CONFIDENTIAL

UK SMOKE CONSTITUENTS STUDY

Part 9: Determination of Volatile Organic Compounds Yields in Cigarette Smoke

Commissioned by:

Tobacco Manufacturers Association

55 Tufton Street

London SW1P 3QL

Report Number 009/2003

March 2003

Prepared by Pete Houlgate

Arista Laboratories Europe

Contact point: Pete Houlgate

Tel: 020 8943 7375

Arista LABORATORIES EUROPE

www.aristalabs.co.uk

Contents

UK SMOKE CONSTITUENTS TESTING STUDY PROTOCOL

Determination of VOCs (Volatile Organic Compounds) Yields in Cigarette Smoke

1. Introduction

This work was undertaken by Arista Laboratories Europe at the request of the Tobacco Manufacturers' Association in accordance with the Study Protocol provided by, and agreed with, the UK Department of Health.

Arista Laboratories Europe acquired the smoke constituent analytical business of LGC Ltd, on the 23rd December 2002. LGC Ltd was previously the contractor for the study.

In agreement with the client, VOCs analysis was carried out at Arista Laboratories USA.

2. Summary

The objective of this study is to determine the yield ratings of selected smoke constituents (Appendix 2) in mainstream cigarette smoke as identified by the United Kingdom Department of Health. The study encompassed 25 brands of cigarettes representing a 58% market share (July 2001) of the UK market. In addition Kentucky reference cigarettes have been smoked as part of the study.

This report details the results for volatile organic compounds (VOCs): 1,3-butadiene, isoprene, acrylonitrile, benzene, toluene and styrene

3. Samples

25 brands of cigarettes were selected because their design parameters are representative of the brands in the UK market place. The selection criteria include a range of "tar" values, ventilation, paper permeability, circumference, length, tobacco weight, blend and market share. The Kentucky reference cigarettes 1R4F and 1R5F were included in this part of the study.

2000 cigarettes of each brand were obtained from a single production batch of current specification (November/December 2001), and stored in plastic containers at 4°C. Cigarettes were selected from packets on a random basis for testing.

Cigarettes were conditioned at a temperature of 22 ± 1°C and 60 ± 3 % relative humidity [1] for a minimum of 48 hours but not exceeding 10 days.

Butt marking was done in accordance with ISO butt length specifications[2]. Filtered cigarettes were smoked to a measured butt length equal to either the tipping paper + 3 mm or filter length + 8 mm whichever was longer. The minimum butt length was 23 mm and this was used for non filter brands. All smoking was conducted in an environment of temperature 22 ± 2°C and 60 ± 5 % relative humidity [1].

4. Smoking

The cigarettes were smoked on a 20 channel linear smoking machine.

5 cigarettes were sub-sampled from packets chosen on a random basis and smoked to determine the yield of VOCs using the method given below (see section 5). Five determinations were performed for each of the 25 brands, 1R4F and 1R5F. As far as was

practicable sub-samples of each brand were smoked on different channels on different smoking runs.

ISO conditions[3] for smoking cigarettes were used. The smoking machine puffing parameters were 35 ± 0.3 cm^3 puff volume with 2.0 ± 0.02 second puff duration once every 60.0 ± 0.5 seconds.

5. Method and Validation

This method is applicable to determination of VOC's in mainstream tobacco smoke by GC-MS. For each sample, five conditioned cigarettes are smoked on a linear 20 channel smoking machine. The mainstream smoke is passed through a Cambridge filter pad and the vapour phase through a bubbler with a Grade 0 sinter containing 20 mL of methanol. The bubbler is cooled in a dry ice/propan-2-ol bath. After smoking each filter pad is transferred to the appropriate bubbler. An internal standard is added, and the bubbler is vortexed briefly. An aliquot of the solution is filtered into an autosampler vial which is then immediately sealed. The vials are stored in a freezer prior to analysis. The extract solutions are analysed by GC-MS.

The full method is given in an Annexe to this report.

The method is in current use and has been validated. The validation data used to show that the method is suitable for use in the study is given in an Annexe to this report.

6. Results & Discussion

The results were tabulated for each brand (see Tables). The mean, standard deviation and relative standard deviation were determined for each set of results.

