



Routine Analytical Chemistry Sub-Group

Technical Report

2008 Collaborative Study of the CORESTA Monitor Test Piece CM6 for the Determination of Nicotine, NFDPM, Carbon Monoxide and Carbon Dioxide in Sidestream Smoke

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1. Background

The CORESTA Recommended Methods (CRMs) for the determination of nicotine, nicotine free dry particulate matter (NFDPM) and carbon monoxide in sidestream cigarette smoke were published in June 2002. These methods recommended the use of a routine analytical smoking machine coupled with a fishtail chimney for the measurement of these analytes. Sidestream smoke was considered as the smoke that is evolved from the cigarette during smoking other than from the mouth end.

The CRMs for the measurement of sidestream smoke are:

CRM No. 54 Determination of nicotine and nicotine-free dry particulate matter in sidestream smoke using a fishtail chimney and a routine analytical/linear smoking machine

CRM No. 55 Determination of carbon monoxide in the vapour phase of cigarette sidestream smoke using a fishtail chimney and a routine analytical/linear smoking machine.

In addition, two equivalent ISO standards were published in 2007:

ISO 20773: Cigarettes – Determination of Nicotine Free Dry Particulate Matter and Nicotine in Sidestream Smoke – Method Using a Routine Analytical Linear Smoking Machine Equipped with a Fishtail Chimney

ISO 20774: Cigarettes – Determination of Carbon Monoxide in Sidestream Smoke – Method using a Routine Analytical Linear Smoking Machine Equipped with a Fishtail Chimney.

The "Routine Analytical Chemistry Sub Group" was given the responsibility to organise a preliminary testing of the CORESTA Monitor test piece CM6 for nicotine, NFDPM, carbon monoxide (CO) and carbon dioxide (CO₂) in sidestream smoke. This preliminary test of the CM6 was carried out during the summer of 2008.

The objectives of the study were:

- to establish preliminary smoke yields of nicotine-free dry particulate matter (NFDPM), nicotine, CO and CO₂ in sidestream smoke from the CM6 test piece
- to establish the conditioned weight of CM6 prior to smoking
- to enable the participating laboratories to compare their own results with results from other laboratories
- to obtain statistical information about possible differences in smoke yields from different smoking machines
- to establish r & R statistics for the CORESTA monitor test piece CM6.

2. Summary

In June 2008 the experimental protocol and results template for the collaborative experiment to establish the r and R values for sidestream yields of the CM6 were circulated to the participating laboratories. Eight replicates were requested for each analyte and the deadline for completion was 29 August 2008. Twelve laboratories participated in the work and the numbers of data sets received from laboratories that were able to follow the protocol for each analyte were:

Conditioned weight of the CM6	11
Sidestream (SS) NFDPM yield	12
Sidestream (SS) Nicotine yield	12
Sidestream (SS) CO yield	12
Sidestream (SS) CO ₂ yield	5

Repeatability (r) & reproducibility (R) values were calculated on the remaining data after the exclusion of outliers and these are shown in Table 1 below.

Table 1. r and R Values

Parameter	No. of Labs	Mean	Repeatability		Reproducibility	
			r	% r	R	% R
Conditioned weight mg/CM6	11	972.49	24.16	2.48	37.71	3.88
Sidestream NFDPM mg/CM6	11	24.49	3.04	12.41	7.62	31.11
Sidestream Nicotine mg/CM6	11	4.92	0.56	11.38	1.29	26.22
Sidestream CO mg/CM6	11	53.02	6.24	11.77	12.35	23.29

A previous collaborative study was carried out in 2002 using the CORESTA monitor test piece CM3 and fifteen laboratories participated. The results from this study are comparable to those obtained from the 2002 study.

3. Participants

Twelve laboratories agreed to participate in the 2008 sidestream collaborative study. A list of the laboratories is given in Appendix A. The laboratories were each given a unique code number and only this code is used in the report. A wide range of smoking machines were used in the study and these are shown in Table 2.

Table 2. Smoking Machines Used

Laboratory Code	Equipment
1 and 12	Borgwaldt RM4
2 and 8	KC Automation KC-5
3, 5 and 9	Cerulean SM405-SV
4	KC Automation KC-10
6	Twenty port linear
7	Hawktech 2000 and KC Automation KC-10
10	Cerulean SM400 with Hawktech C1100
11	Borgwaldt RM1

The large number of different smoking machines used prevented a rigorous statistical comparison of the different machines as the maximum number of any particular machine was three. Similarly only five laboratories provided data for sidestream carbon dioxide so a rigorous statistical analysis of sidestream carbon dioxide data was not carried out.

4. Collaborative Study

4.1. Protocol

The protocol which was circulated to the participating laboratories is to be found in Appendix B. This included diagrams showing a fishtail chimney, the experimental setup for sidestream NFDPM and nicotine collection and the experimental setup for sidestream carbon monoxide and carbon dioxide collection. The laboratories were asked to carry out sidestream analysis of the CM6 monitor test piece using their current equipment and to follow CRMs 54 and 55 as closely as possible. Eight replicate determinations of each analyte were required. Any deviations from CRM 54 or 55 or the experimental protocol were submitted with the results and these are summarised in Appendix C.

4.2. Data

Raw data, including the outliers from all participating laboratories, are given in Appendix D (data identified as outliers are shown as underlined red text). Table 3 summarises the means and standard deviations for the conditioned monitor test piece weight and the sidestream yields of total NFDPM, total nicotine, carbon monoxide and carbon dioxide where measured. Missing data is coded with an asterisk.

Table 3. Laboratory Means and SDs

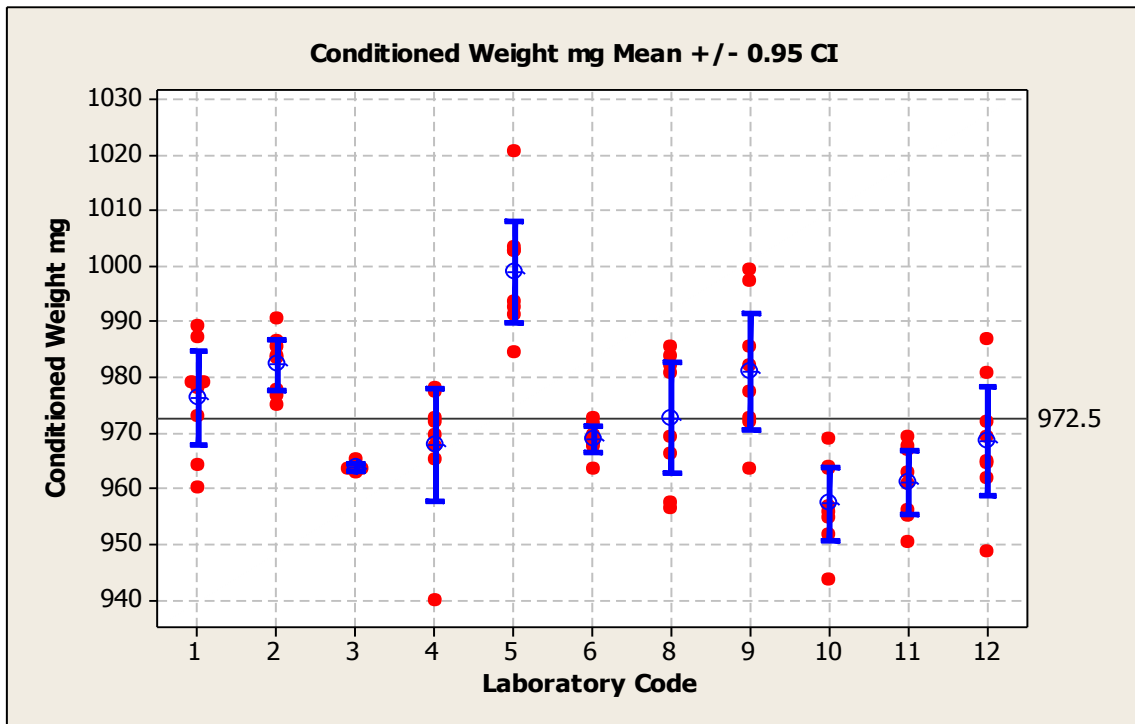
Lab Code	Conditioned Wt mg/CM6		Sidestream							
			NFDPM mg/CM6		Nicotine mg/CM6		CO mg/CM6		CO ₂ mg/CM6	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	976.1	10.2	21.99	0.88	4.836	0.144	48.94	1.01	*	*
2	982.2	5.4	21.51	0.88	5.494	0.317	52.03	3.41	455.2	21.1
3	963.7	0.7	30.66	1.26	4.119	0.216	102.24	2.99	*	*
4	967.7	12.1	24.55	0.75	4.873	0.155	53.42	1.45	*	*
5	998.8	11.0	24.01	0.78	5.588	0.217	63.93	2.28	*	*
6	968.7	2.8	24.80	1.73	5.044	0.166	52.60	1.21	397.1	15.8
7	975.6	*	22.67	1.42	5.006	0.273	51.57	4.37	496.9	6.5
8	972.6	11.9	28.95	3.27	4.424	0.742	56.97	2.97	*	*
9	981.0	12.5	27.63	0.93	5.290	0.104	48.20	3.12	370.0	25.0
10	957.2	8.0	25.20	1.90	4.902	0.243	51.59	1.39	*	*
11	961.0	6.8	21.78	0.96	4.217	0.240	54.36	1.51	462.2	15.0
12	968.4	11.8	24.63	0.82	4.798	0.218	49.61	1.15	*	*

