03	-0,54	-0,52	-0,78	0,07
10	1,12	0,18	0,00	1,65	0,48	0,29	-0,58	0,40	0,96	0,58
11	0,84	0,01	0,75	0,00	0,63	2,20	2,20		2,27	2,42
12										
13	1,99	2,77	2,01	2,27	2,81	-0,09	-0,18	0,19	-0,26	-0,17
14	-1,77	-0,45	-0,83	0,49	-0,93	0,03	-0,53	-0,51	-0,68	-0,34
15	0,06	-0,11	0,42	-0,02	-0,02	1,12	1,29	1,91	3,15	1,58
16						0,85	0,02	0,34	-0,44	7,92
17	0,89	0,96	2,03	0,20	1,37	-2,04	-0,95	-0,41	-0,89	-0,98
18						-0,41	-0,40	-0,40	-0,50	-0,62
19	0,34	-0,28	0,20	-0,19	-0,55	1,68	0,47	1,77	-0,25	0,78
20	-0,50	-1,14	-1,42	-0,51	-0,62	-0,96	-1,32	-1,26	-1,16	-1,07
21	0,04	0,46	-0,26	-0,33	0,51	0,26	0,55	0,72	-0,24	0,21
22	-0,28	1,21	0,33	0,39	-0,05	-0,24	0,92	0,75	0,63	-0,27
23	0,24	-1,22	-0,95	-1,22	-0,72	-0,24	-0,89	-0,68	-0,37	-0,73
24	0,33	-0,44	-0,39	0,65	-0,23	1,39	1,50	5,11	2,17	1,56
25										
26	-0,73	1,04	0,28	0,29	-0,33	-0,18	0,65	-0,25	-0,37	-0,10

3. DATA INTERPRETATION

3.1 Repeatability and Reproducibility

The results for repeatability and reproducibility, Tables 8a-b and Tables 9a-c, 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 that 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 30 of 390 determinations, i.e. 7,7 %, resulted in absolute z-scores of 2 or higher and 14 of 390 determinations, i.e. 3,6 %, in absolute z-scores of 3 or higher. For the cigarettes 34 of 650 determinations (5,2 %) provided absolute z-scores of 2 or higher and 5 determinations (0,8 %) 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 did not deliver any unusual results. However, for filters the proportion of absolute z-scores above 3 is higher than expected. These high z-scores are concentrated in a few laboratories, for which a review of their procedures is recommended.

It can be seen in Table 10 that laboratories 20, 22 and 26 obtained a number of z-scores with absolute values greater than 3. In particular for pressure drop high deviations were observed for all or almost all tested filters for laboratories 20 and 22. Also laboratory 6 had a series of absolute z-scores above 2 for the pressure drop of all measured filter rods. Surprisingly this pattern is not repeated for the measurement of open or closed draw resistance of cigarettes.

It is recommended that laboratories 20, 22 and 6 review their procedures when measuring pressure drop of filter rods.

Laboratories 20 and 22 seemed to have issues with measuring filter F1, as they obtained exceptional z-scores for all parameters. It could be checked whether the sample used for the measurement actually was filter F1.

Compared to the filters there are fewer exceptional z-scores, particularly those with absolute values above 3. This may be due to the higher variability of cigarettes, which contributes more strongly to within-laboratory variability and thus to the global standard deviation. This in turn leads to lower absolute z-scores. A few patterns can be seen in Tables 11a and 11b. Laboratory 11 had a tendency to measure high degrees of filter ventilation. Likewise laboratory 13 measured generally high closed draw resistances. The same holds for laboratory 17 with high values for open draw resistance and laboratory 24 with high values for diameter.

The remaining z-scores do not show any particular pattern that might lead to immediate recommendations for review of the procedures.

In total 8 of the 26 participating laboratories did not obtain any z-scores with an absolute value above 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 2, 3, 5, 7, 12, 19, 23 and 25.

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 13th Collaborative Study on Physical Parameters (2017, 2018, 2019, 2020) 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 seven 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 12 – 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
Weight	0,239	0,392	0,421	0,332	0,300	0,290	0,368
Diameter	0,070	0,063	0,089	0,080	0,084	0,085	0,079
Pressure Drop	2,710	1,715	1,357	1,105	1,124	0,914	1,291

Table 13 – 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
Weight	0,528	0,852	0,817	0,721	0,625	0,647	0,707
Diameter	0,126	0,104	0,103	0,172	0,150	0,132	0,100
Open Draw Resistance	2,104	1,476	1,370	1,632	1,354	1,029	1,459
Closed Draw Resistance	2,403	2,732	2,305	1,984	1,673	1,289	1,829
Degree of Filter Ventilation	2,785	2,211	2,524	1,347	1,432	1,860	1,527

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 2020 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 2019. Tables 14a and 14b show these parameters for the filter rods and Tables 15a and 15b for the cigarettes.

Table 14a – Historical development of repeatability coefficient of variation for parameters measured on filter rods

Parameter	Repeatability Coefficient of Variation %			
	2017	2018	2019	2020
Weight	0,292	0,338	0,321	0,356
Diameter	0,071	0,073	0,069	0,072
Pressure Drop	0,820	0,826	0,861	0,981

Table 14b – Historical development of reproducibility coefficient of variation for parameters measured on filter rods

Parameter	Reproducibility Coefficient of Variation %			
	2017	2018	2019	2020
Weight	0,422	0,428	0,408	0,489
Diameter	0,102	0,105	0,106	0,102
Pressure Drop	1,336	1,382	1,203	1,575

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

Parameter	Repeatability Coefficient of Variation %			
	2017	2018	2019	2020
Weight	0,733	0,628	0,663	0,651
Diameter	0,088	0,097	0,106	0,081
Open Draw Resistance	1,477	1,430	1,471	1,333
Closed Draw Resistance	2,087	1,842	1,573	1,398
Degree of Filter Ventilation	1,037	1,438	1,348	1,113

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

Parameter	Reproducibility Coefficient of Variation %			
	2017	2018	2019	2020
Weight	0,973	0,856	0,880	0,916
Diameter	0,190	0,175	0,165	0,124
Open Draw Resistance	2,100	1,874	1,695	1,886
Closed Draw Resistance	2,767	2,372	1,913	2,226
Degree of Filter Ventilation	1,640	1,986	2,239	1,834

For the filter rods and for the cigarettes no substantial changes in these parameters could be observed from 2017 to 2020.

For cigarettes with the exception of diameter, which has very low variability, the reproducibility coefficient of variation is about 30 % to 45 % higher than the repeatability coefficient of variation for all parameters and this ratio remains stable from 2017 to 2020, 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 this variation parameters so that the results do not suggest a need for revision of any of the concerned standards. 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 9512:2002, Cigarettes -- Determination of ventilation -- Definitions and measurement principles
- ISO 5725-2:1994, 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 13528:2015, 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 13th Collaborative Study (2020) on Physical Parameters

1. Preparation of Samples

1.1 All measurements should take place in an environment according to ISO 3402 (Testing atmosphere: (22±2) °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 and sample 3 on Day 3, sample 4 on Day 4 and sample 5 on Day 5.

1.3 Samples should be unpacked and conditioned at least 48h (conditioning time can affect the level / results of physical parameters !) regarding ISO 3402 (conditioning atmosphere: (22±1) °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 multicapillary standards for filter PD measurements and nominally 200 mmWG multicapillary 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 the 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 4.7.

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. Reier-latest by September 30th

Set e-mail subject line: Collaborative Study 2020 results - PTM Sub-Group
Rename the completed file: Add the company ID at the beginning of the existing file name

APPENDIX B – Data Summary (Mean Values)

The mean value represents the average over all five replicate measurements including all outliers.

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

	Weight					Diameter					Pressure Drop				
	mg					mm					mmWG				
ID	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
1	743,88	442,10	828,24	855,66	861,10	7,14	5,36	7,81	7,80	7,80					
2			828,00	853,10	858,58			7,81	7,81	7,80			293,00	514,18	732,44
3	743,52		819,84	849,88	860,78	7,15		7,80	7,79	7,80	437,38		287,60	508,20	729,88
4	742,15	437,85	820,28	850,92	856,36	7,14	5,35	7,80	7,79	7,78	437,10	495,35	287,76	507,40	723,00
5	747,76	443,25	830,59	857,46	864,34	7,15	5,36	7,81	7,80	7,80	446,74	497,36	294,92	515,80	733,40
6	747,33	445,17	826,83	855,97	865,13	7,13	5,35	7,80	7,79	7,79	410,63		279,27	488,23	705,80
7	744,24	439,70	824,90	852,32	859,32	7,14	5,35	7,81	7,79	7,80	437,94	497,96	290,60	512,04	730,90
8	741,42	437,60	818,34	848,82	858,74	7,13	5,35	7,79	7,78	7,78	439,82	497,06	290,28	514,82	736,44
9	742,24	440,60	822,54	851,54	861,26	7,14	5,35	7,80	7,79	7,79	432,68	484,90	284,38	500,94	716,64
10	745,46	439,70	825,31	855,03	860,10	7,15	5,36	7,81	7,80	7,79	438,06	503,71	293,14	516,01	735,73
11	747,42	442,50	826,02	853,52	864,26	7,13	5,35	7,80	7,80	7,79	331,88	506,58	296,16	511,58	733,58
12	746,84	443,70	829,20	856,46	864,12	7,14	5,35	7,81	7,80	7,79	436,56	500,02	291,02	511,58	732,22
13	747,50	442,52	827,28	858,04	864,78	7,14	5,35	7,80	7,80	7,79	443,42	499,58	286,78	508,54	726,00
14	746,96	441,08	825,96	854,72	862,44	7,15	5,35	7,81	7,80	7,80	436,26	483,06	291,74	505,76	711,04
15	743,86	440,94	825,44	852,72	860,02	7,15	5,36	7,81	7,80	7,80	434,60	504,36	289,52	509,88	727,50
16															
17	750,66	440,70	825,02	855,94	862,92	7,15	5,36	7,81	7,80	7,80	441,84	498,66	291,56	514,00	728,58
18	739,70	438,44	833,74	848,50	843,68	7,13	5,35	7,79	7,79	7,79	434,42	490,62	290,32	510,32	735,52
19	744,22	440,66	824,30	851,62	862,10	7,14	5,36	7,80	7,80	7,80	442,81	504,68	292,06	514,30	734,98
20	743,20	440,58	821,18	854,84	865,04						408,48	448,24	264,80	456,34	631,08
21	747,40	441,24	826,26	855,44	861,74	7,15	5,35	7,81	7,80	7,79	440,68	499,00	291,38	514,30	732,34
22	752,98	439,70	825,32	855,56	861,42	7,21	5,35	7,79	7,79	7,80	365,50	494,94	288,88	480,16	615,90
23	740,97	437,96	820,00	850,80	857,18	7,14	5,35	7,80	7,79	7,78	433,32	492,72	290,00	509,98	723,10
24	745,64	441,18	823,66	855,46	863,88	7,14	5,35	7,81	7,80	7,80					
25	744,52	439,44	828,42	854,74	861,54	7,14	5,36	7,81	7,80	7,80	436,36	496,44	291,74	511,56	726,16
26	767,86	441,86	824,46	855,18	864,00	7,33	5,36	7,79	7,80	7,80	397,66	496,02	295,44	512,54	725,60

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

	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	933,96	961,72	1085,32	785,92	855,00	7,81	7,84	7,82	7,78	7,82	82,36	88,32	125,72	80,24	92,80
2	927,96	959,58	1083,50	786,58	845,92	7,79	7,83	7,81	7,79	7,83	82,14	88,86	129,34	81,94	92,74
3	930,74	961,00	1080,40	781,30	848,40	7,81	7,84	7,82	7,77	7,82	81,60	88,02	124,40	81,92	93,52
4	927,02	951,04	1073,60	779,52	853,00	7,79	7,82	7,81	7,78	7,83	82,30	87,66	124,48	81,42	92,20
5	940,10	972,36	1090,29	794,29	863,36	7,79	7,83	7,81	7,79	7,83	83,06	89,98	128,76	84,60	94,40
6	938,30	971,03	1089,93	794,33	865,53	7,79	7,82	7,80	7,77	7,81	79,27	86,17	123,67	80,37	89,50
7	926,20	959,60	1078,40	783,00	853,60	7,80	7,83	7,81	7,77	7,81	82,60	88,74	125,32	82,96	92,22
8															
9	934,90	967,66	1082,00	791,82	849,64	7,78	7,83	7,81	7,78	7,82	82,72	87,18	124,44	80,00	90,84
10	935,90	963,90	1088,15	798,43	858,92	7,80	7,83	7,81	7,79	7,84	82,25	88,81	125,89	84,78	92,47
11	937,08	971,90	1091,10	787,30	852,78	7,78	7,83	7,80	7,78	7,83	79,24	85,90	154,08	81,48	91,28
12															
13	933,62	962,70	1084,98	795,92	863,48	7,78	7,82	7,80	7,78	7,81	81,44	88,00	127,46	83,74	92,94
14	926,16	961,36	1084,86	791,26	857,84	7,79	7,83	7,81	7,78	7,82	80,02	87,78	125,10	83,28	91,14
15	942,88	969,60	1092,50	791,70	863,02	7,80	7,83	7,81	7,78	7,83	82,50	88,30	125,56	80,76	92,20
16	932,88	964,46	1088,12	789,88	854,30	7,77	7,83	7,81	7,78	7,81	80,24	88,14	126,84	81,36	92,10
17	934,92	962,72	1091,32	787,50	857,76	7,79	7,82	7,81	7,79	7,83	84,24	90,50	130,60	83,56	95,00
18	920,60	952,66	1069,70	781,84	843,86	7,79	7,82	7,80	7,77	7,82	81,30	88,04	126,16	83,94	92,12
19	923,26	957,28	1076,78	781,96	843,70	7,79	7,83	7,81	7,78	7,82	82,88	89,04	126,89	83,52	92,91
20	934,74	966,12	1089,18	791,78	860,94						82,82	87,38	124,34	81,88	91,52
21	947,80	973,06	1095,38	798,60	862,24	7,79	7,81	7,81	7,78	7,82	79,76	87,58	124,98	81,90	91,90
22	941,92	969,00	1093,04	790,00	853,54	7,78	7,82	7,80	7,78	7,82	81,66	89,34	125,96	83,06	93,02
23	924,18	951,76	1077,08	780,92	848,66	7,79	7,81	7,81	7,78	7,81	81,20	87,38	124,60	80,40	91,60
24	938,20	961,40	1088,16	793,52	853,14	7,81	7,84	7,82	7,79	7,82	81,64	87,92	122,24	82,92	92,08
25															
26	941,58	967,22	1095,14	793,46	857,10	7,79	7,82	7,81	7,78	7,82	82,46	90,00	127,92	83,74	92,74

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

	Closed Draw Resistance					Degree of Filter Ventilation				
	mg					%				
ID	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	211,20	144,44	181,12	109,32	156,82	79,40	53,53	39,04	34,96	54,16
2	213,10	144,90	184,84	111,72	156,76	78,63	52,80	37,55	34,56	53,50
3	210,16	142,54	180,20	110,26	156,30	79,64	53,69	39,85	34,64	54,04
4	210,48	140,48	179,28	108,88	153,12	78,47	51,02	37,96	33,18	52,23
5	216,18	147,06	187,52	115,28	161,56	78,09	52,28	39,19	34,16	53,49
6	205,00	142,67	178,67	109,00	154,40	78,93	53,18	38,10	33,70	58,37
7	217,40	144,58	181,74	111,94	155,56	79,46	52,64	38,92	33,32	53,43
8										
9	211,78	141,72	180,26	107,80	153,88	78,40	52,54	38,50	33,51	53,92
10	217,02	144,97	182,55	115,59	158,17	79,50	52,50	39,14	34,54	54,30
11	216,04	144,52	184,92	111,60	158,58	81,09	54,96		35,31	55,67
12										
13	220,10	151,86	188,86	117,10	164,54	79,18	52,86	38,99	33,82	53,74
14	206,76	143,30	179,96	112,78	154,32	79,29	52,54	38,51	33,57	53,62
15	213,26	144,22	183,88	111,54	156,80	80,19	54,16	40,18	35,84	55,05
16						79,96	53,03	39,10	33,71	59,77
17	216,22	147,06	188,94	112,08	160,60	77,56	52,17	38,58	33,44	53,14
18						78,91	52,66	38,59	33,67	53,41
19	214,26	143,77	183,17	111,13	155,35	80,65	53,43	40,09	33,82	54,45
20	211,26	141,46	178,10	110,36	155,16	78,46	51,84	37,99	33,28	53,07
21	213,18	145,72	181,74	110,78	158,26	79,47	53,50	39,36	33,83	54,03
22	212,04	147,72	183,58	112,54	156,72	79,06	53,83	39,38	34,35	53,67
23	213,90	141,26	179,58	108,64	154,90	79,05	52,22	38,39	33,75	53,33
24	214,22	143,34	181,34	113,16	156,22	80,41	54,35	42,40	35,26	55,04
25										
26	210,46	147,26	183,42	112,30	155,96	79,10	53,59	38,69	33,75	53,80

APPENDIX C – Data Summary (Standard Deviations)

The standard deviation represents the standard deviation of a replicate measurement calculated from the five replicate measurements.