A summary of the results is included at the beginning (Page 6). Linear least squares regression analysis has been carried out for each VOC yield versus carbon monoxide (Page 7 to 12) and VOC yield versus NFDPM (Page 13 to 18) for the twenty five cigarette brands (excluding 1R4F and 1R5F).

A reporting limit has been used based on the limit of quantitation for the method (<0.8 to 3.1 μg cig^{-1} depending on the analyte – see validation report).

7. Outlier Test

It was agreed as part of the study protocol that Dixon's outlier test would be performed on each set of results. This has been carried out and where an outlier has been detected then the result has been flagged "95%". A judgement was then made as to whether to use the original results or recalculate the mean excluding the outlier. The CV values for each analyte across the 25 brands were examined before making this judgement. As a result of this, the original results have been used in the summary table as comparison of the CV values did not confirm that there are true outliers present in the original data.

8. Information provided in the Appendices and Annex

Appendix 1 contains technical opinions and interpretations about the method, validation data and the results.[4].

Appendix 2 lists the specific analytes to be determined in the study.

Appendix 3 contains a brief glossary of selected abbreviations and terms used in this report

Appendix 4 contains a brief description of the cigarettes used in this survey. It also lists the butt lengths determined for each brand of cigarette.

The Annex to this report lists the method used to determine the VOCs' yields in cigarette smoke. It also contains a summary of the validation data used to show that the method was suitable for the purposes of the bench mark study.

---

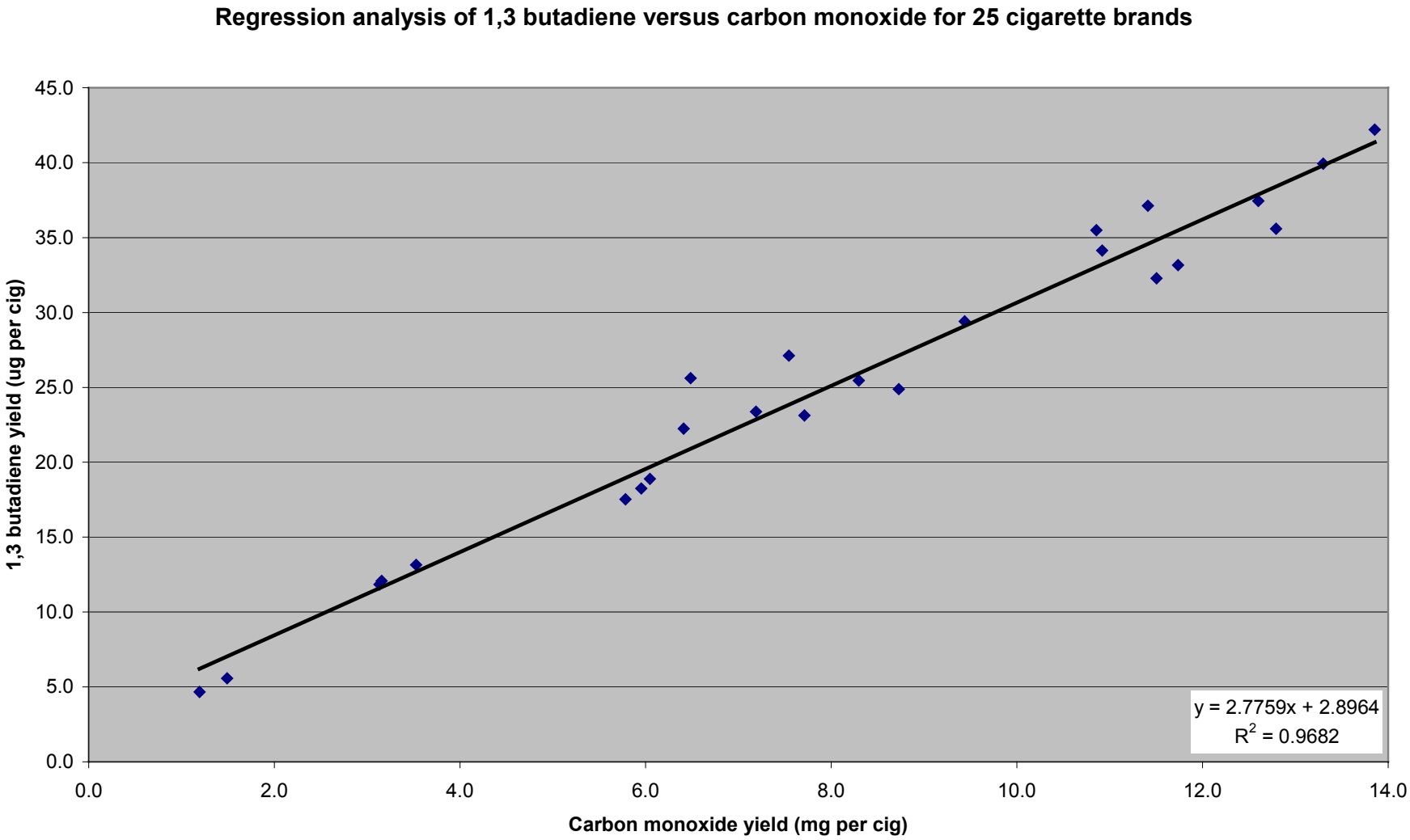
[1] ISO 3402:1999 – Tobacco and tobacco products – atmosphere for conditioning and testing
[2] ISO 4387: 2000 - Methods for chemical analysis of tobacco and tobacco products: Determination of total and nicotine- free dry particulate matter using a routine analytical smoking machine
[3] ISO 3308:2000 – Routine analytical cigarette smoking machine: Definitions and standard conditions
[4] NB When evaluating a set of results obtained using a particular method it is important to put the results in context and this is what we have set out to do in this Appendix.