Note laboratory 7 only reported a single mean of the conditioned weight of 40 cigarettes.

4.2.1. Conditioned Weight

Plot 1 below gives the raw data for the conditioned weight of the CM6 test pieces. The plot shows mean values with 95% confidence interval (CI) superimposed in blue.

Plot 1. Mean Values \pm 0.95 CI for Conditioned Weight

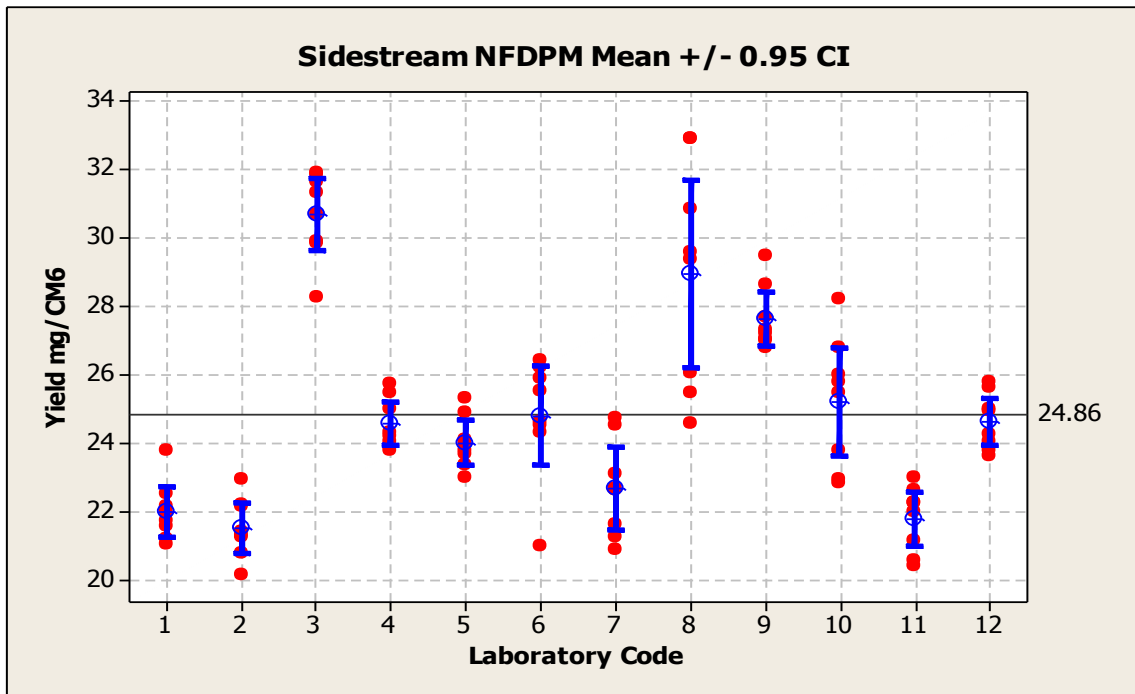


The annual smoking of the CM6 monitor test piece to determine mainstream yields, also carried out in the summer of 2008 with 40 laboratories participating, recorded an average weight for the conditioned CM6 of 974.0 mg after removal of outlying data. This agrees very well with this study.

4.2.2. Sidestream NFDPM

Plot 2 below gives the raw data for the sidestream NFDPM yield of the CM6 test pieces. The plot shows mean values with 95% CI superimposed in blue.

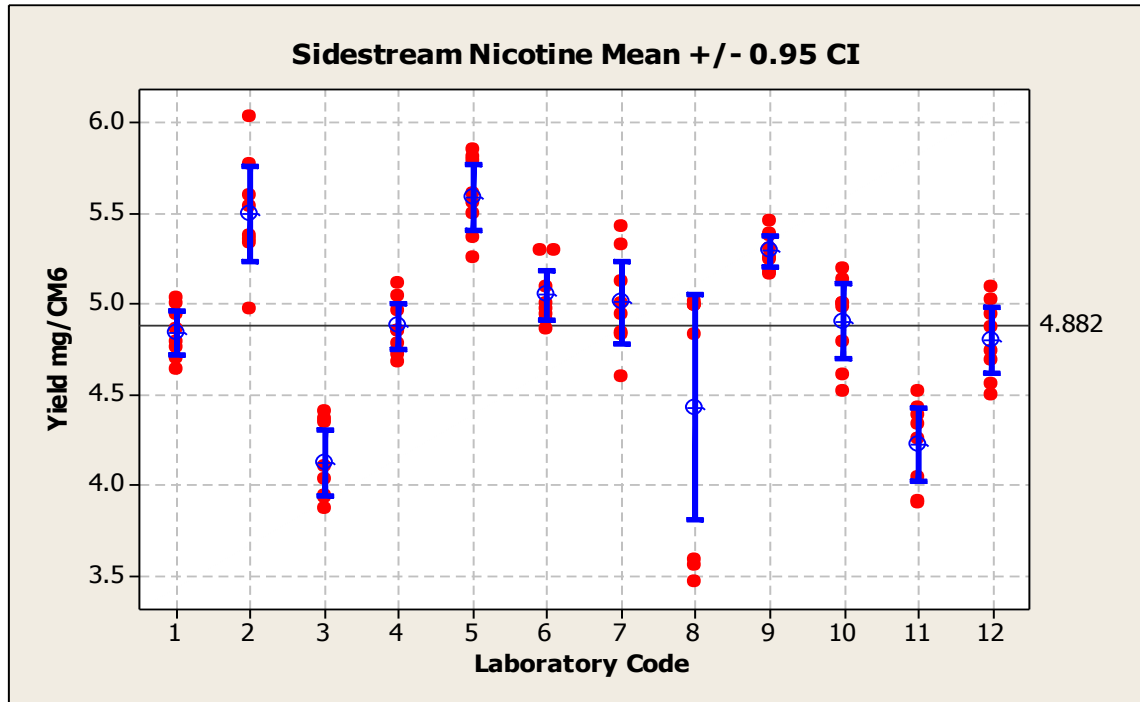
Plot 2. Mean Values \pm 0.95 CI for Sidestream NFDPM Yield



4.2.3. Sidestream Nicotine

Plot 3 below gives the raw data for the sidestream nicotine yield of the CM6 test pieces. The plot shows mean values with 95% CI superimposed in blue.