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

	Weight					Diameter					Pressure Drop				
	mg					mm					mmWG				
ID	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
1	2,58	1,56	2,63	2,76	1,54	0,002	0,004	0,004	0,003	0,003					
2			2,38	1,44	3,43			0,007	0,002	0,005			1,76	1,53	4,65
3	3,50		2,41	3,16	0,61	0,005		0,009	0,005	0,007	6,02		3,52	2,71	1,52
4	3,51	0,80	3,34	1,69	1,51	0,005	0,010	0,002	0,005	0,005	3,45	7,30	2,19	1,40	3,08
5	2,79	2,32	2,73	1,75	2,97	0,003	0,005	0,004	0,006	0,005	4,25	12,09	3,42	3,34	6,52
6	2,06	0,60	1,72	2,12	4,20	0,003	0,002	0,006	0,006	0,007	17,65		4,37	7,70	10,27
7	2,60	3,40	1,23	2,69	2,90	0,010	0,010	0,001	0,005	0,005	1,39	6,99	2,55	2,34	7,24
8	3,75	1,65	1,69	2,97	2,45	0,007	0,002	0,003	0,005	0,003	4,38	1,98	1,06	3,45	6,11
9	2,62	2,10	3,55	2,63	3,08	0,005	0,005	0,004	0,007	0,007	8,79	17,38	2,46	6,41	5,98
10	3,41	1,59	2,44	1,96	2,03	0,004	0,003	0,005	0,011	0,004	5,34	3,51	1,84	3,89	4,16
11	1,90	3,25	0,89	0,55	2,21	0,004	0,007	0,006	0,007	0,004	1,82	1,88	1,29	1,08	1,40
12	3,97	2,27	3,65	1,82	3,25	0,012	0,008	0,007	0,004	0,003	4,47	6,29	2,11	2,69	3,34
13	3,35	1,73	1,80	1,15	4,20	0,003	0,004	0,004	0,004	0,005	6,41	7,52	1,41	3,28	5,89
14	2,25	1,61	3,01	1,57	3,68	0,008	0,006	0,006	0,007	0,006	4,07	12,51	2,58	5,54	7,23
15	1,55	1,39	0,81	1,91	2,25	0,006	0,004	0,004	0,003	0,007	1,56	2,91	1,75	1,23	2,16
16															
17	1,56	1,81	2,26	1,92	2,36	0,003	0,003	0,004	0,002	0,002	2,80	4,13	2,15	4,88	3,94
18	3,20	2,40	20,99	1,74	18,24	0,007	0,006	0,009	0,001	0,009	2,62	9,72	1,77	1,51	7,38
19	2,66	1,75	1,15	1,37	2,73	0,003	0,002	0,004	0,002	0,003	3,25	3,99	1,19	2,62	4,96
20	4,39	0,97	1,60	1,83	1,19						5,22	2,71	5,78	10,93	15,48
21	0,23	0,51	0,54	0,26	0,51	0,001	0,001	0,005	0,003	0,006	0,33	0,61	0,29	0,91	0,73
22	10,43	2,32	4,33	1,16	2,74	0,076	0,006	0,033	0,005	0,003	10,14	7,95	6,00	4,24	2,77
23	3,21	1,02	2,18	1,38	3,50	0,005	0,004	0,004	0,003	0,004	2,62	1,03	1,60	2,24	1,78
24	3,60	1,27	2,93	1,84	2,58	0,006	0,003	0,005	0,002	0,002					
25	2,95	2,35	2,24	0,98	2,77	0,002	0,004	0,005	0,003	0,004	1,94	5,16	1,84	2,60	3,24
26	34,00	3,06	3,38	1,23	4,41	0,276	0,003	0,031	0,004	0,007	61,51	8,81	8,40	3,00	3,93

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

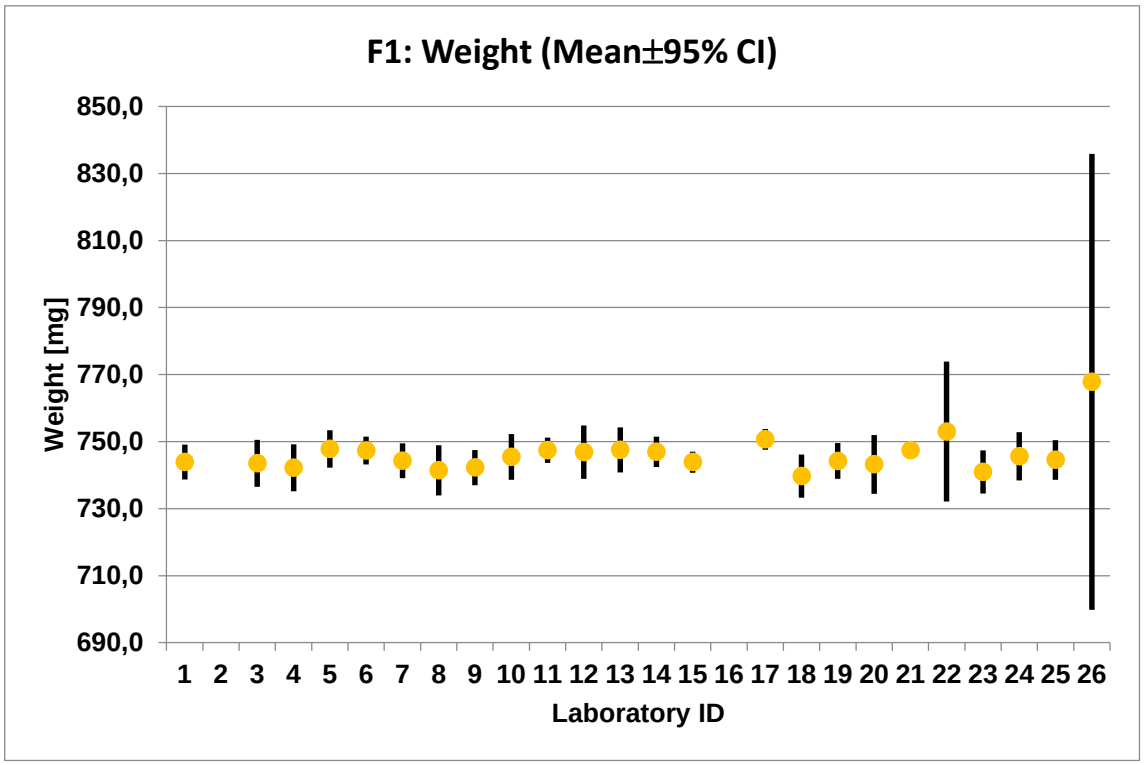
	Weight					Diameter					Open Draw Resistance				
	mg					mm					mmWG				
ID	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	4,41	10,62	6,50	4,45	4,05	0,003	0,005	0,006	0,003	0,007	1,29	0,74	1,67	2,59	0,60
2	5,72	7,32	7,33	7,08	5,55	0,007	0,003	0,012	0,008	0,012	0,65	1,32	1,04	1,07	0,80
3	6,10	5,07	1,88	7,96	10,81	0,006	0,005	0,005	0,005	0,007	0,79	0,68	1,16	1,76	1,25
4	3,35	6,61	6,49	4,18	5,24	0,005	0,002	0,002	0,010	0,007	0,91	0,51	1,49	0,85	0,41
5	5,26	4,65	5,10	6,96	2,42	0,004	0,008	0,005	0,005	0,005	0,94	1,34	0,65	1,38	1,32
6	5,24	2,06	9,73	2,84	0,71	0,004	0,006	0,002	0,009	0,010	0,80	1,19	1,77	0,60	0,40
7	2,49	3,21	11,26	4,06	5,94	0,006	0,005	0,007	0,004	0,008	1,31	0,56	2,14	2,43	1,02
8															
9	2,76	3,92	6,42	8,35	11,07	0,004	0,005	0,006	0,007	0,014	0,69	0,81	2,05	0,49	1,34
10	9,77	6,30	4,57	5,69	8,32	0,008	0,007	0,007	0,009	0,010	1,22	0,90	1,14	0,69	1,10
11	3,09	2,28	1,36	1,63	3,11	0,005	0,004	0,003	0,003	0,005	0,94	0,92	0,29	1,29	0,61
12															
13	5,87	6,02	6,57	2,42	5,62	0,006	0,004	0,006	0,008	0,007	0,54	1,70	1,33	1,05	0,95
14	11,24	4,55	7,59	3,11	4,21	0,007	0,003	0,003	0,005	0,009	0,92	1,05	1,54	2,36	1,51
15	14,05	7,23	13,08	6,28	3,65	0,009	0,004	0,008	0,009	0,004	0,55	1,95	3,87	2,68	0,93
16	9,89	5,96	5,03	4,32	5,12	0,015	0,003	0,004	0,006	0,007	1,13	1,02	0,89	1,52	0,62
17	6,31	5,39	6,92	4,11	3,23	0,004	0,008	0,005	0,014	0,013	1,63	1,20	2,21	1,83	1,25
18	2,62	5,77	1,80	8,53	4,49	0,005	0,004	0,006	0,004	0,003	0,45	1,32	1,19	1,51	1,16
19	4,96	4,42	4,74	5,97	5,73	0,007	0,006	0,007	0,007	0,004	1,37	1,23	1,16	0,40	0,64
20	2,82	5,76	5,35	4,97	4,10						1,58	1,38	0,81	1,24	1,40
21	0,32	1,42	1,06	0,76	0,69	0,006	0,003	0,002	0,005	0,002	0,21	0,64	0,48	0,47	0,26
22	2,11	5,96	6,56	8,04	3,91	0,005	0,007	0,007	0,004	0,005	1,88	1,01	0,99	0,52	0,52
23	8,18	5,64	3,79	6,19	4,86	0,008	0,005	0,005	0,002	0,006	1,48	0,51	0,54	0,88	0,96
24	4,06	3,04	6,85	8,03	5,61	0,002	0,003	0,005	0,010	0,006	0,59	1,33	6,19	1,50	1,40
25															
26	8,41	2,87	9,08	8,08	5,04	0,006	0,004	0,006	0,005	0,007	0,89	0,76	0,81	1,56	0,85

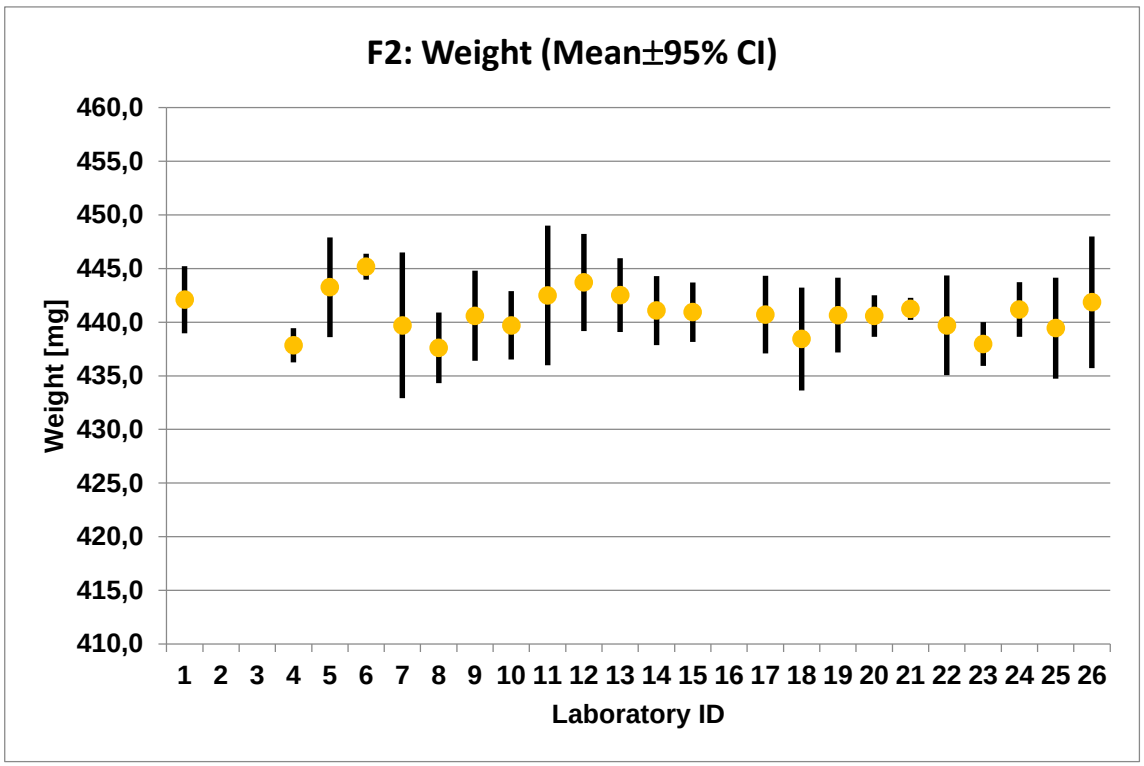
Appendix C.2b: Standard deviations of closed draw resistance and degree of filter ventilation of cigarettes for all laboratories (ID)

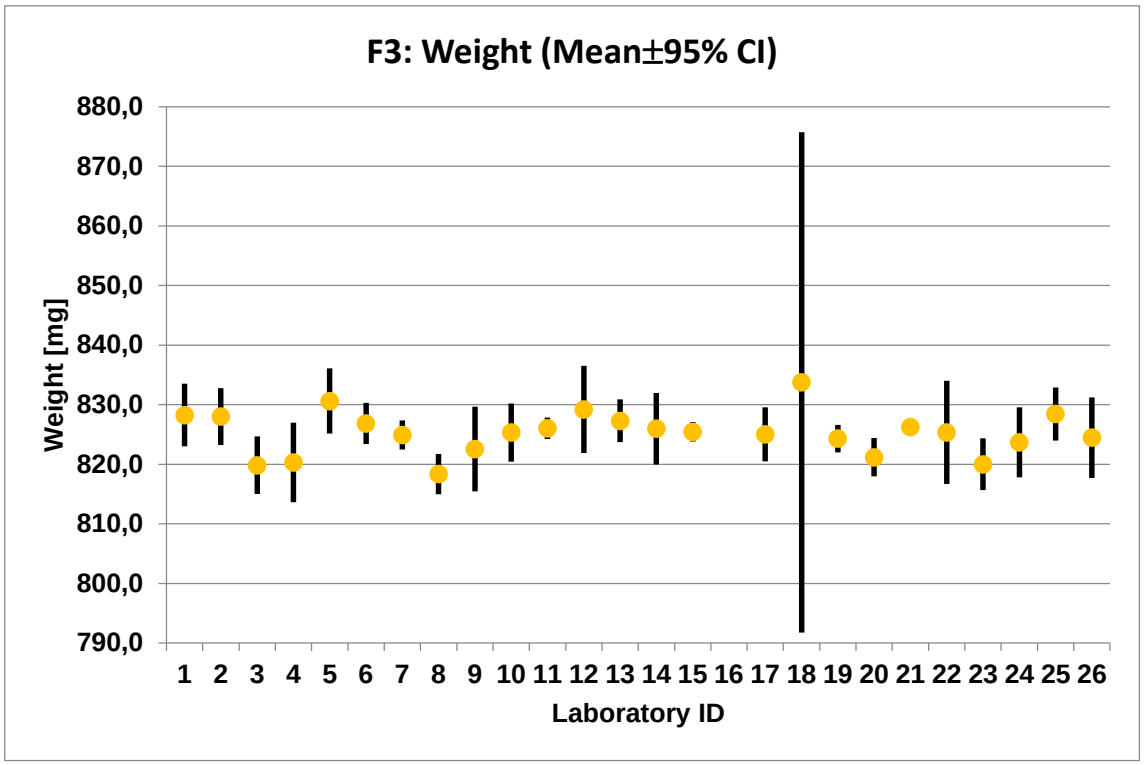
	Closed Draw Resistance					Degree of Filter Ventilation				
	mg					%				
ID	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	4,05	2,14	2,18	1,77	1,26	0,22	0,67	0,52	1,83	0,38
2	2,35	2,89	0,75	1,49	1,36	0,21	0,57	1,09	0,48	0,27
3	4,25	0,86	1,80	1,89	3,10	0,25	0,61	0,77	0,39	0,59
4	3,00	0,84	2,40	1,41	3,12	0,18	0,54	0,34	0,50	0,46
5	1,99	1,22	1,51	2,25	2,07	0,35	0,35	0,50	0,31	0,19
6	3,91	1,56	0,81	0,17	0,82	0,20	0,24	0,84	0,53	7,46
7	3,77	1,19	3,24	3,95	1,40	0,41	0,30	0,60	0,48	0,50
8										
9	2,97	1,53	3,34	0,60	2,69	0,24	0,61	0,49	0,59	0,99
10	5,09	2,15	1,84	0,95	2,14	0,50	0,36	0,51	0,39	0,40
11	0,49	0,66	0,63	0,42	0,58	0,39	0,46		0,36	0,40
12										
13	3,21	2,25	2,05	2,02	1,90	0,47	0,38	0,52	0,46	0,37
14	3,62	2,21	2,26	2,16	2,81	0,43	0,65	0,29	0,71	0,28
15	3,24	2,18	4,55	1,57	0,60	0,24	0,71	0,63	1,92	0,34
16						0,55	0,76	0,26	0,91	12,88
17	4,79	1,99	3,78	2,65	2,17	0,64	0,65	0,38	0,43	0,31
18						0,25	0,28	0,36	0,66	0,70
19	4,10	2,12	2,50	1,11	1,49	0,67	0,43	0,91	0,56	0,17
20	2,23	2,03	2,50	1,88	1,65	0,41	0,44	0,77	0,45	0,54
21	0,38	0,72	0,29	0,52	0,74	0,32	0,22	0,23	0,31	0,11
22	8,11	2,10	1,00	1,39	2,03	0,39	0,49	0,74	0,66	0,51
23	3,25	0,53	1,64	1,02	0,45	0,21	0,35	0,77	0,38	0,27
24	2,35	1,64	2,12	2,08	1,36	0,31	0,71	2,91	1,06	0,93
25										
26	7,61	0,83	1,76	2,28	2,05	0,58	0,47	0,59	0,40	0,36