Tables

Summary of mean results for 25 cigarette brands plus 1R4F and 1R5F

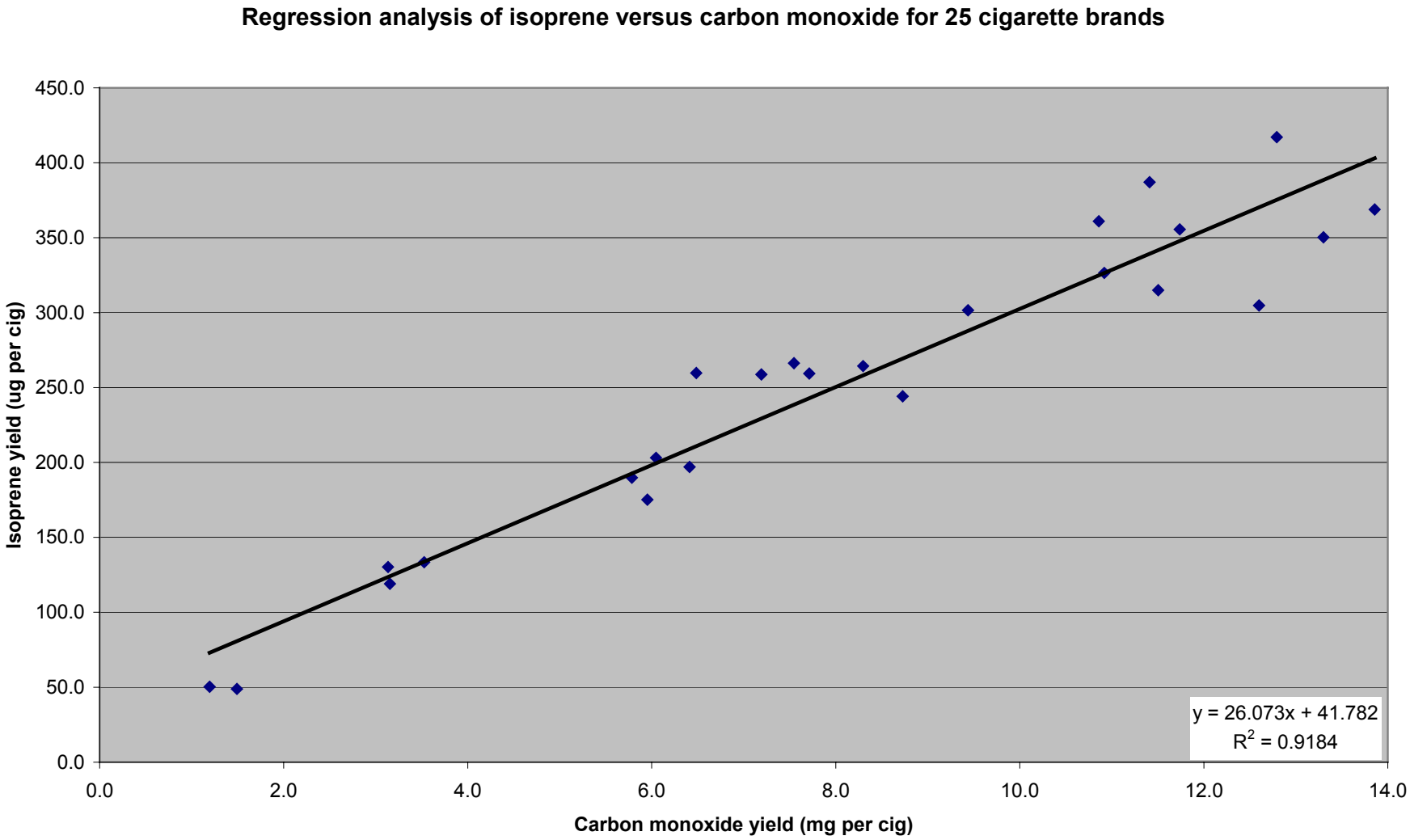
	1,3-butadiene µg/cig	Isoprene µg/cig	Acrylonitrile µg/cig	Benzene µg/cig	Toluene µg/cig	Styrene µg/cig	NFDPM mg/cig	Carbon Monoxide mg/cig
1R4F	31.0	343	8.07	40.6	72.3	5.29	9.06	12.26
1R5F	12.6	136	2.17	15.7	23.0	1.51	1.92	3.36
Benson & Hedges King Size	33.2	356	8.86	43.1	74.0	7.70	10.30	11.74
Berkely Superkings	32.3	315	8.55	43.5	71.0	6.73	9.69	11.50
Camel Ultra Lights	11.8	130	2.08	17.4	23.9	1.30	3.09	3.13
Consulate Menthol	25.5	264	6.56	35.3	58.0	4.59	7.06	8.30
Gitanes Caporal Filter	37.4	305	13.2	55.8	101	12.1	12.00	12.60
Lambert & Butler King Size	39.9	350	10.9	51.6	87.2	10.7	11.93	13.30
Lambert & Butler Lights King Size	25.6	260	5.93	33.1	54.8	4.89	5.24	6.48
Lambert & Butler Ultra Lights	5.58	48.9	<1.3	6.66	8.58	<0.8	1.61	1.49
Marlboro King Size	35.6	417	10.9	49.0	93.0	10.0	12.69	12.79