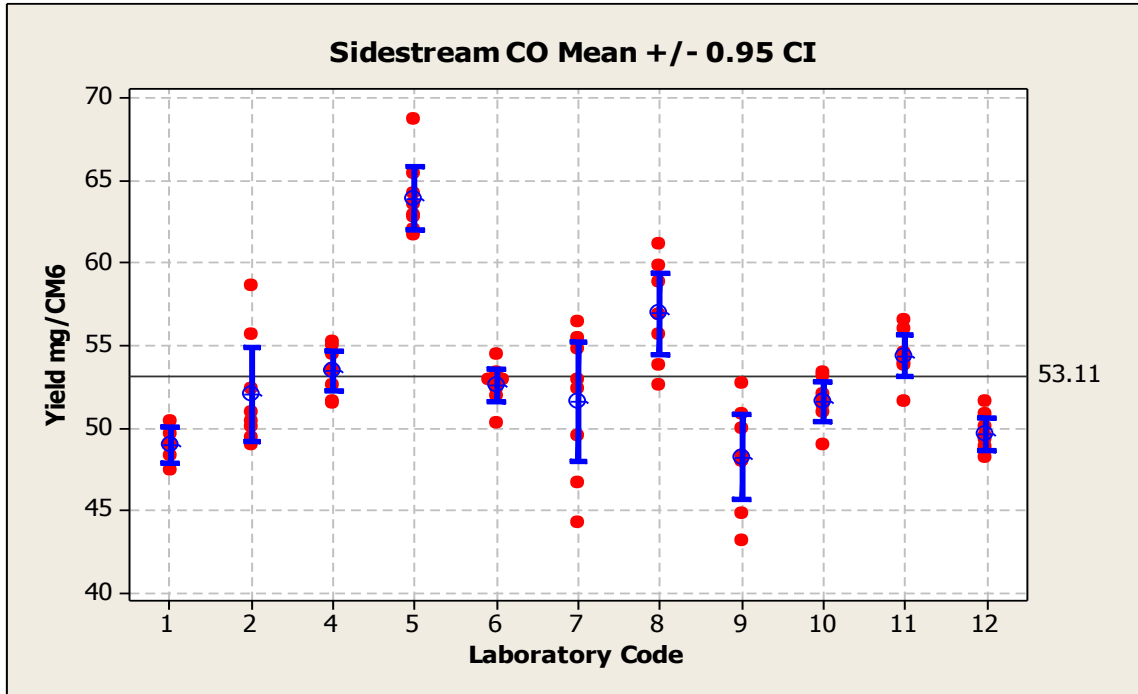
Plot 3. Mean Values \pm 0.95 CI for Sidestream Nicotine Yield



4.2.4. Sidestream Carbon Monoxide

For the sidestream carbon monoxide data one set of results were excluded as obvious outliers as the values were approximately double those of the other laboratories. Plot 4 below gives the remaining data for the sidestream carbon monoxide yield of the CM6 test pieces. The plot shows mean values with 95% CI superimposed in blue.

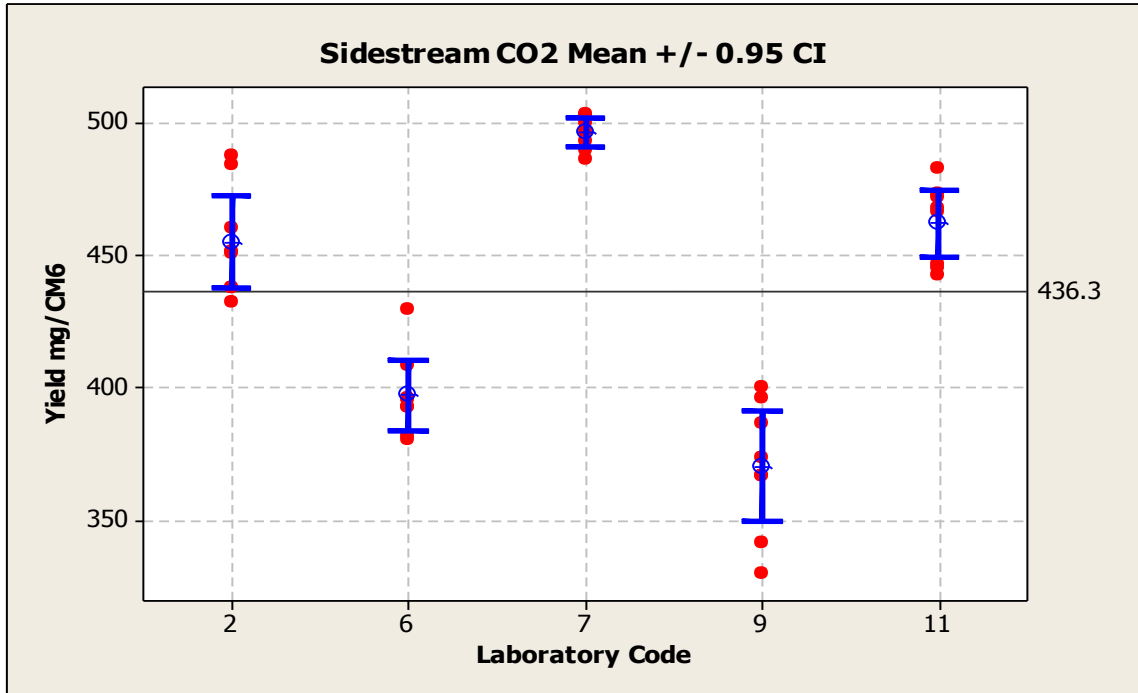
Plot 4. Mean Values \pm 0.95 CI for Sidestream CO Yield



4.2.5. Sidestream Carbon Dioxide

Only five of the participating laboratories provided data for sidestream carbon dioxide yields. Plot 5 below gives the raw data for the sidestream carbon dioxide yield of the CM6 test pieces. The plot shows mean values with 95% CI superimposed in blue.

Plot 5. Mean Values \pm 0.95 CI for Sidestream CO₂ Yield



Due to the small number of laboratories reporting data a statistical analysis was not carried out on the sidestream carbon dioxide data. The overall mean sidestream yield of carbon dioxide was 436.3 mg/CM6 with an SD of 49.6. The minimum mean yield was 370.0 mg/CM6 and the maximum mean yield was 496.9 mg/CM6.

5. Statistical Analysis

The statistical analysis comprised of two steps. In the first step the data was reviewed and any obvious outliers were rejected. In this stage only the data from one laboratory was rejected. This was for sidestream carbon monoxide yield where the data from one laboratory was approximately twice that of the other laboratories. Outlier testing was then carried out on the remaining data according to ISO 5725 using Cochran's test to eliminate within laboratory variance followed by Grubb's test to eliminate between laboratory outliers. Table 4 summarises those laboratories that were excluded using these tests.

Table 4. Outlying Laboratories

Analyte	Cochran's Outliers	Grubb's Outliers
Conditioned Weight	None	None
Sidestream NFDPM	8	None
Sidestream Nicotine	8	None
Sidestream Carbon Monoxide	None	None

For the four components shown in the table above a total of 374 data points were collected with 24 being rejected. The rejected data points were 6.4 % of the total data points collected.

APPENDIX A

List of Participating Laboratories

Altadis
Arista Laboratories, Richmond, USA
BAT Germany, Analytical Service Laboratory Bayreuth
China National Tobacco Quality Supervision and Test Centre of CNTC
Filtrona Technology Centre
Japan Tobacco
KT & G Central Research Institute
Labstat International Incorporated
Philip Morris International, Product Quality
R.J. Reynolds Tobacco Company
Reemstma SAL
Wattenspapier

APPENDIX B

Experimental Protocol

Initial study of the CORESTA Monitor Test Piece CM6 for the Determination of Nicotine, NFDPM, CO and CO₂ in Sidestream Smoke Using Fishtail Chimney and A Routine Analytical/Linear Smoking Machine Experimental protocol – June 2008

Introduction

The "Routine Analytical Chemistry Sub Group" has been given the responsibility to organize a preliminary and then biennial testing of the CORESTA Monitor test piece CM6 for nicotine, NFDPM, CO and CO₂ in sidestream smoke. A preliminary test of the CM6 is planned for summer 2008. CM6 was released to Cerulean and Borgwaldt KC for sale in March 2008.