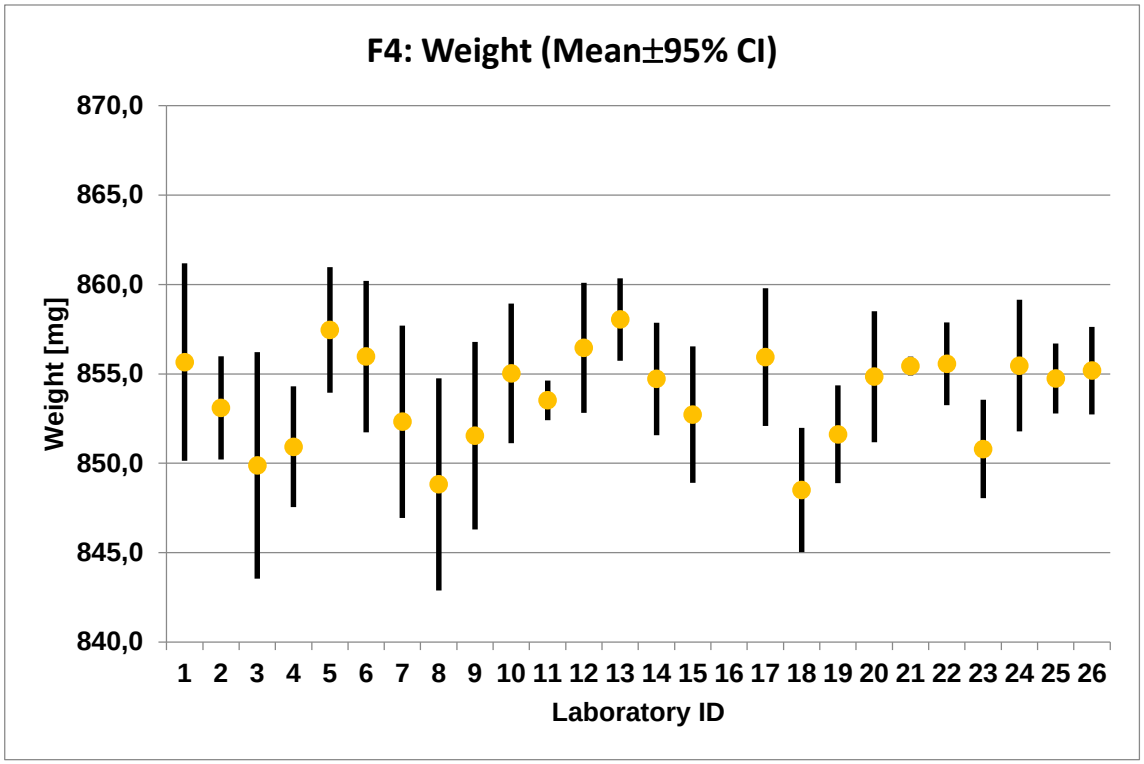
APPENDIX D – Results for Filter Rods (Diagrams)

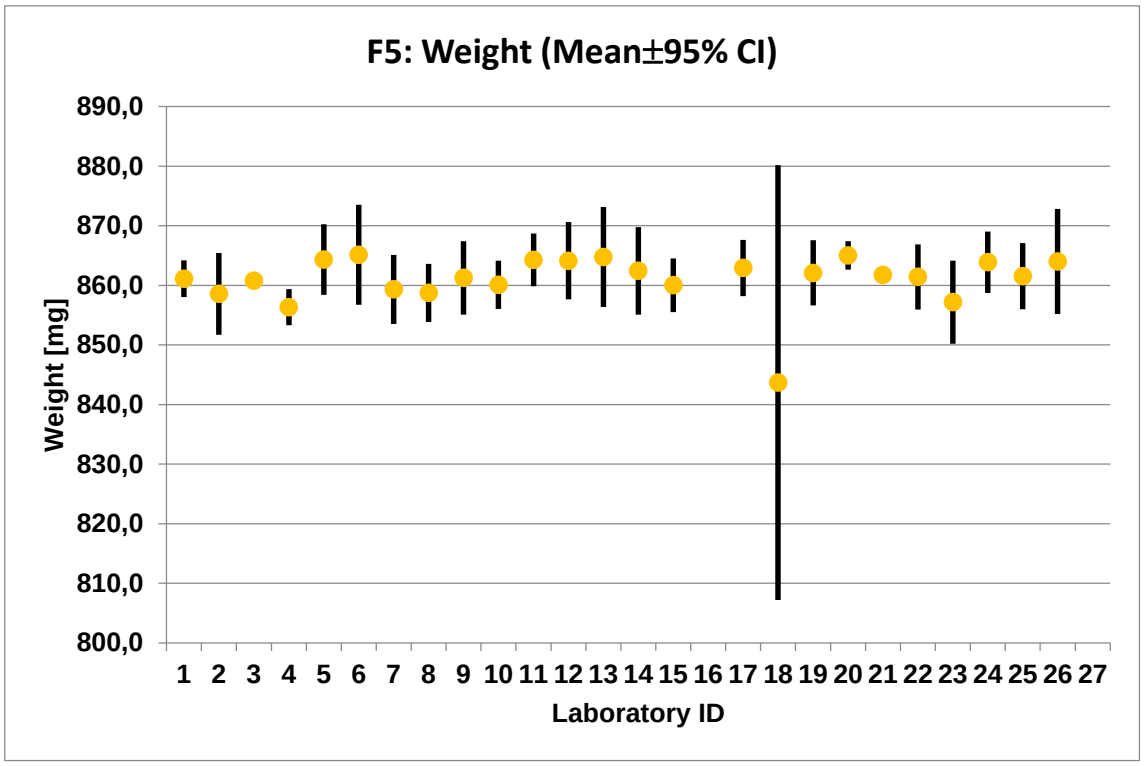
Appendix D.1: Weights of filter rods F1-F5



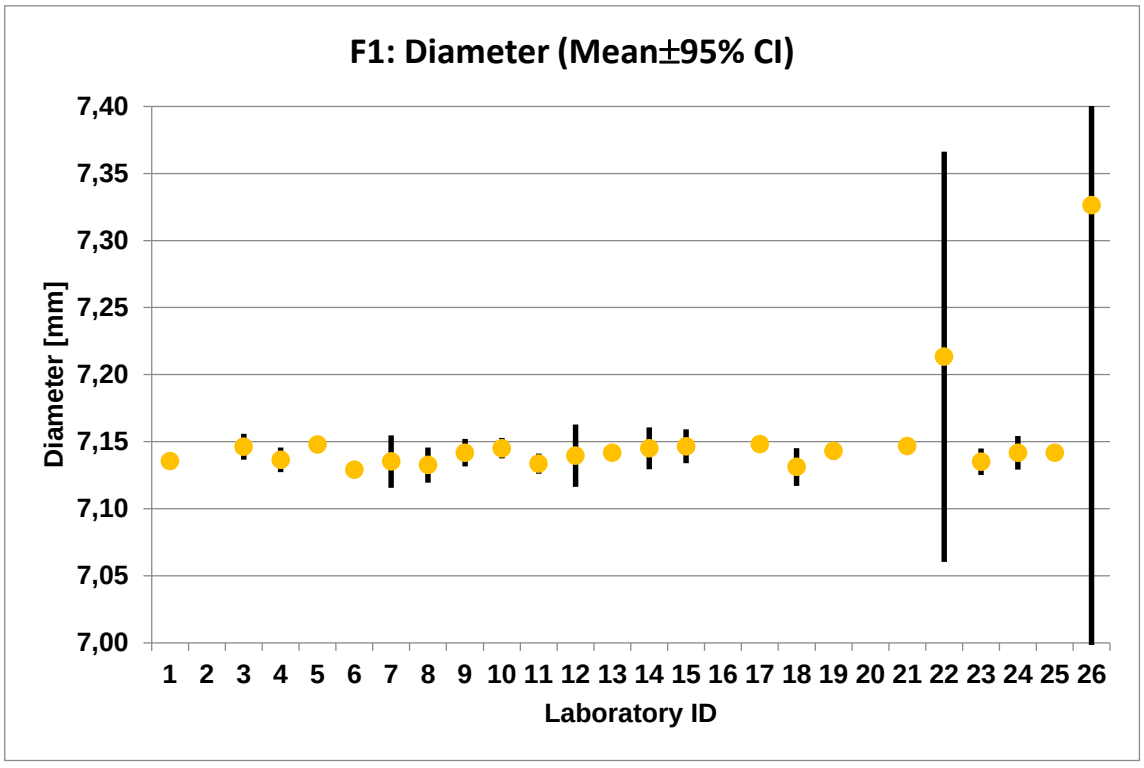


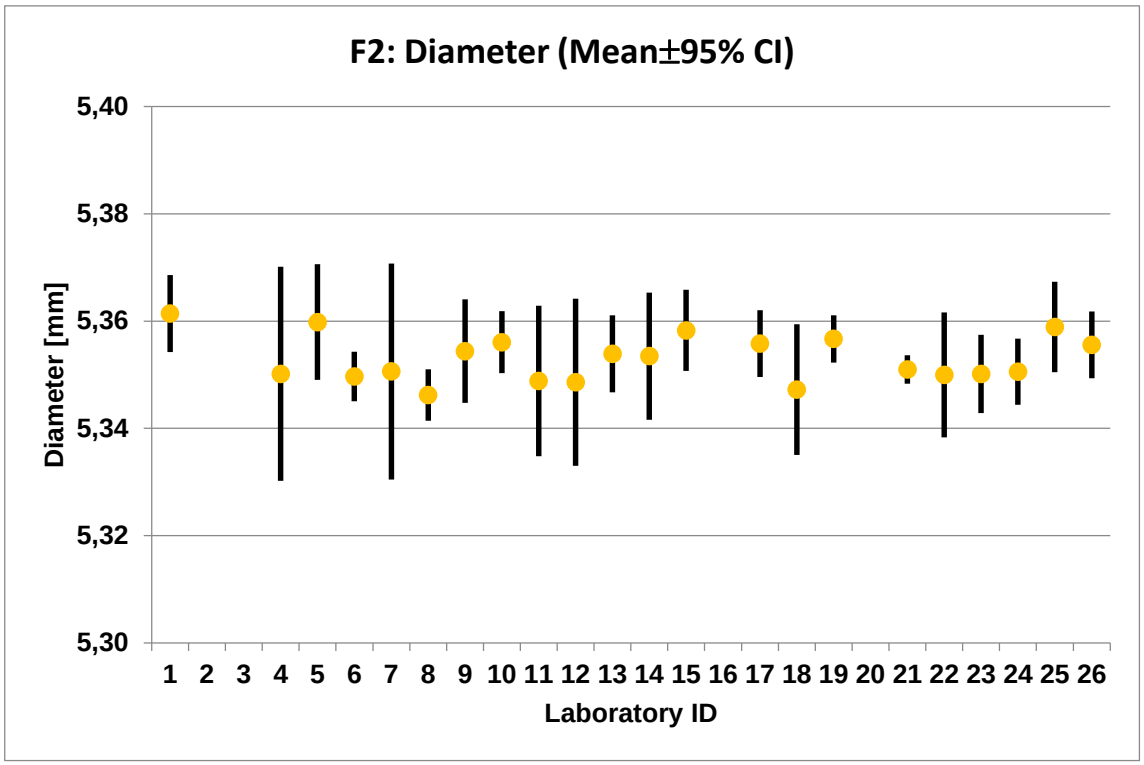

F3: Weight (Mean±95% CI)
Weight [mg]
880,0
870,0
860,0
850,0
840,0
830,0
820,0
810,0
800,0
790,0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

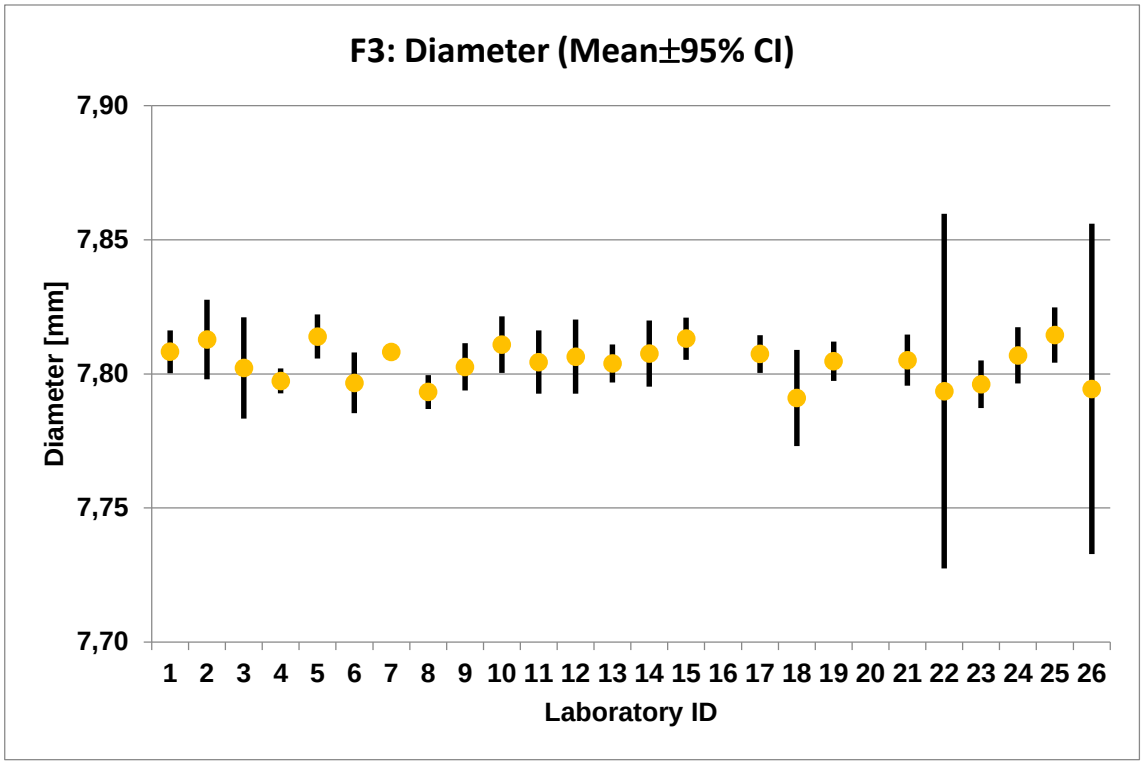

F4: Weight (Mean±95% CI)
Weight [mg]
870,0
865,0
860,0
855,0
850,0
845,0
840,0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

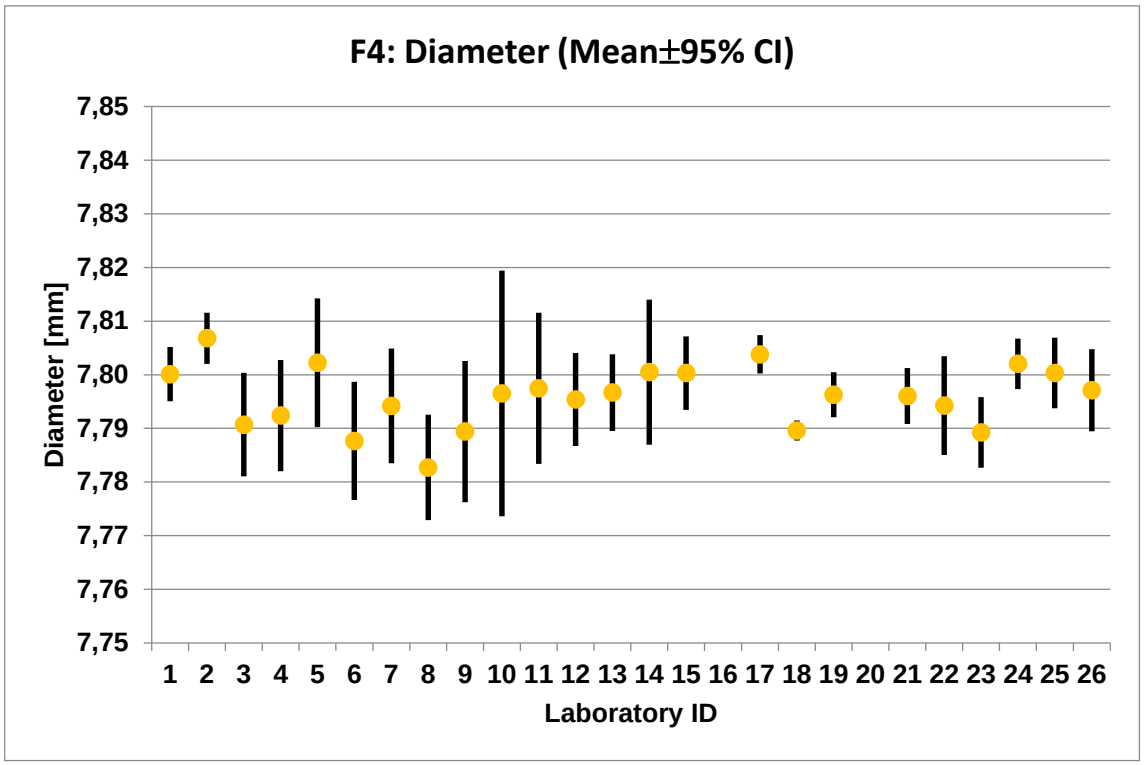


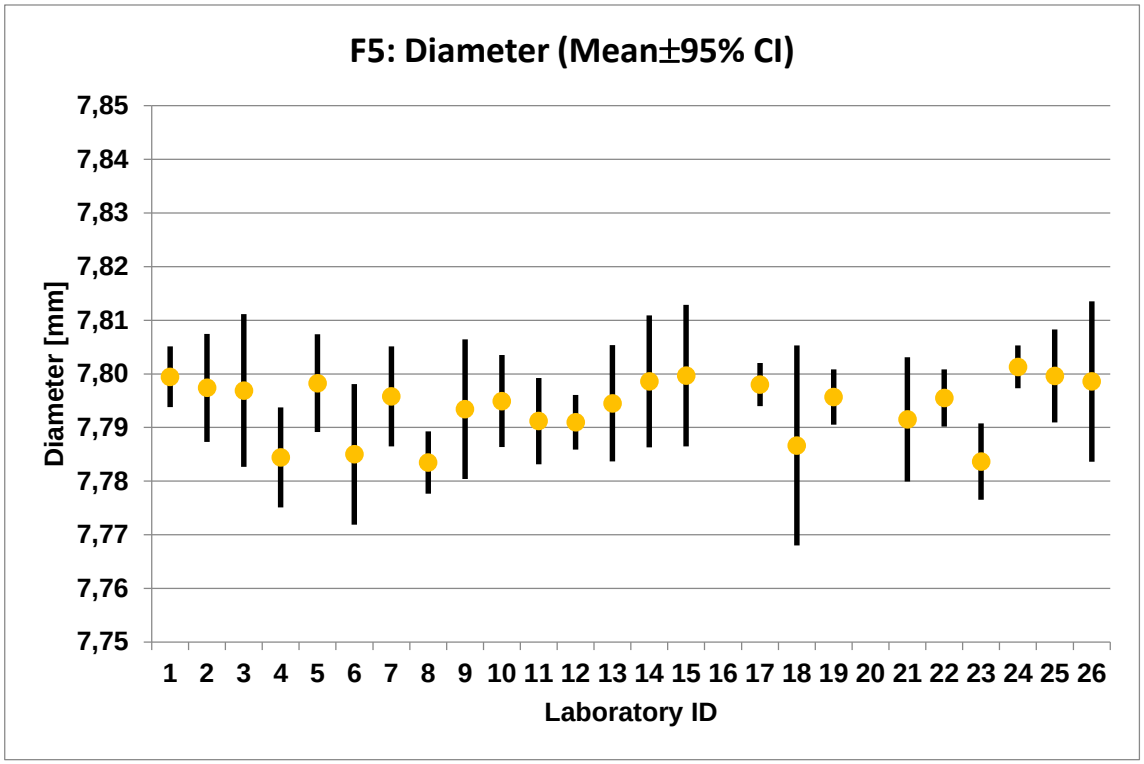
Appendix D.2: Diameters of filter rods F1-F5