Marlboro Lights King Size	23.4	259	4.50	28.3	44.8	2.74	6.10	7.19
Mayfair Lights King Size	24.9	244	7.02	32.7	55.9	5.44	7.23	8.73
Mayfair Menthol King Size	18.3	175	3.55	22.4	35.1	2.31	4.65	5.95
Red Band Lights King Size	22.2	197	5.36	32.5	48.9	3.43	5.55	6.41
Regal Filter	34.1	326	9.66	44.0	75.2	9.14	10.65	10.92
Regal King Size	42.2	369	11.7	57.5	97.7	11.8	11.96	13.86
Rothman Royals 120s	29.4	302	7.97	40.1	69.2	6.05	10.39	9.44
Rothman Royals King Size	35.5	361	9.61	48.0	82.8	8.86	11.00	10.86
Senior Service	23.1	259	8.10	33.7	59.6	7.06	11.92	7.71
Silk Cut Extra Mild	12.1	119	2.11	16.6	22.8	1.34	2.67	3.16
Silk Cut King Size	17.5	190	4.38	26.3	41.2	2.96	5.62	5.78
Silk Cut Ultra King Size	4.66	50.3	<1.3	6.25	7.56	<0.8	1.01	1.20
Superkings	37.1	387	11.4	52.4	90.4	9.46	10.71	11.41
Superkings Lights	27.1	266	6.93	37.6	59.2	4.94	8.09	7.54
Superkings Ultra Lights	13.1	134	2.50	17.2	25.7	1.82	3.08	3.53
Vogue Superslims	18.9	203	6.43	24.3	42.8	5.12	7.38	6.05