Objective of the Study

The study objectives are:

- to establish preliminary smoke yields of nicotine-free dry particulate matter (NFDPM), nicotine, CO and CO₂ in sidestream smoke from CM6.
- to establish the conditioned weight of CM6 prior to smoking
- to enable the participating laboratories to compare own results with results from other laboratories and to continue this comparison over time
- to obtain statistical information about possible differences in smoke yields from different smoking machines

The experiment will use the 'fishtail chimney' method of sidestream smoke collection under defined conditions as specified in CORESTA Recommended Methods 54 & 55. Mainstream deliveries should also be reported for information.

To establish r & R statistics for the CORESTA Monitor Test Piece.

Limitations

The laboratories participating in the study use different linear smoking machines, ranging from 20-channel to single channel. Although the statistical analysis of this study will be based upon the between-laboratory and within-laboratory variability, and an evaluation of repeatability (r) will be made, any evaluation of reproducibility (R) will be subject to this limitation.

The specifications of ISO 3308 regarding air velocity control cannot be met under the conditions of sidestream smoke collection. However, the procedure does not substantially distort the mainstream smoking characteristics of a cigarette. It can be performed on any single-port or multiport linear machine.

Two different methods of carbon monoxide determination are in use amongst the participating laboratories. These are:

- 3.3.1 On-line continuous determination of carbon monoxide in the sidestream smoke
- Collection of sidestream smoke in a bag for subsequent off-line analysis of carbon monoxide content.

Products to be used in the study

The product to be used in the study is the CORESTA Monitor Test Piece CM6.

There will be no selection of cigarettes for smoking other than the rejection of any obviously damaged or imperfectly assembled cigarette.

Product Code	Product	Representing
M1	CM6	CORESTA Monitor Test Piece

Smoking Machines and Smoking Plan

The smoking machines to be used will have either:

- 1 port
- 4 ports
- 5 ports
- 8 ports
- 20 ports

depending on what is available to each laboratory.

The measurement of carbon monoxide is done simultaneously (although on different channels) by some laboratories, and separately by others.

If a single-port machine is to be used, then the products will be smoked by repeating the M1 eight times for sidestream 'tar' and nicotine and eight times for sidestream CO and CO₂. Each smoking run within a sequence consists of 3 cigarettes smoked in immediate succession on to the same pad. For the sidestream vapour phase components, a time-saving may be achieved by smoking three cigarettes simultaneously on three channels operated in parallel and analysing the combined effluents.

The following sequence should be used for a 4-port smoking machine: Again, separate smokings are required for the sidestream vapour phase components.

		Channel			
		1	2	3	4
Run	1	M1	M1	M1	M1
	2	M1	M1	M1	M1

If a 5-port machine is to be used then the sequence becomes:

		Channel				
		1	2	3	4	5
Run	1	M1	M1	M1	M1	*
	2	M1	M1	M1	M1	*

Where * denotes an unused channel. Again, separate smokings are required for the sidestream vapour phase components.

If an 8-port machine is to be used then the sequence becomes:

		Channel							
		1	2	3	4	5	6	7	8
Run	1	M1	M1	M1	M1	M1	M1	M1	M1

If a 16-port machine is to be used then the sequence becomes:

		Channel															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Run	1	M1		M1		M1		M1		M1		M1		M1		M1	

Again, separate smokings are required for the sidestream vapour phase components.

Where CO measurements are normally made simultaneously with NFDPM and nicotine measurements, e.g. where 4 channels of a 20-port smoking machine are reserved for CO analysis, then the cigarette codes should be used to fill these dedicated CO channels. For example, if channels 5, 10, 15 and 20 are used for CO determination, the sequencing would be as shown in the table below:

Smoking plan for NFDPM, nicotine and CO (simultaneously)

		Channel																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Run	1	M1		M1		M1	M1		M1		M1	M1		M1		M1		M1		M1	M1
Run	2					M1					M1					M1					M1

Variables

The variables to be reported for statistical analysis are:

- puff number
- MS TPM
- MS nicotine
- MS water
- MS NFDPM
- MS CO
- MS CO₂ (if measured)
- SS pad TPM
- SS pad Water
- SS 'tar' (total – from chimney and pad)
- SS nicotine (total – from chimney, pad and impinger)
- SS CO
- SS CO₂ (if measured)
- Mean weight of the monitor after conditioning (just prior to smoking)

Note: The average carbon monoxide concentration and collection time for each measurement should also be included, so that where suspect carbon monoxide deliveries are reported, a first check can be made by the statistician before contacting the laboratory concerned.

Ancillary Variables

The ancillary variables are:

- type of smoking machine used
- laboratory temperature during smoking
- relative humidity (RH %) in the laboratory during smoking
- atmospheric pressure in the laboratory during smoking

These variables should be included in the documentation of the method (see below).

Method of reporting data

Data entry

Data should be entered into the Excel template supplied with this protocol. Missing data are to be coded as *. Please adhere exactly to the format, as any changes cause delays in processing the data. Do not add any calculations of means or standard deviations. Any comments on the data should be made on a separate worksheet.

Dimensions and rounding of data

-	puff number	##.#
-	MS TPM	##.## mg/test piece
-	MS Nicotine	##.### mg/test piece
-	MS Water	##.## mg/test piece
-	MS NFDPM	##.## mg/test piece
-	MS CO	##.## mg/test piece
-	MS CO ₂ (if measured)	###.# mg/test piece
-	SS pad TPM	##.## mg/test piece
-	SS pad Nicotine	##.### mg/test piece
-	SS chimney Nicotine	##.### mg/test piece
-	SS impinger Nicotine	##.### mg/test piece
-	Total SS Nicotine	##.### mg/test piece
-	Chimney 'Tar'	##.## mg/test piece
-	Total SS 'Tar'	##.## mg/test piece
-	SS CO	##.## mg/test piece
-	SS CO ₂ (if measured)	###.# mg/test piece
-	Weight of CM6	####.# mg/test piece

[Note that the rounding of the data to the formats shown above will take place after any calculations that may be required. All calculations should be made using the laboratory data as recorded, using the maximum number of digits available.]

Data transfer

The completed Excel template should be sent to Linda Crumpler for transmission to the statistician for analysis. It should be sent by e-mail, no later than August 29, 2008 for inclusion in discussion at the Sub-group meeting on September 30, 2008.

Internal Documentation of Tests

Each laboratory will document the method used, noting any deviations from the CORESTA Recommended Methods.