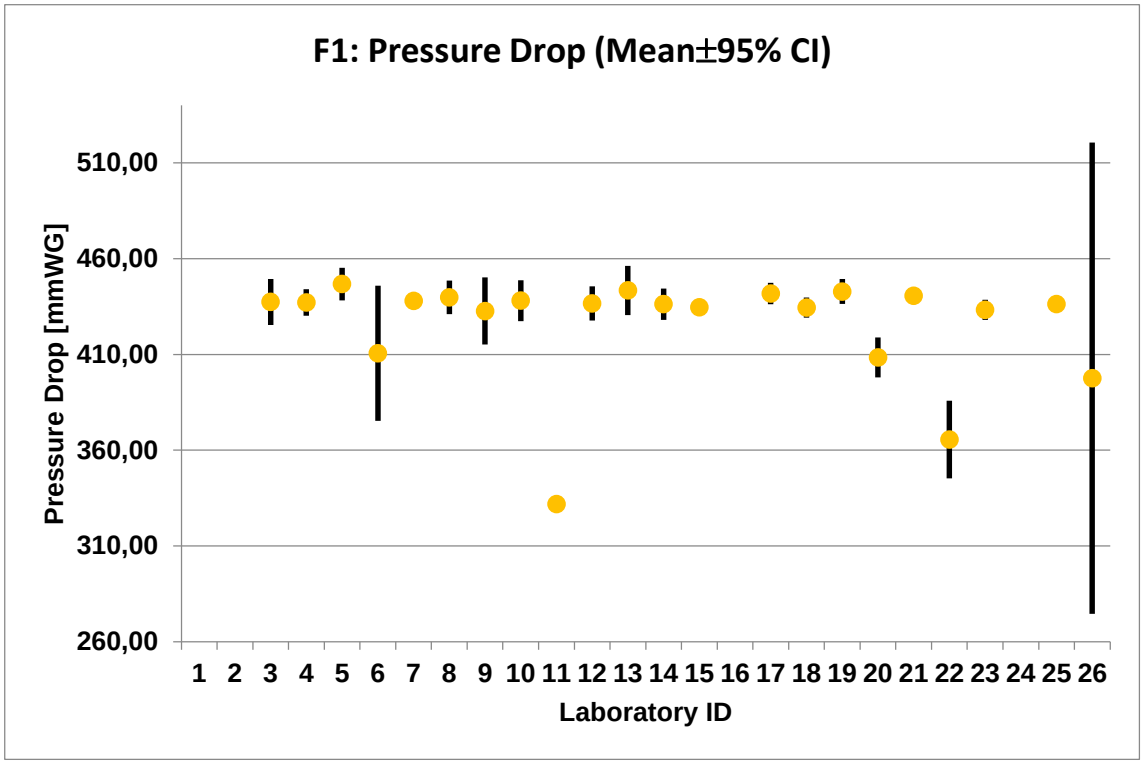

F2: Diameter (Mean±95% CI)
Diameter [mm]
5,40
5,38
5,36
5,34
5,32
5,30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

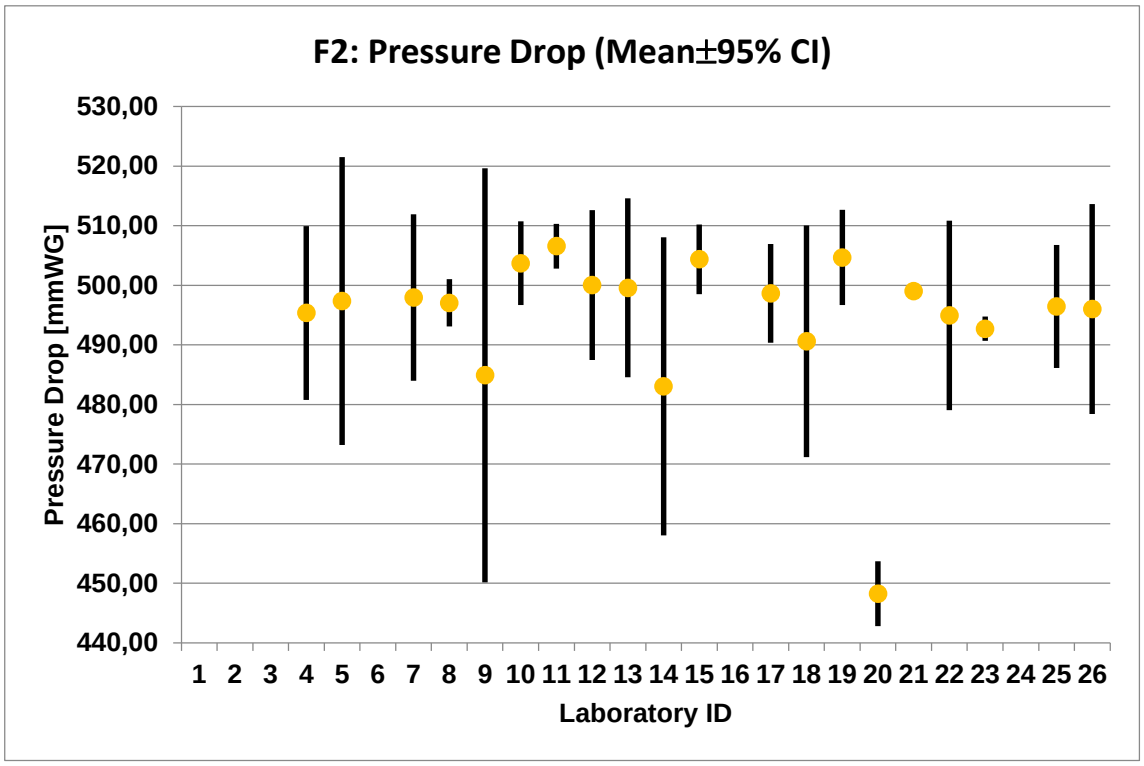

F3: Diameter (Mean±95% CI)
Diameter [mm]
7,90
7,85
7,80
7,75
7,70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

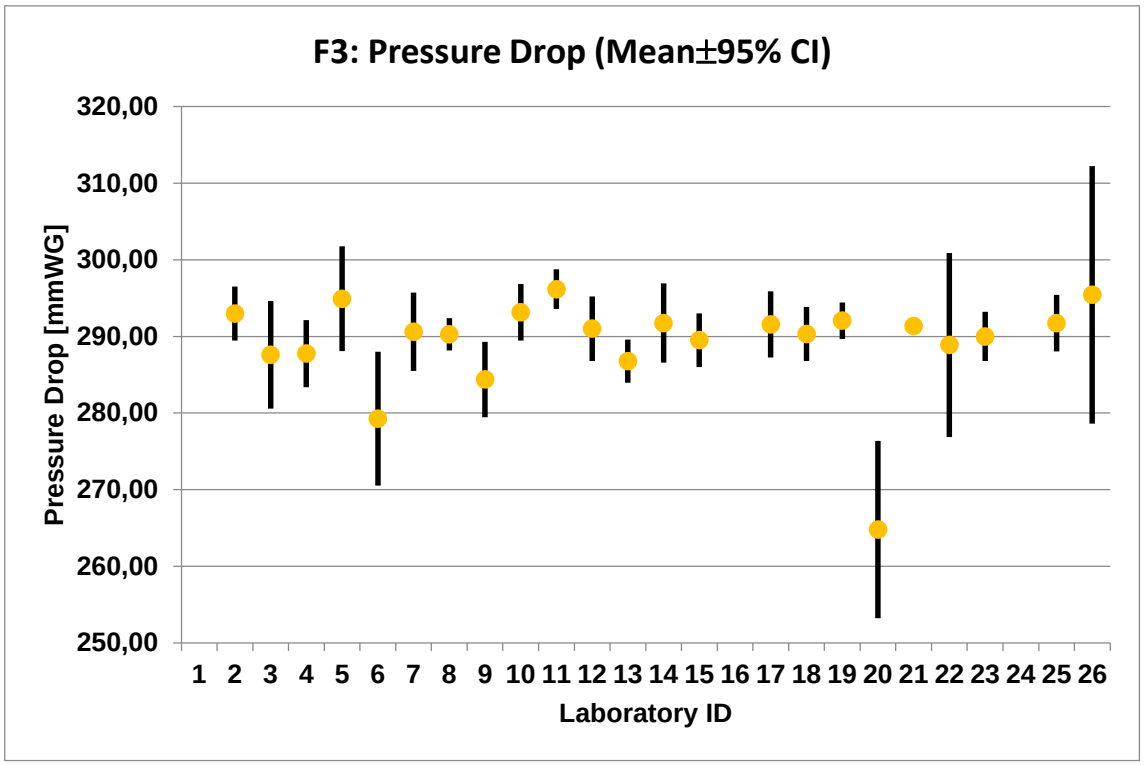

F4: Diameter (Mean±95% CI)
Diameter [mm]
7,85
7,84
7,83
7,82
7,81
7,80
7,79
7,78
7,77
7,76
7,75
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

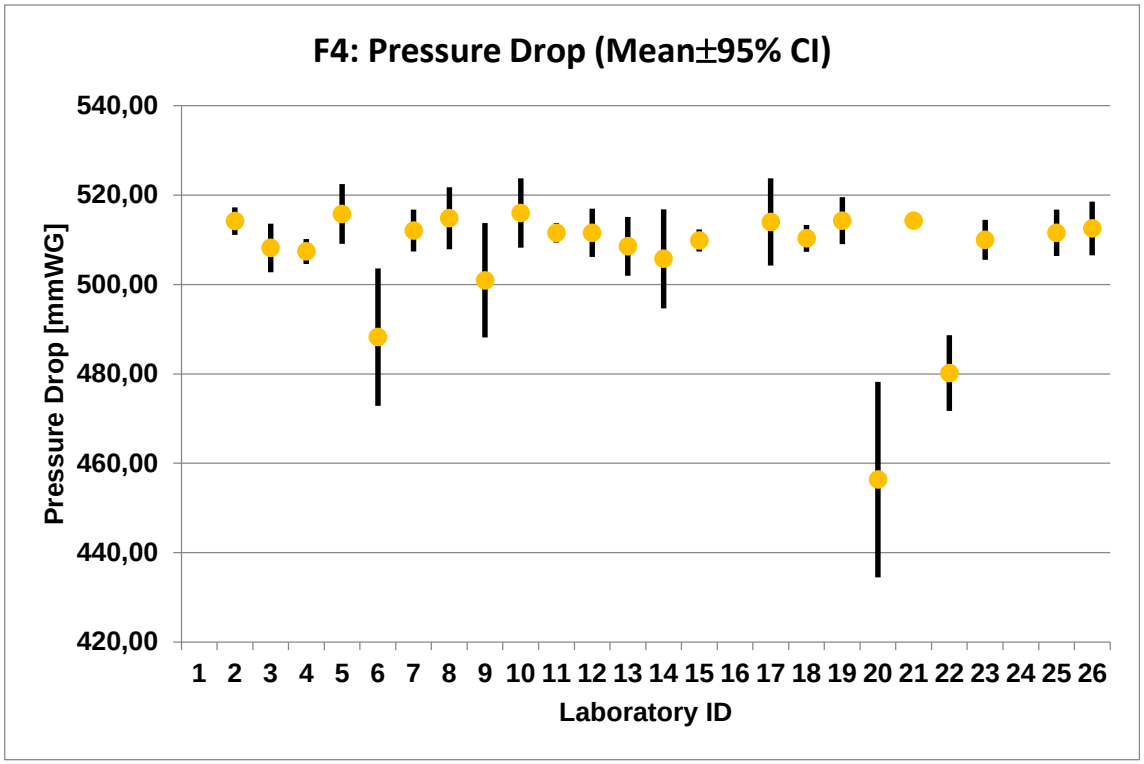

F5: Diameter (Mean±95% CI)
Diameter [mm]
7,85
7,84
7,83
7,82
7,81
7,80
7,79
7,78
7,77
7,76
7,75
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

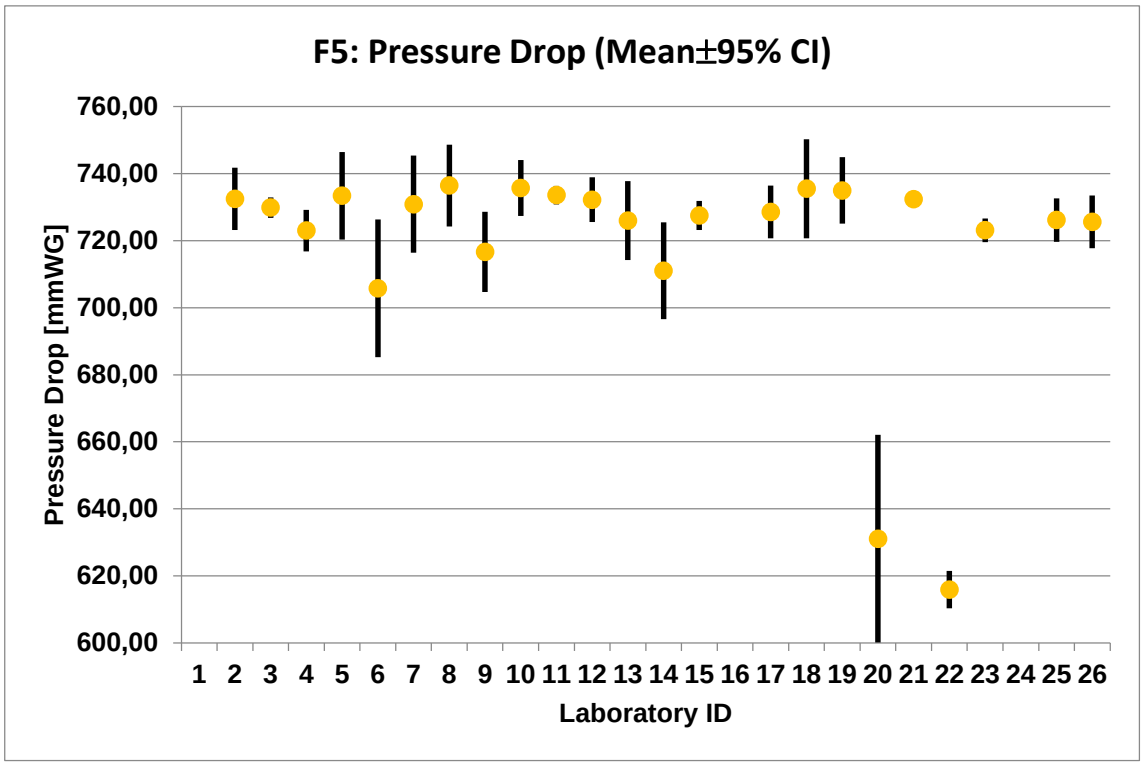
Appendix D.3: Fully encapsulated pressure drops of filter rods F1-F5





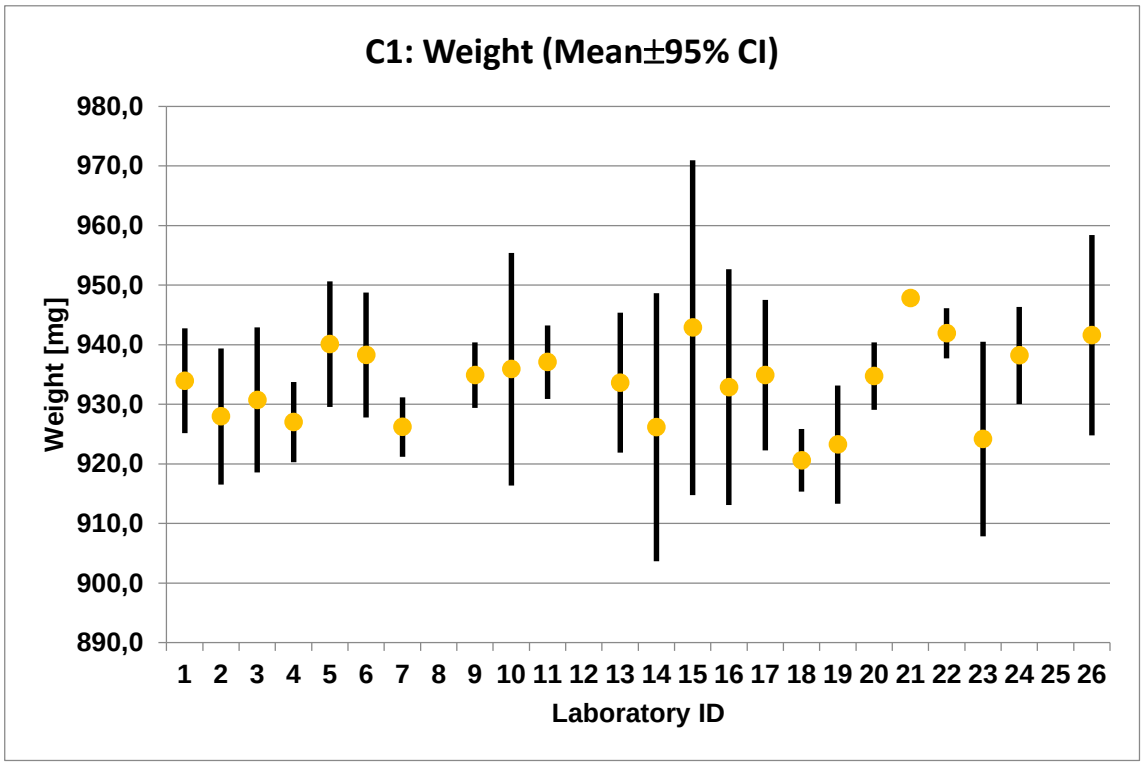

F3: Pressure Drop (Mean±95% CI)
Pressure Drop [mmWG]
320,00
310,00
300,00
290,00
280,00
270,00
260,00
250,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