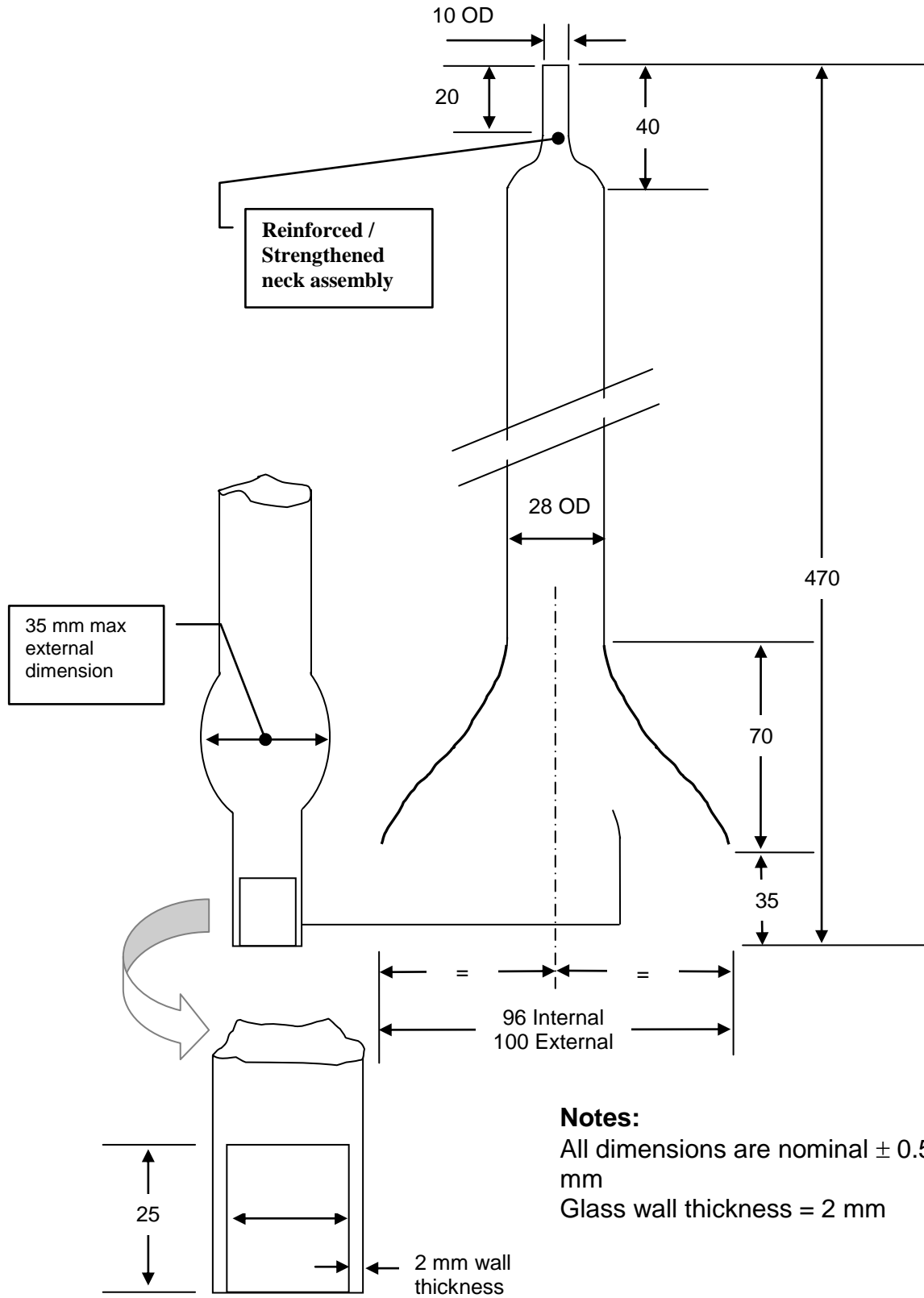
It is requested that intermediate results and calibration data should be held in an accessible form, so that they can readily be checked if it is necessary to find the cause of suspect data. An example is CO average concentrations in effluent gas, and corresponding collection time. The aim should be that any outliers identified during the statistical analysis can be rapidly checked, preferably directly by the laboratory concerned, or alternatively by the statistician when supplied with such data.

It is requested that each laboratory retain a copy of this documentation for at least six months after the completion of the study, in order to be able to respond to any queries that may result from the analysis of the data.

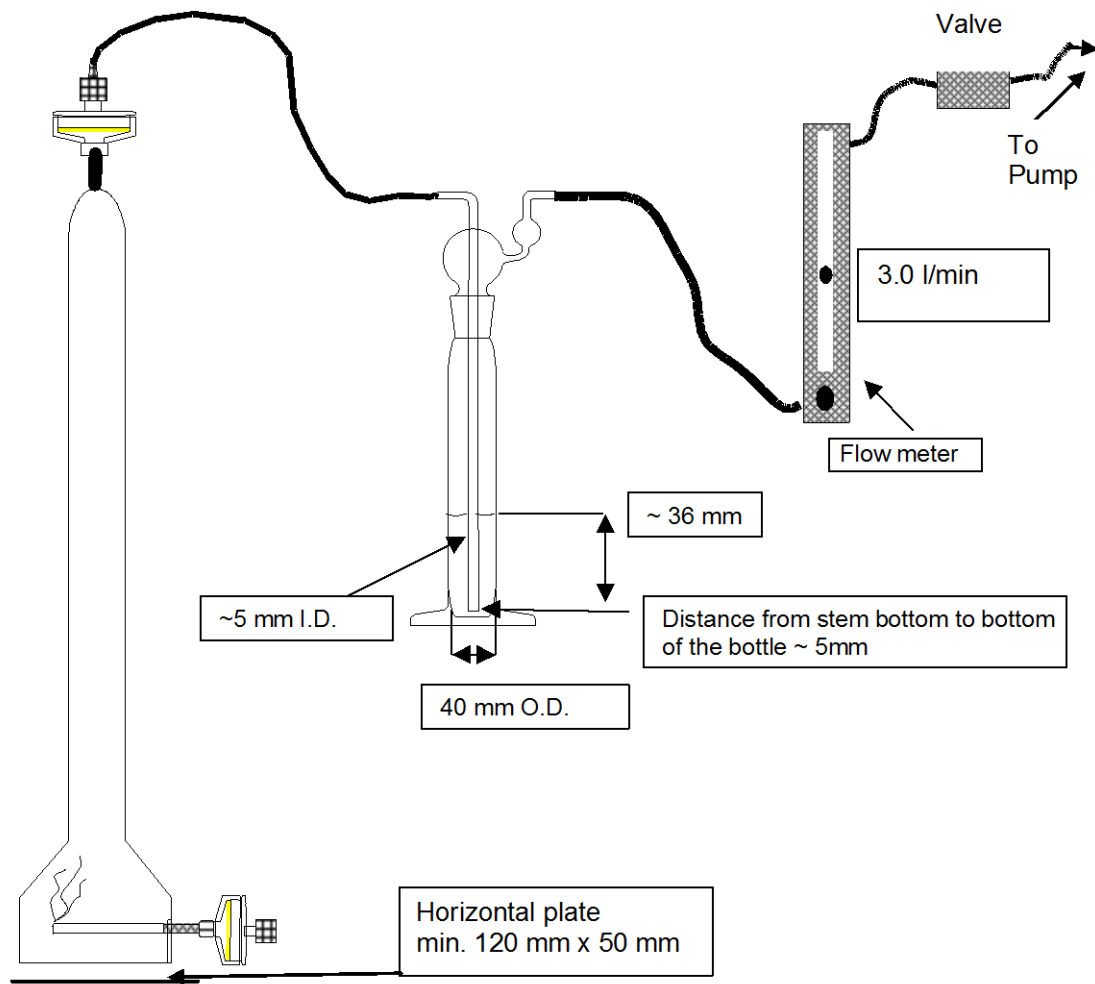
Butt length for Collaborative Experiment

Butt length shall be set at 32 mm.

Fishtail Chimney Dimensions

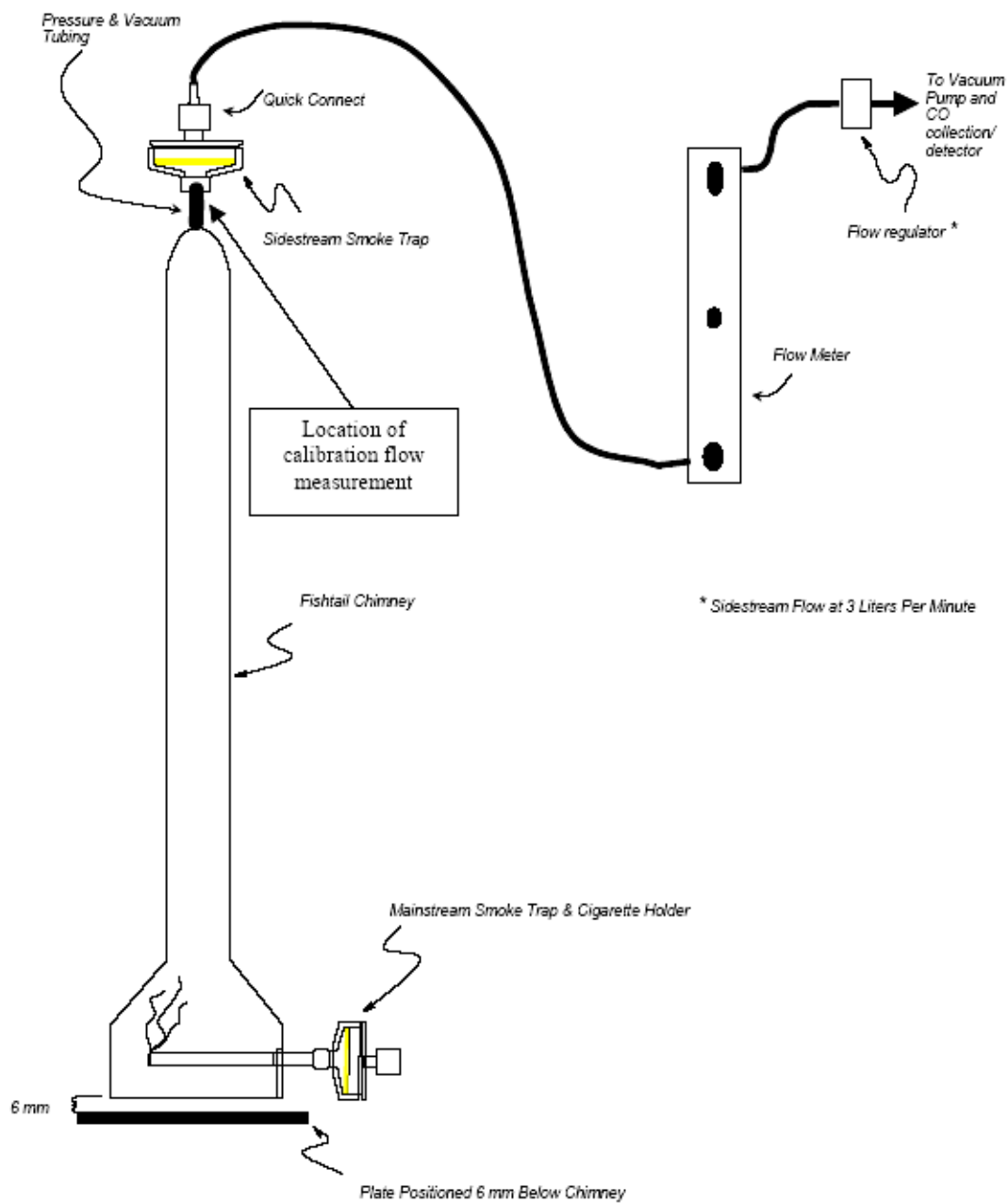


Sidestream Smoke Collection for NFDPM and Nicotine



Distance from chimney bottom to horizontal plate = 6mm

Sidestream Smoke Collection for Carbon Monoxide and Carbon Dioxide



APPENDIX C

Departures from Experimental Protocol

The table below lists the minor departures from the experimental protocol reported from the laboratories participating in the study.

Laboratory Code	Departure from Protocol
1	Only six replicate values for sidestream CO reported
2	No correction for background carbon dioxide. Solvent volume of 30 ml used for impinger, pad and chimney extraction rather than the recommended values of 40 ml impinger, 20 ml pad and 50 ml chimney.
1,4,5,8,9 and 10	No mainstream CO reported
7	Only one weight for 40 cigarettes reported for conditioned weight

APPENDIX D

Conditioned Weight and Mainstream Data

Lab Code	Conditioned	Puff	MS TPM	MS Water	MS Nicotine	MS NFDPM	MS CO	MS CO ₂
	Weight (mg/t.p.)	Number	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)
1	978.0	10.20	18.67	1.57	1.453	15.65	*	*
	964.0	10.50	20.00	2.27	1.600	16.13	*	*
	979.0	9.80	18.33	1.63	1.473	15.23	*	*
	960.0	11.00	19.33	2.09	1.527	15.72	*	*
	989.0	10.60	19.33	1.65	1.420	16.27	*	*
	979.0	10.90	19.67	1.86	1.513	16.29	*	*
	973.0	10.50	17.33	1.52	1.327	14.49	*	*
	987.0	10.50	19.33	1.87	1.493	15.97	*	*
2	990.3	10.67	20.97	2.58	1.543	16.84	18.68	54.28
	974.7	10.33	20.33	2.29	1.548	16.50	18.51	53.67
	985.3	11.00	18.70	2.19	1.513	15.00	18.33	53.37
	983.7	10.63	21.23	2.74	1.612	16.88	18.91	54.37
	986.3	11.67	22.30	3.15	1.898	17.25	18.60	53.91
	977.5	10.67	21.80	2.87	1.841	17.09	18.26	51.97
	976.7	10.33	19.50	2.13	1.728	15.64	17.73	50.58
	983.2	11.00	20.13	2.56	1.776	15.80	18.87	52.36
3	963.5	9.30	18.55	1.77	1.480	15.31	15.28	*
	963.7	9.70	19.00	2.12	1.500	15.39	14.49	*
	964.0	9.40	18.47	1.77	1.367	15.33	14.92	*
	965.1	9.20	18.10	1.99	1.430	14.68	15.31	*
	962.8	9.00	18.33	1.69	1.473	15.17	14.80	*
	963.4	9.40	18.80	2.09	1.417	15.29	14.74	*
	963.5	8.90	18.47	2.16	1.470	14.83	15.48	*
	963.8	9.50	18.40	1.18	1.477	15.75	15.26	*
4	967.3	10.00	20.17	2.15	1.495	16.53	*	*
	977.1	9.90	19.73	2.00	1.465	16.27	*	*
	972.0	10.00	20.13	2.05	1.533	16.55	*	*
	939.8	9.70	20.07	2.06	1.484	16.53	*	*
	969.5	10.00	20.77	2.19	1.559	17.02	*	*
	965.0	9.70	20.60	2.27	1.519	16.81	*	*
	977.9	10.00	20.17	1.95	1.549	16.67	*	*
	972.6	9.90	19.87	1.90	1.517	16.45	*	*