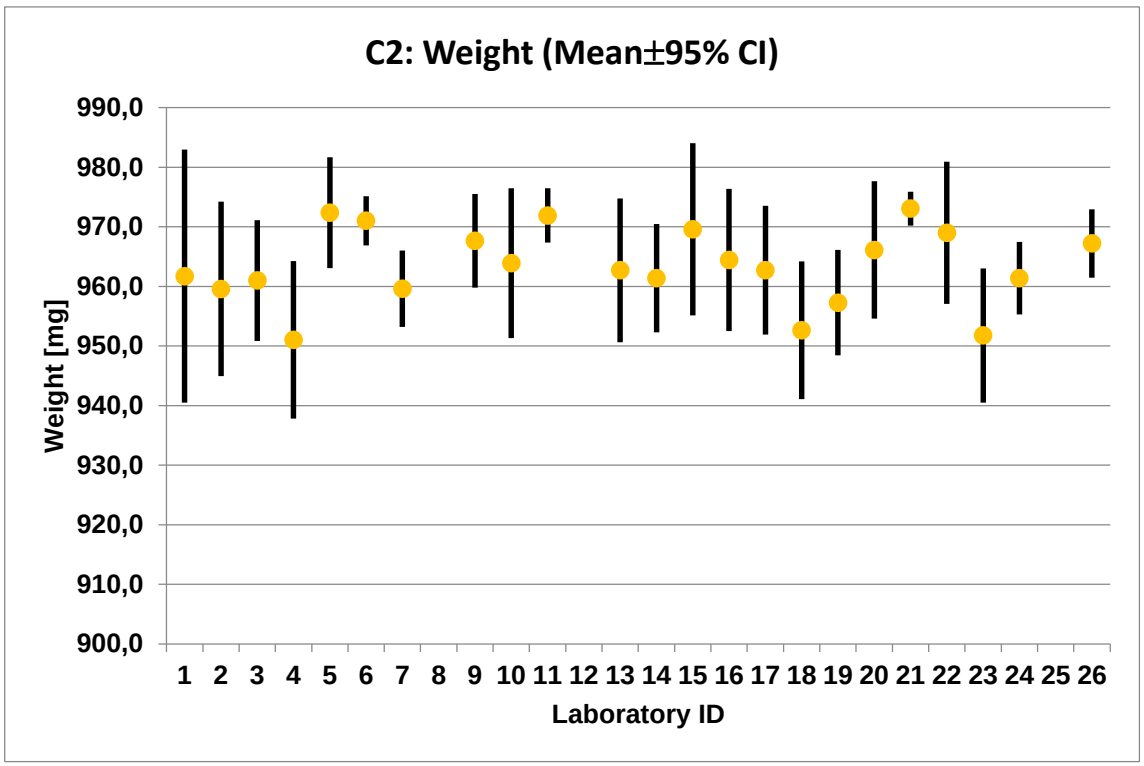

F4: Pressure Drop (Mean±95% CI)
Pressure Drop [mmWG]
540,00
520,00
500,00
480,00
460,00
440,00
420,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

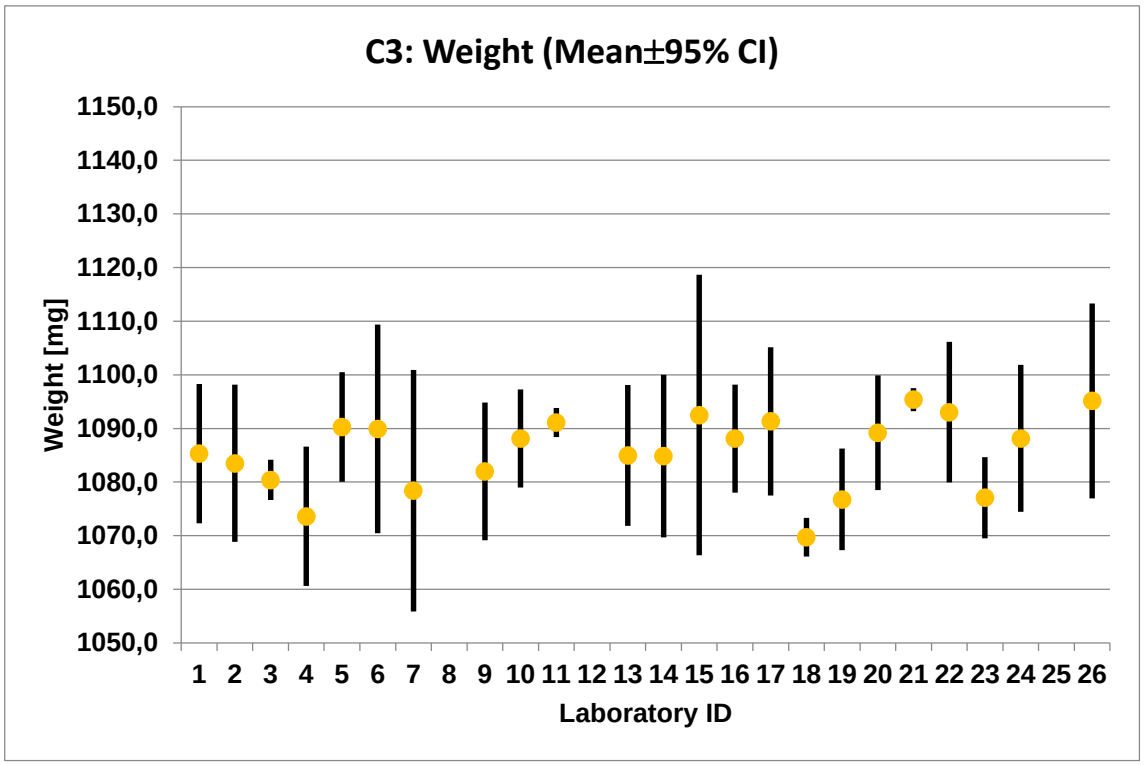

F5: Pressure Drop (Mean±95% CI)
Pressure Drop [mmWG]
760,00
740,00
720,00
700,00
680,00
660,00
640,00
620,00
600,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

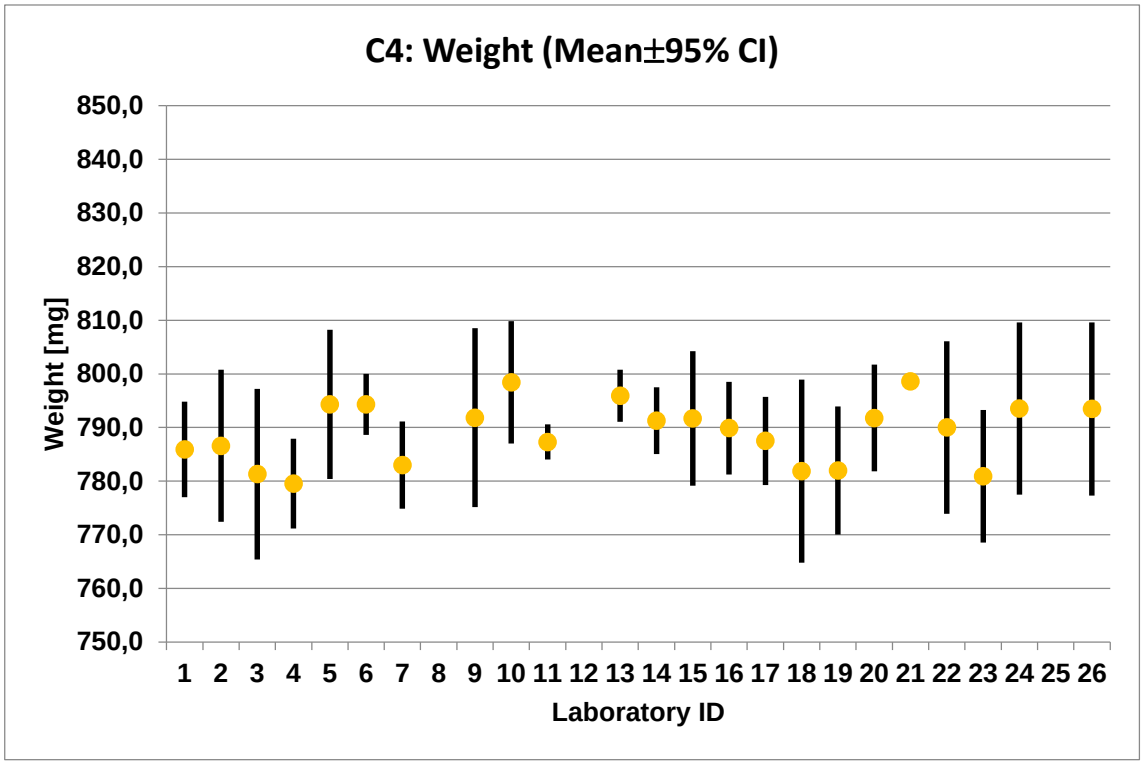
APPENDIX E – Results for Cigarettes (Diagrams)

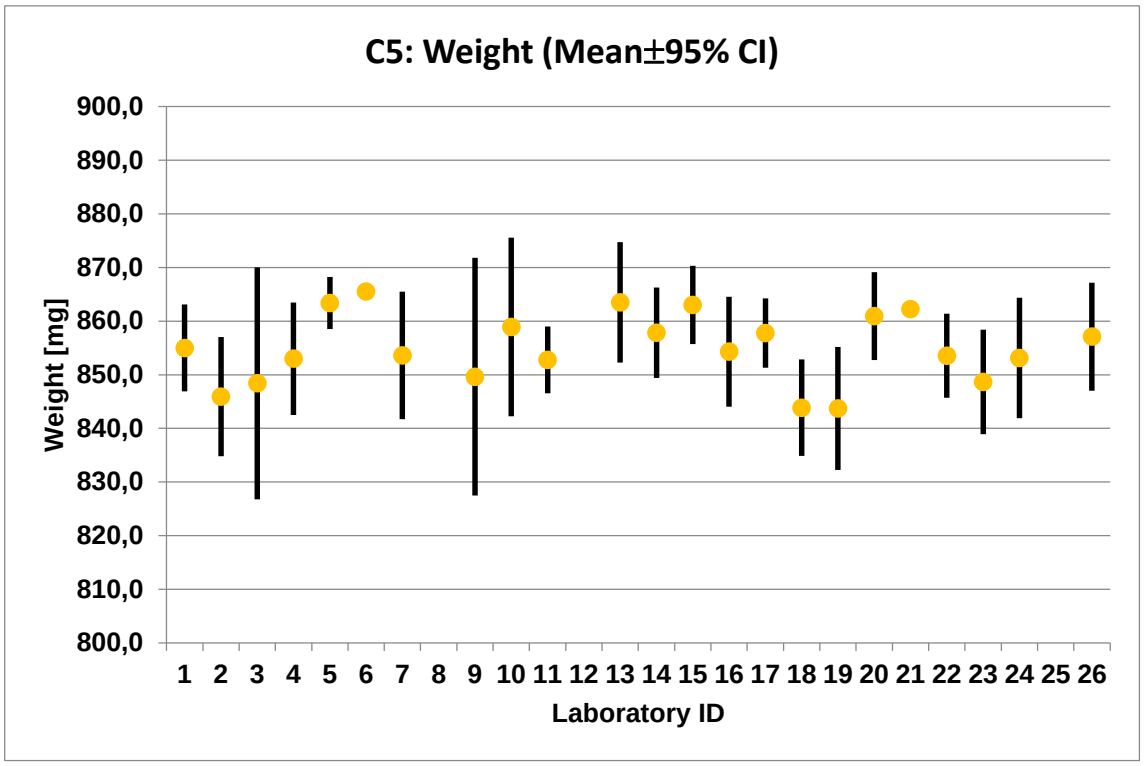
Appendix E.1: Weights of cigarettes C1-C5



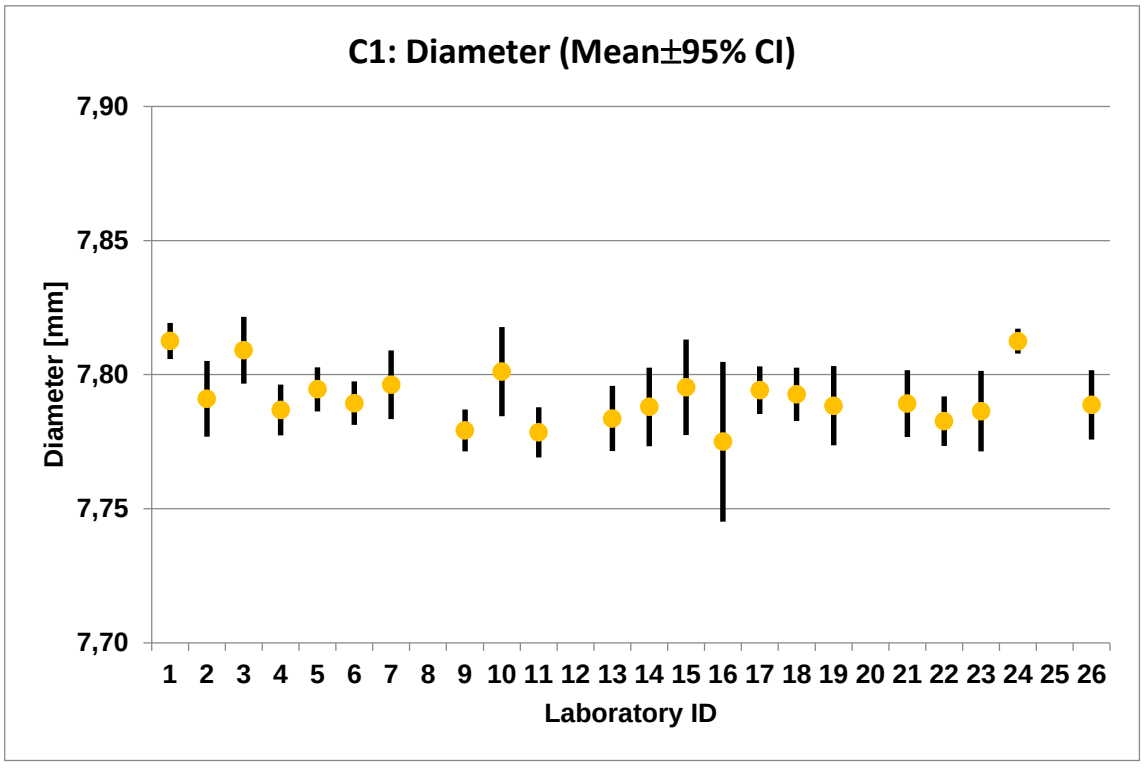


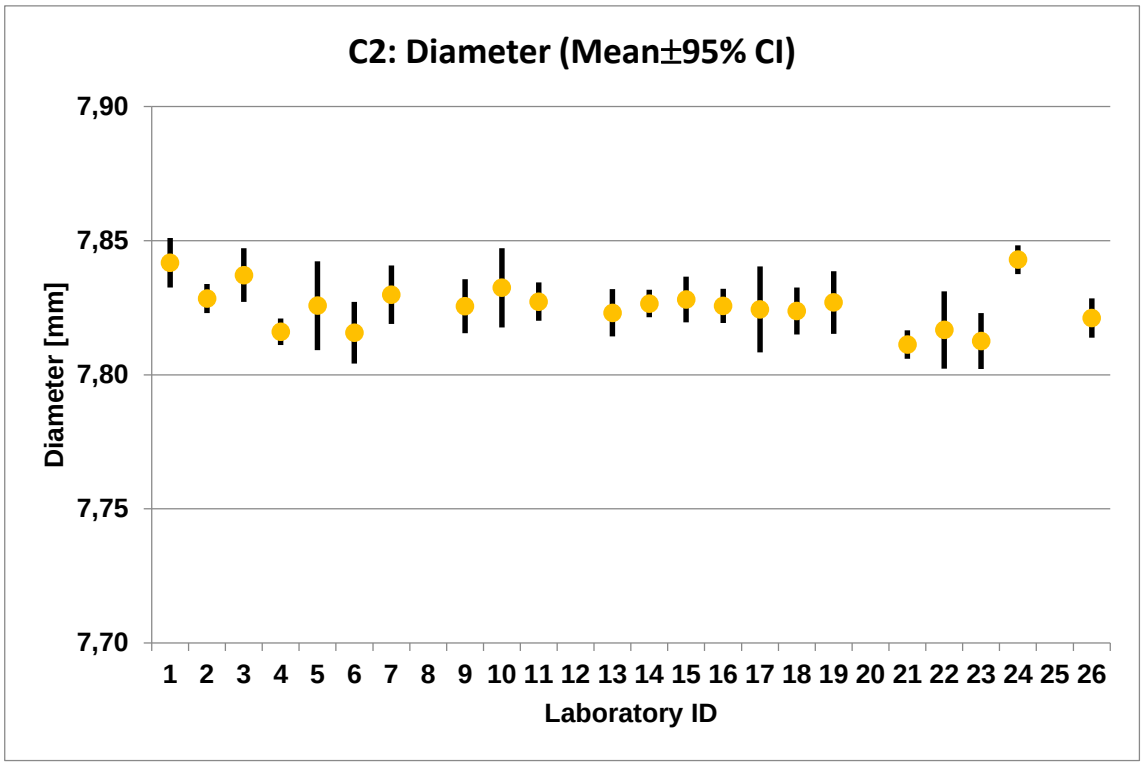

C3: Weight (Mean±95% CI)
Weight [mg]
1150,0
1140,0
1130,0
1120,0
1110,0
1100,0
1090,0
1080,0
1070,0
1060,0
1050,0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