Lab Code	Conditioned	Puff	MS TPM	MS Water	MS Nicotine	MS NFDPM	MS CO	MS CO ₂
	Weight (mg/t.p.)	Number	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)
5	991.2	11.33	20.61	3.39	1.683	15.54	*	*
	1020.3	11.31	19.91	3.25	1.578	15.09	*	*
	993.5	10.58	20.51	3.24	1.624	15.66	*	*
	1002.7	10.97	21.42	3.86	1.628	15.93	*	*
	1003.2	11.18	21.02	3.86	1.671	15.49	*	*
	984.3	10.53	20.09	3.31	1.502	15.29	*	*
	1002.6	10.82	20.54	3.55	1.640	15.35	*	*
	992.5	10.67	21.04	3.56	1.608	15.87	*	*
6	972.5	10.10	20.10	2.20	1.610	16.30	18.50	44.40
	968.8	9.90	19.90	1.90	1.570	16.40	18.60	44.90
	971.5	9.90	21.00	2.30	1.670	17.10	19.10	45.70
	969.6	10.80	20.10	1.80	1.640	16.60	18.10	52.40
	963.4	10.00	19.30	1.70	1.530	16.00	17.00	46.80
	968.6	10.80	20.20	2.00	1.570	16.60	18.60	47.80
	967.5	10.10	20.90	2.00	1.720	17.20	19.50	45.90
	967.7	10.70	20.50	2.10	1.680	16.80	16.10	52.00
7	*	8.7	17.20	1.25	1.385	14.57	15.14	49.9
	*	9.1	17.40	1.02	1.371	15.01	14.97	49.1
	*	8.6	16.64	1.16	1.330	14.15	14.95	49.2
	*	9.1	17.54	1.29	1.356	14.89	14.54	45.2
	*	8.7	16.38	1.29	1.302	13.79	14.64	47.6
	*	9.1	17.42	1.08	1.385	14.95	14.32	44.1
	*	8.9	17.32	1.25	1.391	14.68	15.46	49.8
	*	9.4	18.52	1.55	1.440	15.53	14.98	46.7
8	985.5	9.90	14.97	1.07	1.110	12.79	*	*
	983.7	10.30	15.53	1.50	1.041	12.99	*	*
	957.4	10.70	16.90	2.20	1.110	13.59	*	*
	966.2	9.70	18.17	1.23	1.382	15.56	*	*
	981.9	10.30	19.60	1.53	1.493	16.58	*	*
	956.3	10.70	21.33	1.93	1.540	17.86	*	*
	969.0	10.30	20.70	2.16	1.509	17.03	*	*
	980.7	10.00	19.30	1.03	1.388	16.88	*	*
9	997.0	11.00	19.83	1.80	1.668	16.37	*	*
	972.6	10.50	18.50	1.75	1.635	15.12	*	*
	971.7	10.30	18.70	1.97	1.628	15.10	*	*
	977.2	10.50	20.60	2.12	1.647	16.83	*	*

Lab Code	Conditioned	Puff	MS TPM	MS Water	MS Nicotine	MS NFDPM	MS CO	MS CO ₂
	Weight (mg/t.p.)	Number	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)
	985.3	10.30	18.27	1.52	1.467	15.28	*	*
	981.9	10.40	20.90	1.76	1.615	17.53	*	*
	963.3	10.10	19.77	1.49	1.551	16.73	*	*
	999.3	11.00	21.50	1.85	1.658	17.99	*	*
10	956.5	10.43	19.70	2.00	1.431	16.27	*	*
	963.7	10.07	20.33	1.59	1.463	17.28	*	*
	954.6	10.20	20.57	1.66	1.514	17.39	*	*
	963.4	10.33	21.37	1.92	1.531	17.91	*	*
	968.8	10.33	20.53	1.86	1.474	17.20	*	*
	955.6	10.07	20.80	1.86	1.477	17.46	*	*
	951.4	9.77	19.37	1.76	1.380	16.22	*	*
	943.4	10.33	19.77	1.68	1.394	16.69	*	*
11	969.0	9.70	18.00	2.13	1.260	14.61	14.80	43.70
	954.8	9.90	16.20	2.13	1.204	12.87	13.40	45.50
	967.6	10.30	17.67	2.11	1.269	14.29	14.40	45.20
	962.6	9.60	16.10	2.05	1.224	12.83	15.10	46.40
	950.2	9.57	18.20	2.96	1.320	13.92	16.30	49.60
	956.0	10.17	17.97	3.04	1.338	13.58	14.80	46.40
	966.6	9.93	16.87	1.79	1.311	13.77	14.55	44.80
	960.8	10.00	17.27	1.90	1.292	14.07	15.20	46.00
12	964.2	9.40	17.63	1.08	1.46	15.09	17.61	*
	964.6	9.43	16.83	1.04	1.40	14.39	17.37	*
	986.5	9.07	16.70	1.15	1.44	14.11	16.39	*
	971.8	9.17	16.80	1.46	1.40	13.94	15.70	*
	961.8	9.23	17.10	1.46	1.41	14.23	15.85	*
	980.8	9.43	16.80	1.46	1.37	13.97	16.54	*
	969.0	9.67	18.20	1.62	1.50	15.08	17.87	*
	948.4	8.87	17.73	1.59	1.40	14.74	15.48	*

Sidestream Data

Lab Code	SS Pad TPM	SS Pad Nicotine	SS Pad Water	SS Pad NFDPM	Ch NFDPM UV	Tot SS NFDPM UV	Imp Nicotine	Ch Nicotine	Tot SS Nicotine	SS CO	SS CO ₂
	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)
1	25.00	3.53	1.60	19.87	2.63	22.49	0.68	0.817	5.033	47.41	*
	23.67	3.23	1.61	18.83	3.17	22.01	0.63	0.900	4.760	50.34	*
	23.00	3.28	1.47	18.25	2.92	21.18	0.67	0.750	4.697	48.95	*
	23.00	3.39	2.16	17.45	3.58	21.03	0.55	0.917	4.853	49.03	*
	23.33	3.15	1.31	18.87	2.70	21.57	0.82	0.667	4.630	48.30	*
	24.67	3.31	1.41	19.94	3.86	23.80	0.75	0.933	4.997	49.58	*
	24.00	3.23	1.57	19.20	2.96	22.16	0.78	0.767	4.783	*	*
	23.67	3.33	1.43	18.91	2.79	21.70	0.80	0.800	4.933	*	*
2	26.40	3.909	2.61	19.88	0.90	20.78	0.15	0.917	4.973	49.44	460.1
	28.23	4.220	2.86	21.15	1.03	22.18	0.11	1.016	5.350	52.37	450.9
	29.57	4.500	3.91	21.16	0.96	22.12	0.12	0.971	5.592	50.92	451.5
	26.83	4.177	3.38	19.28	0.84	20.12	0.15	1.012	5.336	55.68	484.2
	27.37	4.387	2.65	20.33	0.97	21.30	0.30	1.083	5.765	48.94	437.8
	26.87	4.079	2.47	20.32	1.09	21.41	0.25	1.041	5.372	50.32	437.5
	26.77	4.242	2.33	20.19	1.03	21.22	0.22	1.074	5.537	49.99	432.1
	29.70	4.653	3.28	21.77	1.15	22.92	0.17	1.206	6.027	58.60	487.8
3	48.15	3.48	18.88	25.79	4.90	30.69	0.00	0.455	3.935	<u>107.47</u>	*
	48.10	3.88	17.92	26.31	5.30	31.61	0.00	0.465	4.340	<u>101.55</u>	*
	47.03	3.49	19.29	24.25	5.65	29.90	0.00	0.533	4.027	<u>102.88</u>	*
	45.13	3.63	16.03	25.48	6.33	31.81	0.00	0.467	4.097	<u>97.25</u>	*
	40.47	3.35	13.80	23.32	4.94	28.26	0.00	0.520	3.870	<u>99.77</u>	*
	49.33	3.87	19.41	26.05	5.25	31.30	0.00	0.523	4.397	<u>103.99</u>	*
	48.67	3.88	18.48	26.31	5.55	31.86	0.00	0.483	4.363	<u>102.59</u>	*
	47.67	3.49	18.38	25.79	4.07	29.86	0.00	0.433	3.927	<u>102.38</u>	*
4	27.90	3.557	2.96	21.38	2.92	24.30	0.26	1.032	4.849	52.58	*
	27.70	3.471	2.75	21.48	2.71	24.19	0.24	0.964	4.675	54.98	*
	28.73	3.754	2.74	22.24	2.77	25.01	0.26	1.029	5.043	51.45	*
	27.23	3.560	2.50	21.17	2.62	23.79	0.24	0.976	4.776	51.62	*
	29.20	3.778	2.95	22.47	3.25	25.72	0.26	1.076	5.114	54.48	*
	27.03	3.463	2.65	20.92	3.10	24.02	0.28	0.975	4.718	55.23	*
	27.80	3.630	2.89	21.28	2.61	23.89	0.27	0.950	4.850	53.43	*
	29.13	3.747	2.68	22.70	2.78	25.48	0.30	0.908	4.955	53.58	*
5	30.93	4.308	5.84	20.78	2.87	23.65	0.07	1.120	5.498	63.53	*
	32.87	4.442	7.23	21.21	2.89	24.10	0.03	1.132	5.604	68.75	*
	30.61	4.170	5.91	20.54	2.42	22.96	0.09	0.987	5.247	62.90	*

Lab Code	SS Pad TPM	SS Pad Nicotine	SS Pad Water	SS Pad NFDPM	Ch NFDPM UV	Tot SS NFDPM UV	Imp Nicotine	Ch Nicotine	Tot SS Nicotine	SS CO	SS CO ₂
	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)
	32.71	4.433	7.19	21.08	2.72	23.80	0.06	1.062	5.555	65.45	*
	31.32	4.487	5.37	21.47	2.52	23.99	0.08	1.283	5.850	61.75	*
	30.99	4.252	5.95	20.79	2.55	23.34	0.07	1.038	5.360	62.03	*
	32.60	4.621	5.53	22.46	2.42	24.88	0.06	1.121	5.802	62.81	*
	33.45	4.592	6.16	22.70	2.62	25.32	0.07	1.123	5.785	64.25	*
6	27.30	3.520	1.90	21.90	2.40	24.30	0.51	0.830	4.860	51.90	429.6
	29.00	3.690	2.10	23.20	2.70	25.90	0.49	0.900	5.090	52.90	395.0
	27.20	3.570	1.70	21.90	2.50	24.50	0.49	0.850	4.910	52.40	380.6
	24.90	3.760	2.10	19.00	2.00	21.00	0.68	0.850	5.290	50.30	381.5
	28.60	3.520	1.90	23.30	2.90	26.20	0.51	0.910	4.940	52.50	395.8
	28.30	3.550	2.00	22.80	2.70	25.50	0.63	0.830	5.000	52.90	392.7
	26.90	3.520	1.60	21.80	2.80	24.60	0.56	0.890	4.970	54.50	408.6
	29.60	3.820	2.40	23.40	2.90	26.40	0.52	0.950	5.290	53.40	392.9
7	25.85	3.684	1.81	20.36	2.34	22.69	1.088	0.548	5.320	54.83	502.9
	24.60	3.316	1.51	19.77	1.85	21.63	1.105	0.414	4.835	52.86	493.0
	25.50	3.369	1.61	20.52	2.56	23.08	1.020	0.548	4.937	52.39	496.7
	25.53	3.384	1.78	20.37	2.23	22.61	1.118	0.494	4.996	44.27	503.4
	23.97	3.236	1.90	18.83	2.03	20.86	1.117	0.470	4.823	46.68	489.9
	23.86	3.164	1.60	19.10	2.16	21.26	0.964	0.466	4.594	49.55	499.8
	27.27	3.828	2.10	21.33	3.16	24.49	0.894	0.699	5.422	56.48	502.8
	27.17	3.679	1.86	21.62	3.12	24.74	0.796	0.645	5.120	55.47	486.4
8	25.43	2.69	2.49	20.25	4.34	<u>24.59</u>	0.22	0.642	<u>3.552</u>	61.21	*
	25.23	2.52	2.10	20.61	4.83	<u>25.44</u>	0.32	0.623	<u>3.463</u>	55.68	*
	29.90	2.26	1.81	25.83	7.04	<u>32.87</u>	0.53	0.791	<u>3.581</u>	58.90	*
	31.01	3.66	3.38	23.97	6.86	<u>30.83</u>	0.27	1.054	<u>4.984</u>	56.89	*
	29.83	3.66	2.12	24.05	5.53	<u>29.58</u>	0.51	0.839	<u>5.009</u>	59.87	*
	25.97	3.40	2.39	20.18	5.87	<u>26.05</u>	0.44	0.989	<u>4.829</u>	56.91	*
	32.37	3.73	2.53	26.11	6.77	<u>32.88</u>	0.29	0.967	<u>4.987</u>	52.53	*
	30.47	3.79	2.60	24.08	5.27	<u>29.35</u>	0.37	0.830	<u>4.990</u>	53.74	*
9	31.13	4.23	2.99	23.92	3.14	27.06	0.09	1.057	5.380	50.83	395.7
	30.73	4.04	2.56	24.13	3.54	27.67	0.07	1.140	5.250	44.74	341.1
	30.87	4.15	2.73	23.99	3.02	27.01	0.08	1.068	5.300	47.97	366.7
	30.63	4.12	2.38	24.14	3.16	27.30	0.07	1.052	5.240	43.17	329.8
	32.73	4.17	2.55	26.02	3.45	29.47	0.09	1.108	5.370	52.74	400.5
	30.13	4.01	2.41	23.71	3.05	26.76	0.09	1.072	5.170	47.98	366.6
	30.53	4.01	2.23	24.30	2.89	27.19	0.10	1.052	5.160	49.96	386.8
	32.27	4.26	2.33	25.68	2.92	28.60	0.10	1.087	5.450	48.24	373.3
10	30.47	3.52	3.50	23.45	4.74	28.19	0.37	1.244	5.132	50.93	*

Lab Code	SS Pad TPM	SS Pad Nicotine	SS Pad Water	SS Pad NFDPM	Ch NFDPM UV	Tot SS NFDPM UV	Imp Nicotine	Ch Nicotine	Tot SS Nicotine	SS CO	SS CO ₂
	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)	(mg/t.p.)
	29.40	3.61	2.56	23.23	3.52	26.75	0.55	1.034	5.193	48.90	*
	28.30	3.46	2.08	22.76	2.99	25.75	0.56	0.957	4.981	51.48	*
	28.20	3.42	2.31	22.46	3.50	25.97	0.50	1.075	4.998	51.32	*
	28.17	3.45	2.29	22.42	3.02	25.44	0.55	0.994	4.999	51.57	*
	26.40	3.25	2.87	20.29	2.63	22.92	0.39	0.975	4.608	53.34	*
	24.87	3.03	1.80	20.05	2.77	22.81	0.58	0.905	4.512	52.02	*
	26.43	3.29	1.95	21.19	2.58	23.77	0.56	0.930	4.788	53.17	*
11	25.97	3.507	2.64	19.82	1.34	21.15	0.45	0.556	4.516	56.51	466.3
	24.73	3.246	2.33	19.15	1.27	20.42	0.46	0.546	4.248	53.77	482.7
	27.97	3.400	2.93	21.64	1.35	22.98	0.41	0.568	4.377	54.07	445.5
	26.53	3.294	2.45	20.79	1.21	22.00	0.55	0.581	4.422	54.61	446.9
	26.50	2.966	2.51	21.02	1.24	22.26	0.50	0.426	3.897	54.47	473.2
	26.74	3.255	2.07	21.41	1.20	22.61	0.53	0.547	4.331	53.90	471.8
	25.94	2.946	2.00	20.99	1.25	22.23	0.51	0.455	3.909	51.55	442.7
24.36	3.098	2.04	19.22	1.31	20.54	0.44	0.497	4.034	56.01	468.2	
12	27.00	3.79	1.91	21.30	3.65	24.95	1.12	0.18	5.090	50.05	*
	26.03	3.53	1.84	20.66	3.14	23.80	0.99	0.22	4.740	49.46	*
	27.20	3.67	1.60	21.93	3.69	25.62	1.13	0.22	5.020	51.61	*
	26.13	3.61	2.10	20.42	4.56	24.98	1.06	0.20	4.870	50.79	*
	25.83	3.39	2.08	20.36	3.26	23.62	0.93	0.17	4.490	48.15	*
	25.77	3.36	1.85	20.56	3.46	24.02	1.01	0.18	4.550	48.86	*
	27.73	3.61	2.30	21.82	3.93	25.75	1.11	0.22	4.940	49.31	*
26.30	3.42	2.25	20.63	3.64	24.27	1.04	0.22	4.680	48.64	*	