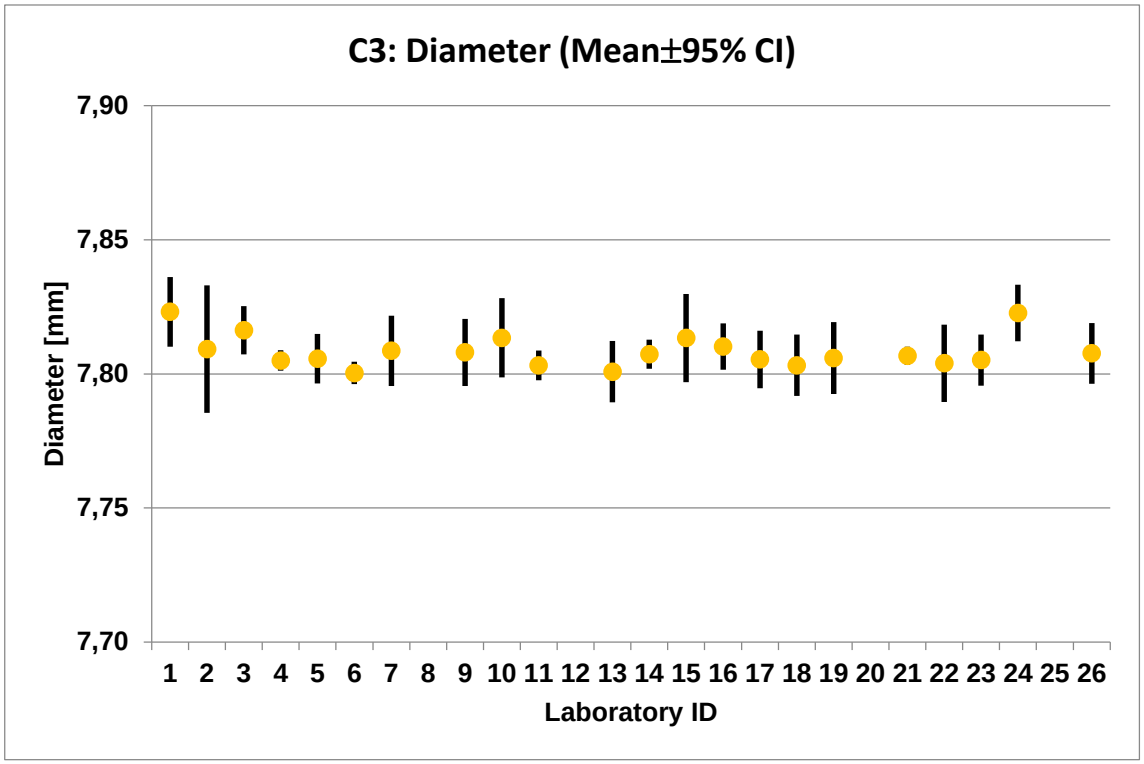

C4: Weight (Mean±95% CI)
Weight [mg]
850,0
840,0
830,0
820,0
810,0
800,0
790,0
780,0
770,0
760,0
750,0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

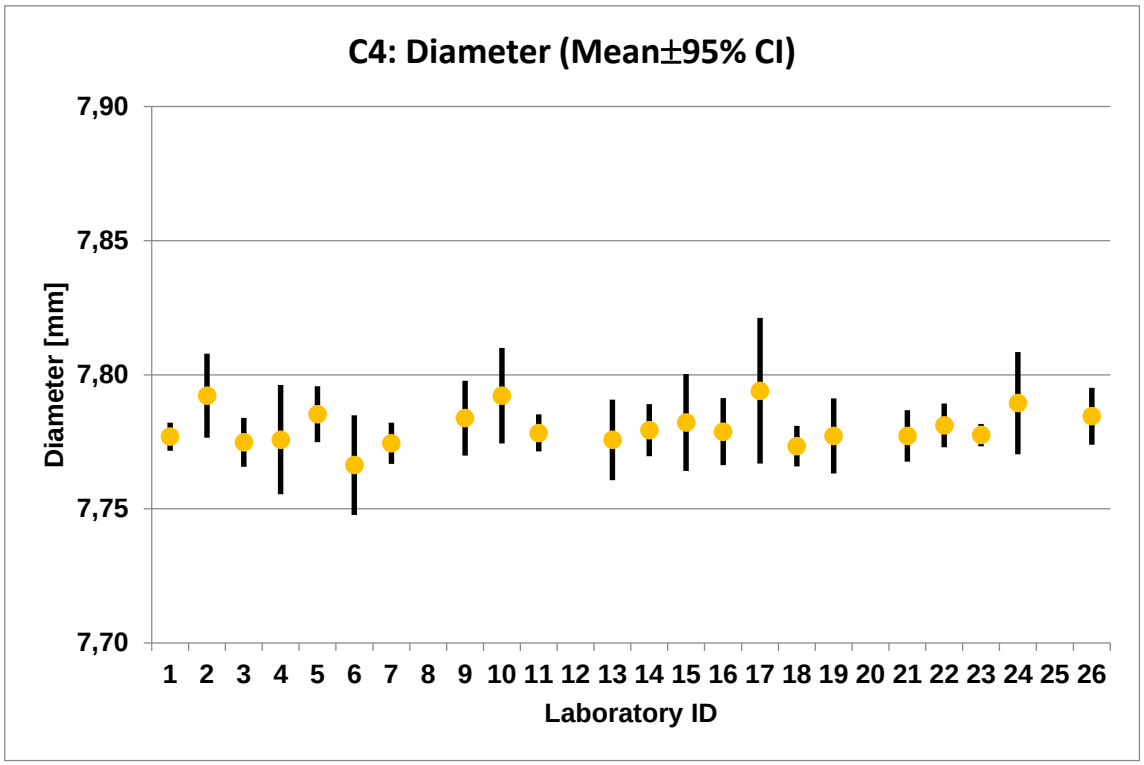


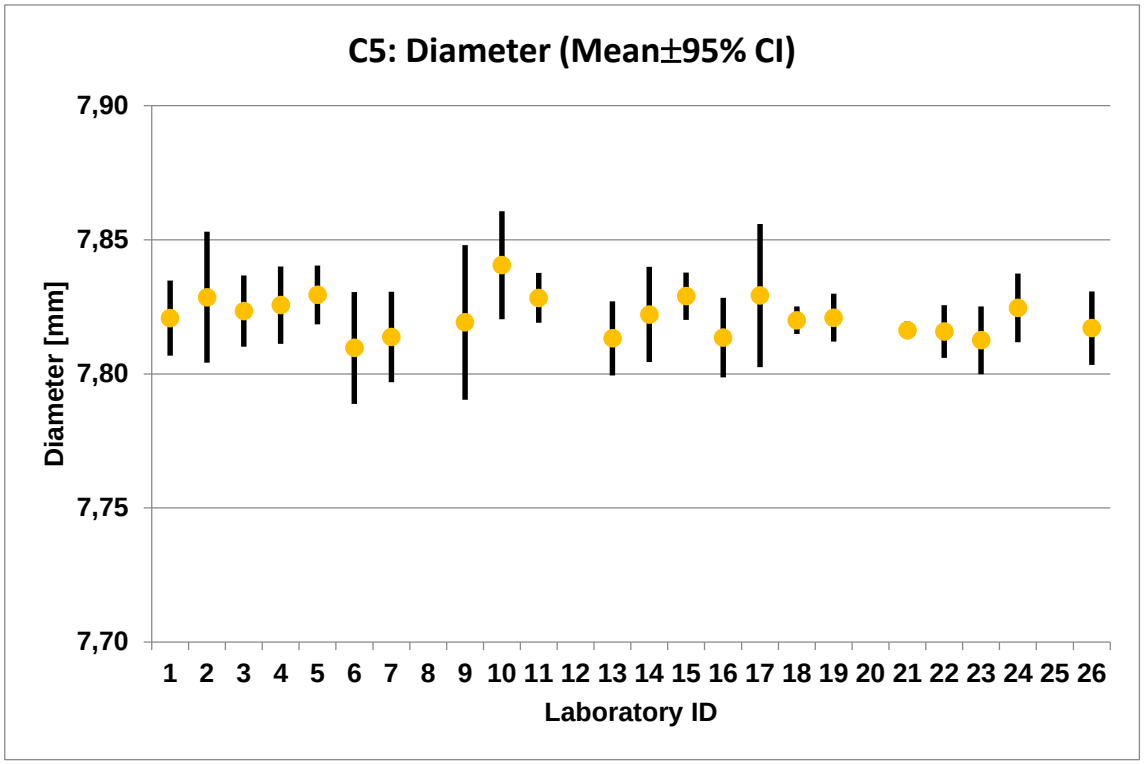
Appendix E.2: Diameters of cigarettes C1-C5



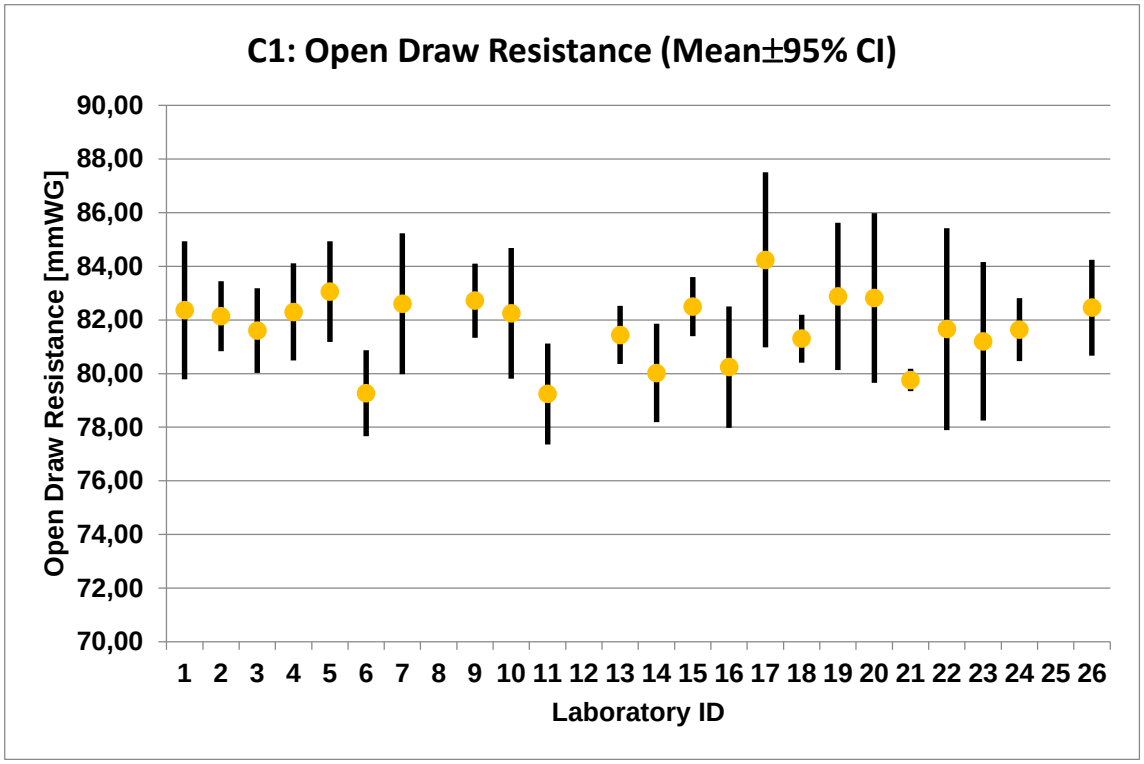

C2: Diameter (Mean±95% CI)
7,90
7,85
7,80
7,75
7,70
Diameter [mm]
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

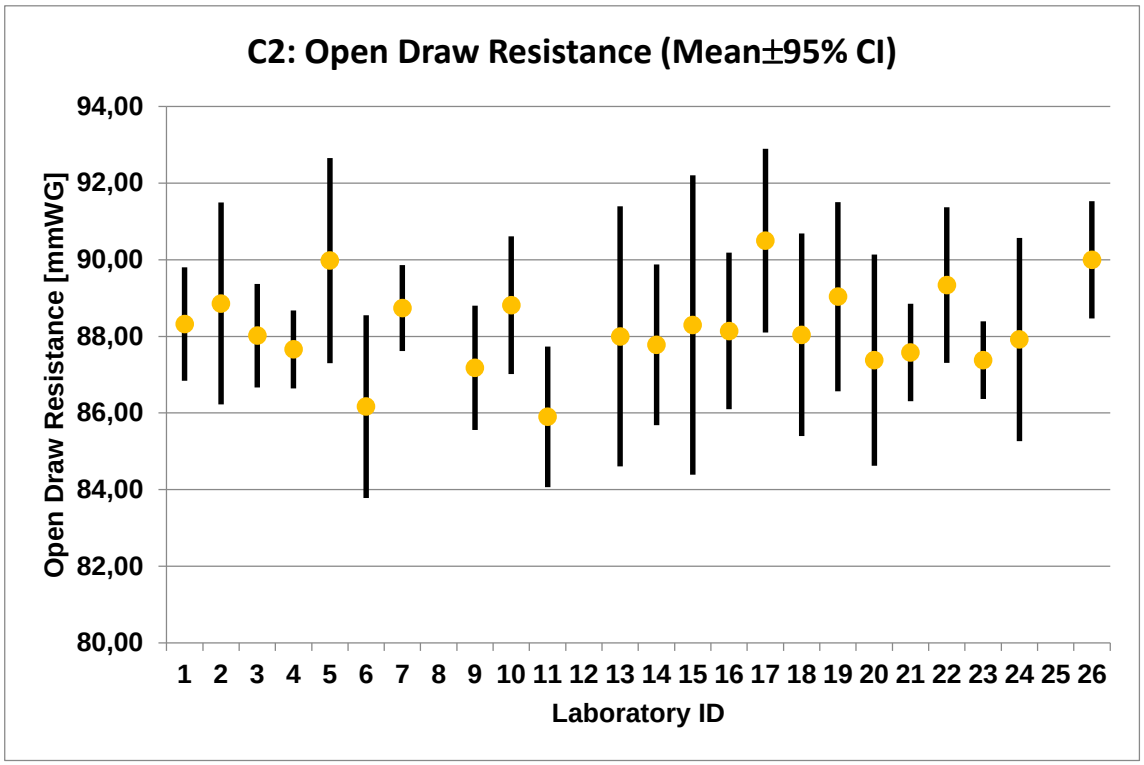

C3: Diameter (Mean±95% CI)
7,90
7,85
7,80
7,75
7,70
Diameter [mm]
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

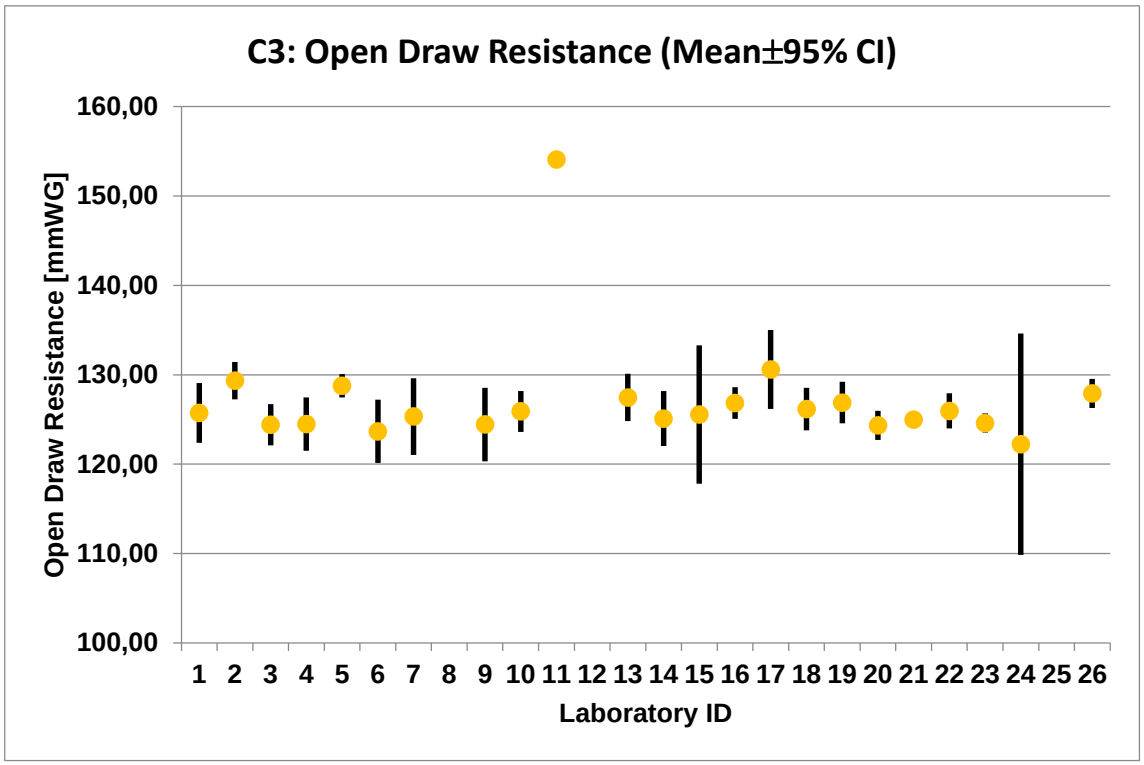

C4: Diameter (Mean±95% CI)
Diameter [mm]
7,90
7,85
7,80
7,75
7,70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

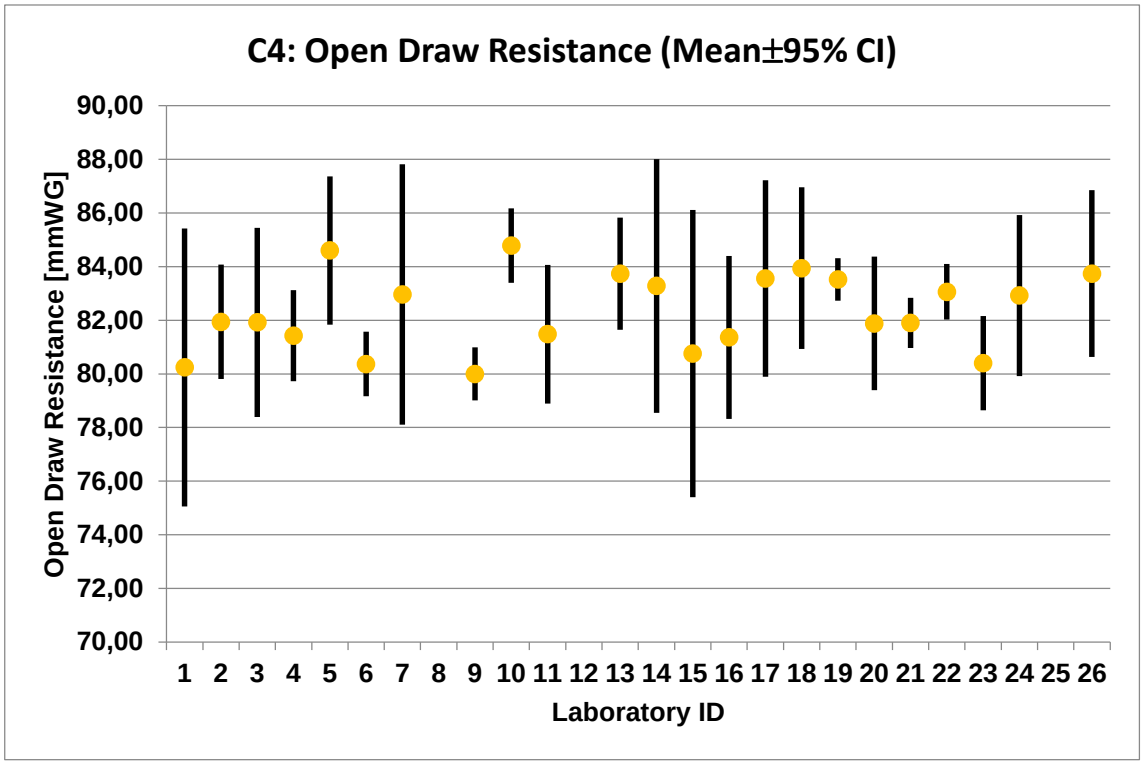

C5: Diameter (Mean±95% CI)
Diameter [mm]
7,90
7,85
7,80
7,75
7,70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

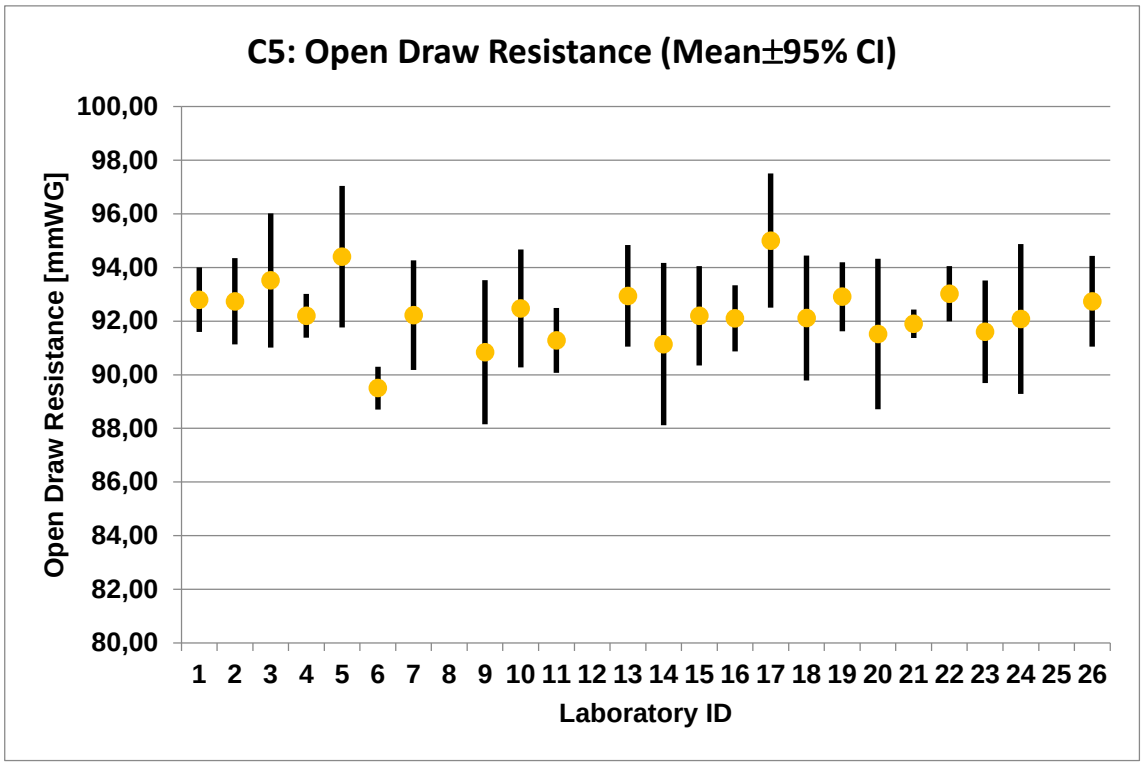
Appendix E.3: Open draw resistances of cigarettes C1-C5



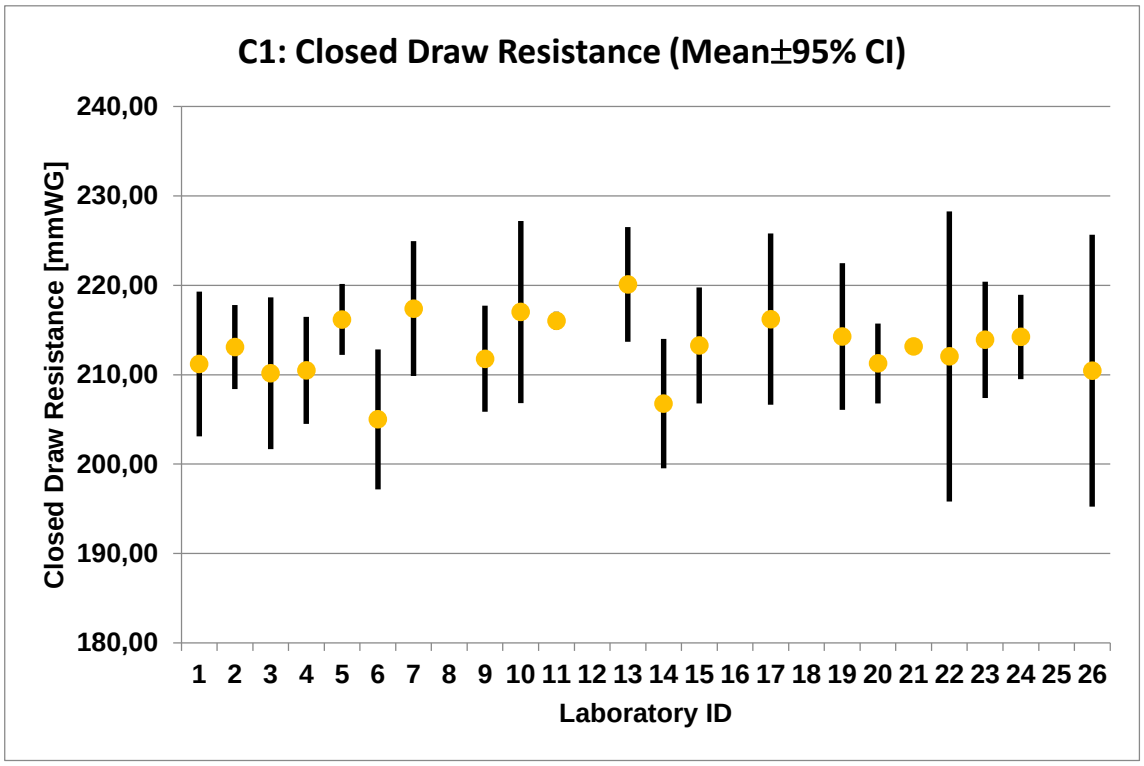


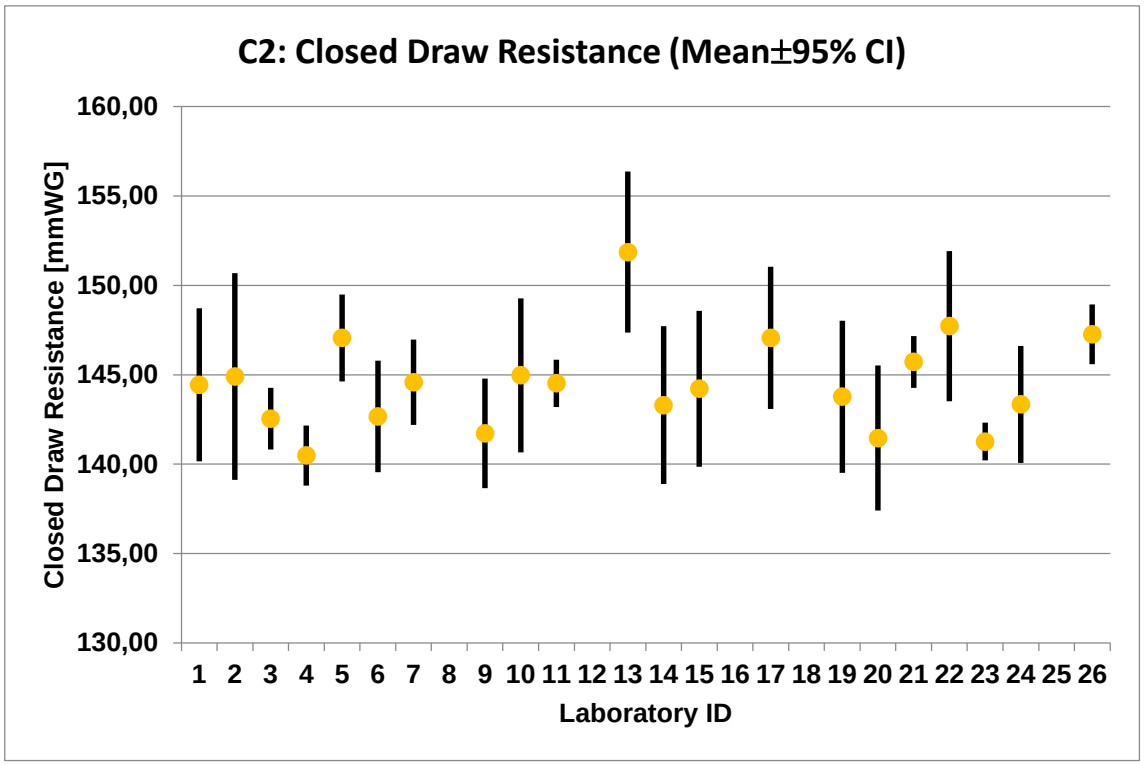

C3: Open Draw Resistance (Mean±95% CI)
Open Draw Resistance [mmWG]
160,00
150,00
140,00
130,00
120,00
110,00
100,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

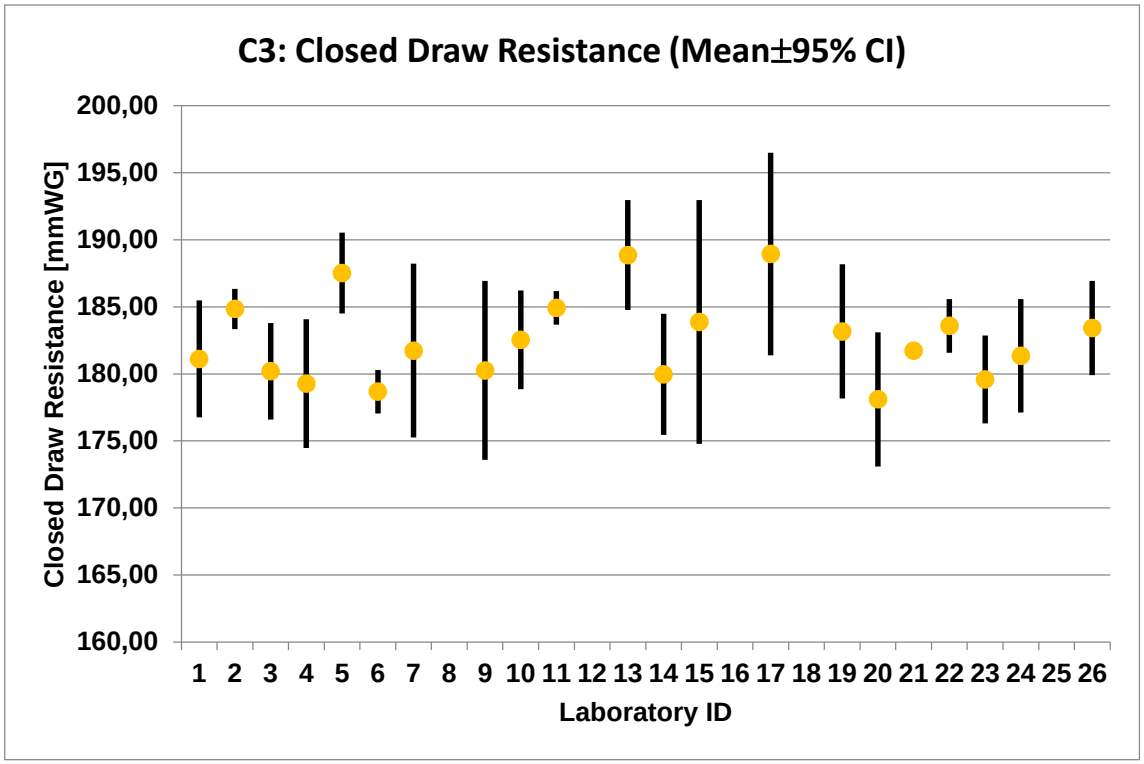

C4: Open Draw Resistance (Mean±95% CI)
Open Draw Resistance [mmWG]
90,00
88,00
86,00
84,00
82,00
80,00
78,00
76,00
74,00
72,00
70,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

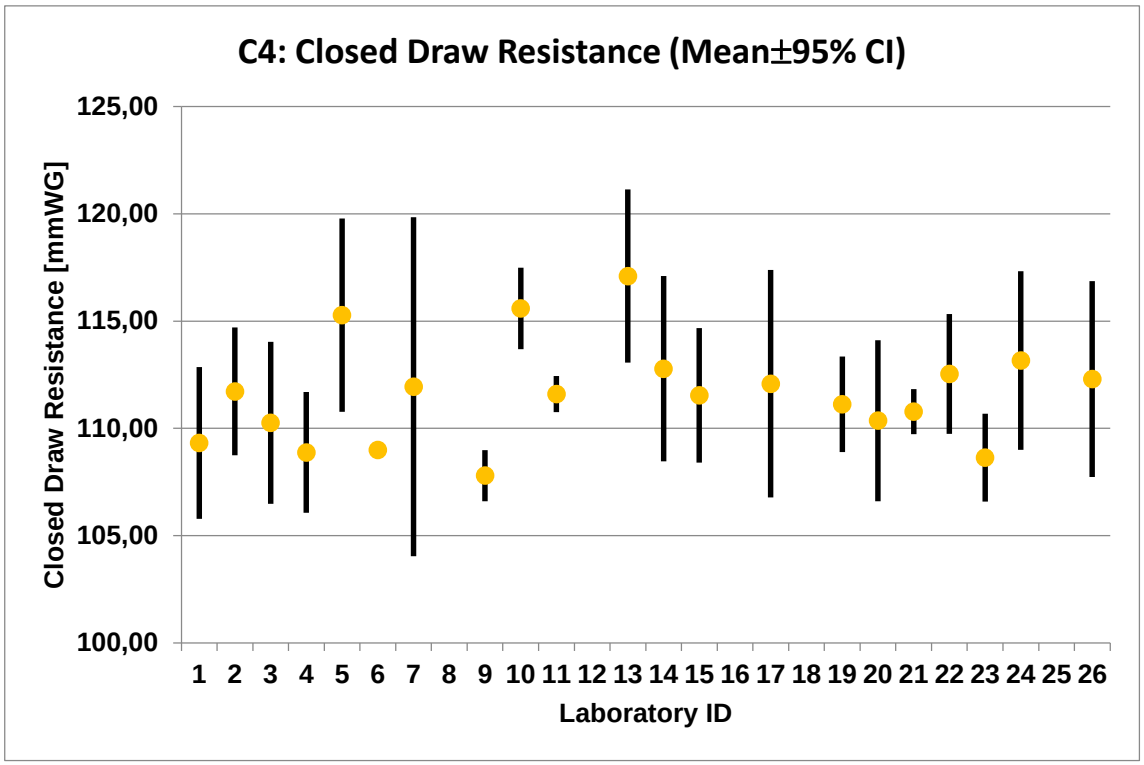


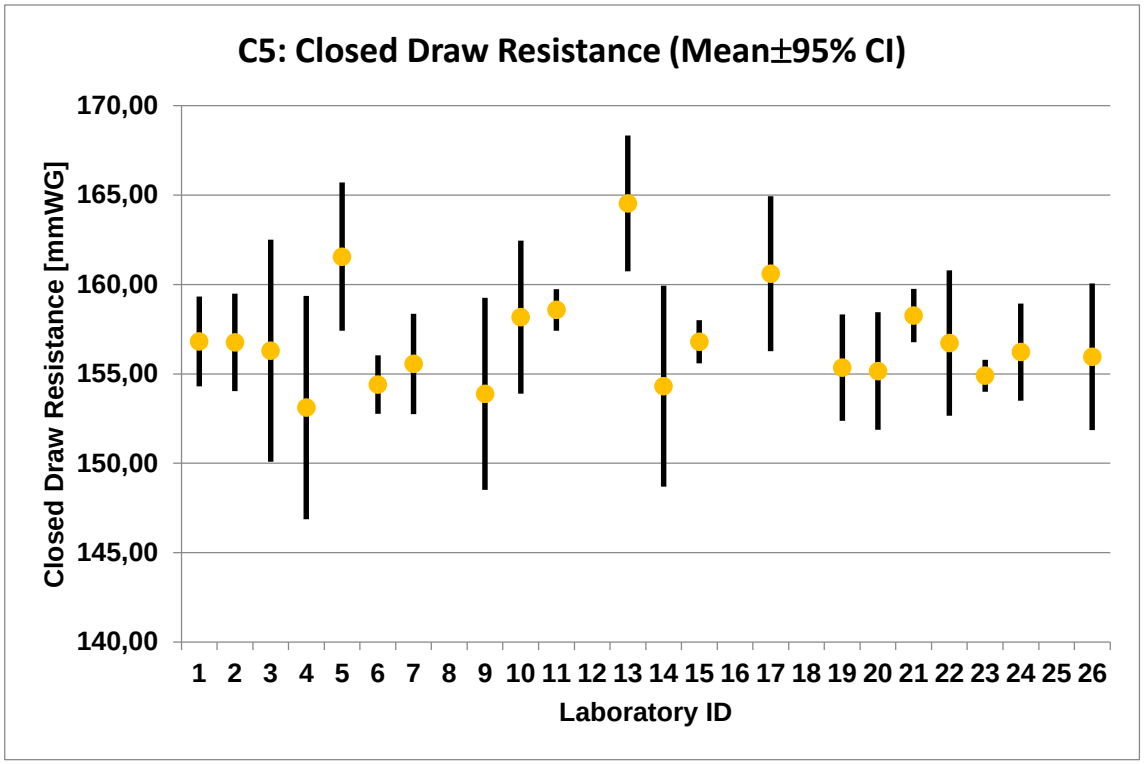
Appendix E.4: Closed draw resistances of cigarettes C1-C5



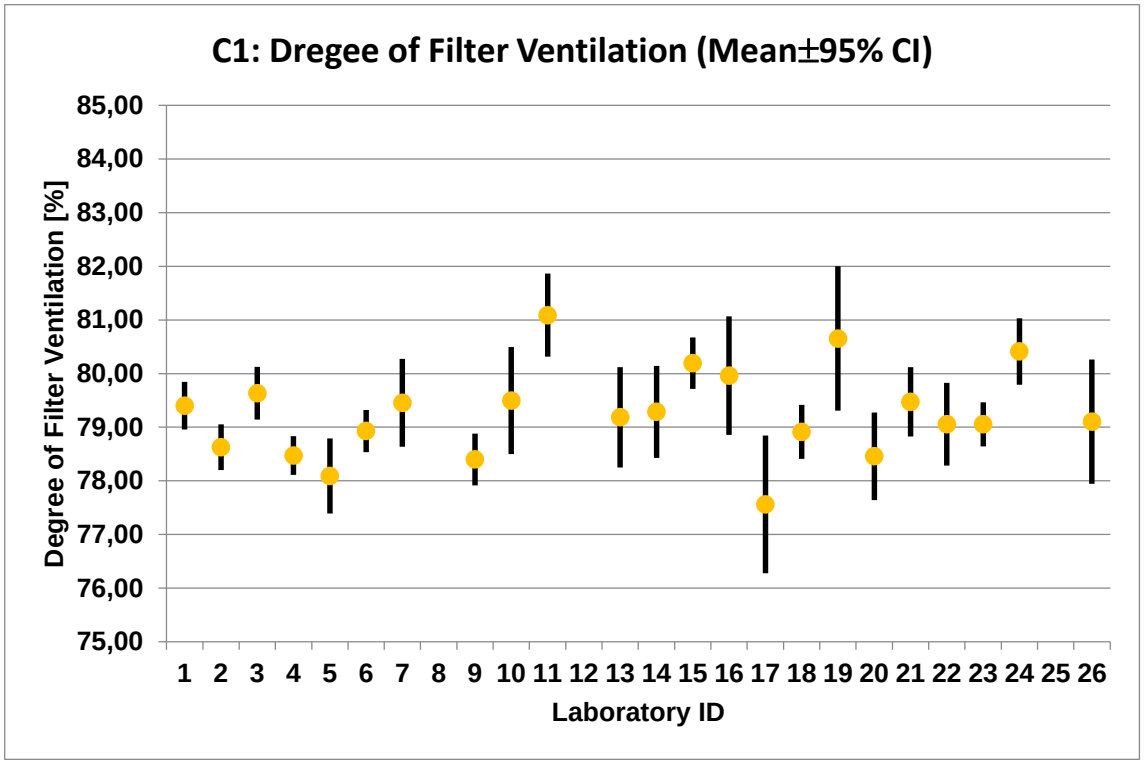

C2: Closed Draw Resistance (Mean±95% CI)
Closed Draw Resistance [mmWG]
160,00
155,00
150,00
145,00
140,00
135,00
130,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

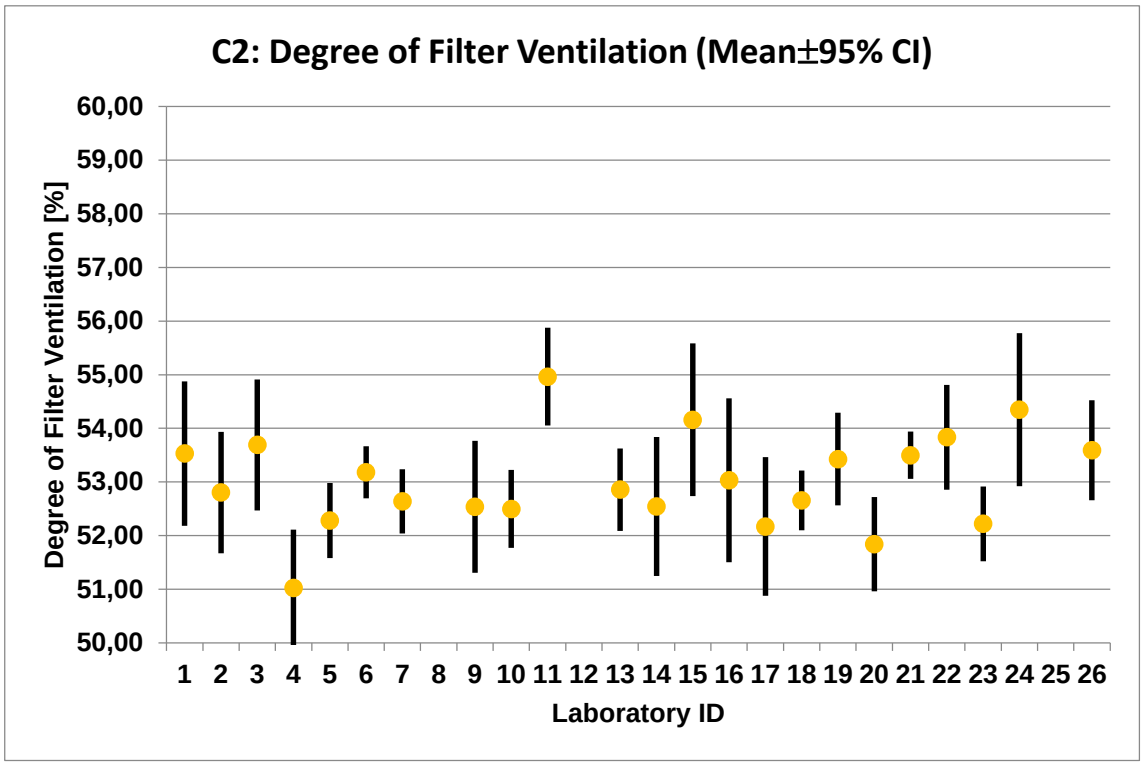

C3: Closed Draw Resistance (Mean±95% CI)
Closed Draw Resistance [mmWG]
200,00
195,00
190,00
185,00
180,00
175,00
170,00
165,00
160,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

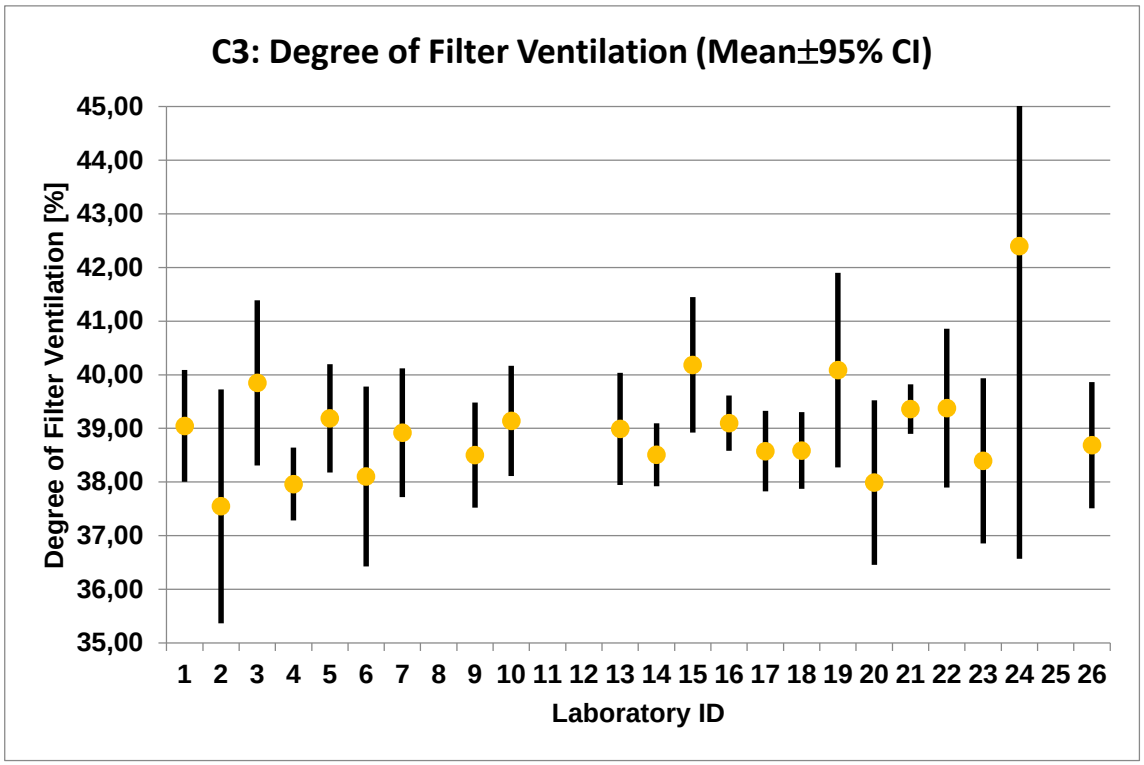

C4: Closed Draw Resistance (Mean±95% CI)
Closed Draw Resistance [mmWG]
125,00
120,00
115,00
110,00
105,00
100,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

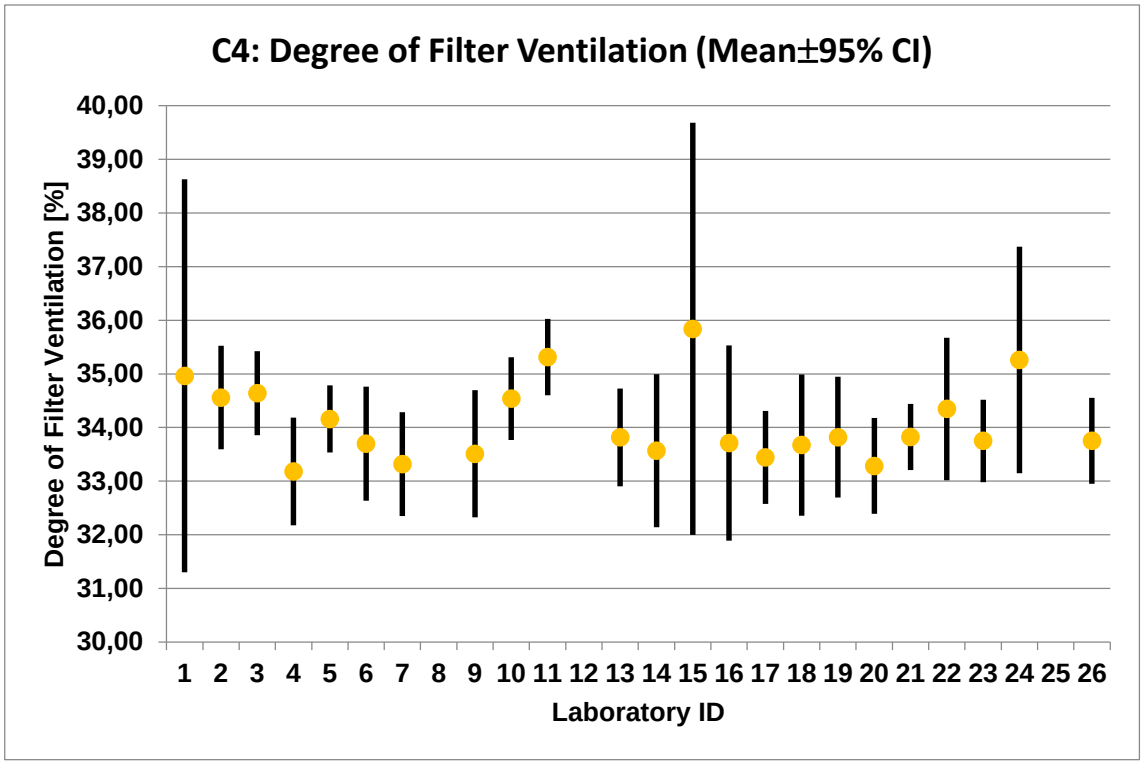

C5: Closed Draw Resistance (Mean±95% CI)
Closed Draw Resistance [mmWG]
170,00
165,00
160,00
155,00
150,00
145,00
140,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID

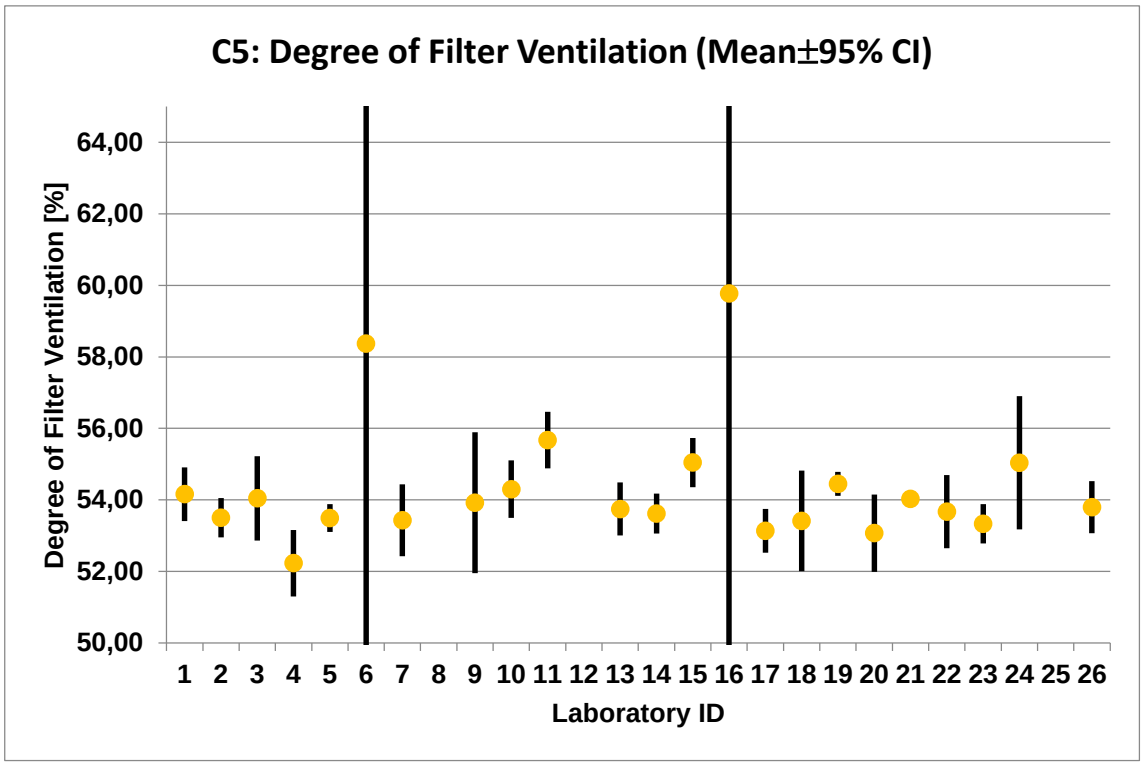
Appendix E.5: Degrees of filter ventilation of cigarettes C1-C5






C3: Degree of Filter Ventilation (Mean±95% CI)
Degree of Filter Ventilation [%]
45,00
44,00
43,00
42,00
41,00
40,00
39,00
38,00
37,00
36,00
35,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID


C4: Degree of Filter Ventilation (Mean±95% CI)
Degree of Filter Ventilation [%]
40,00
39,00
38,00
37,00
36,00
35,00
34,00
33,00
32,00
31,00
30,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID


C5: Degree of Filter Ventilation (Mean±95% CI)
Degree of Filter Ventilation [%]
64,00
62,00
60,00
58,00
56,00
54,00
52,00
50,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Laboratory ID