Regression analysis of 1,3-butadiene versus carbon monoxide



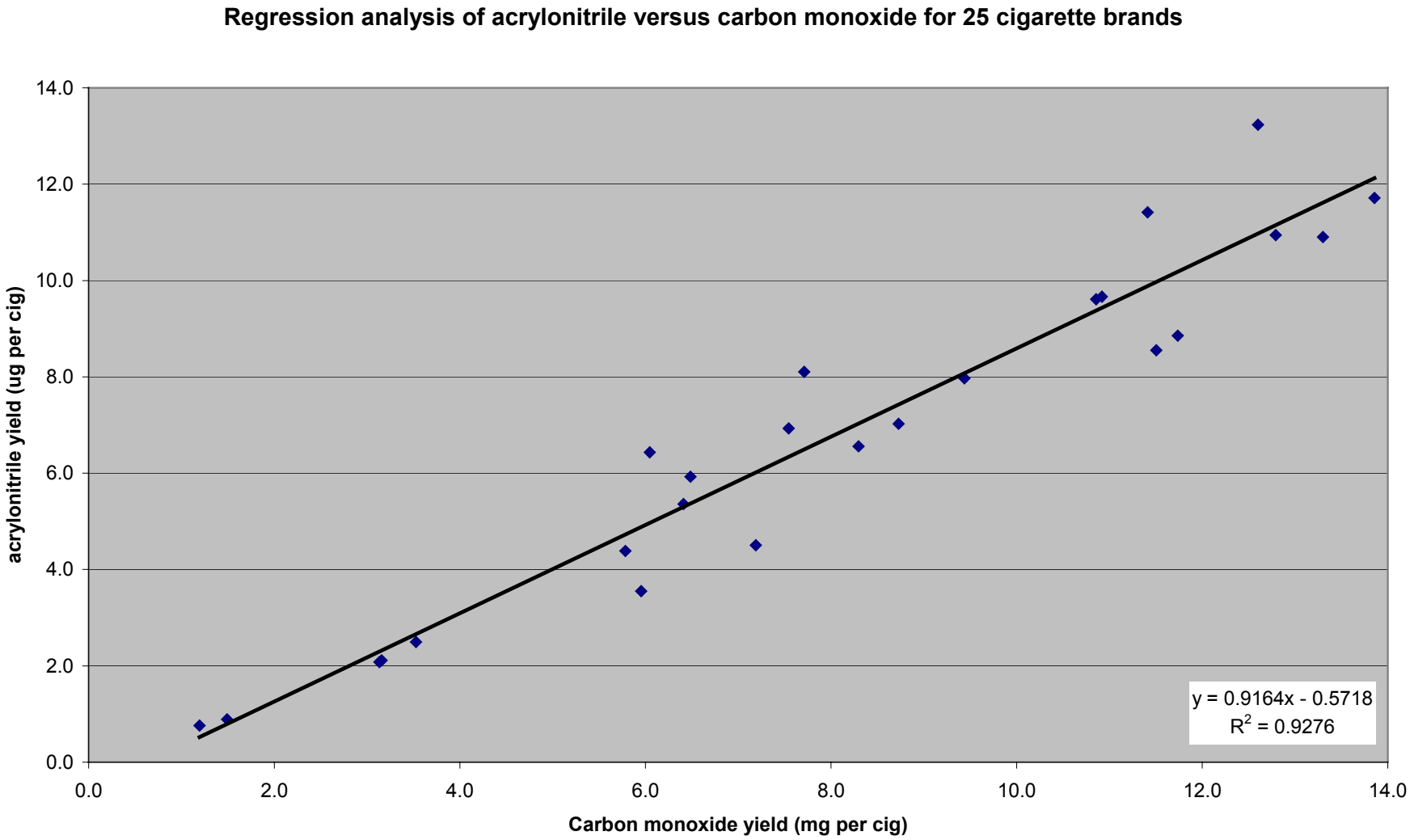
The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of isoprene versus carbon monoxide



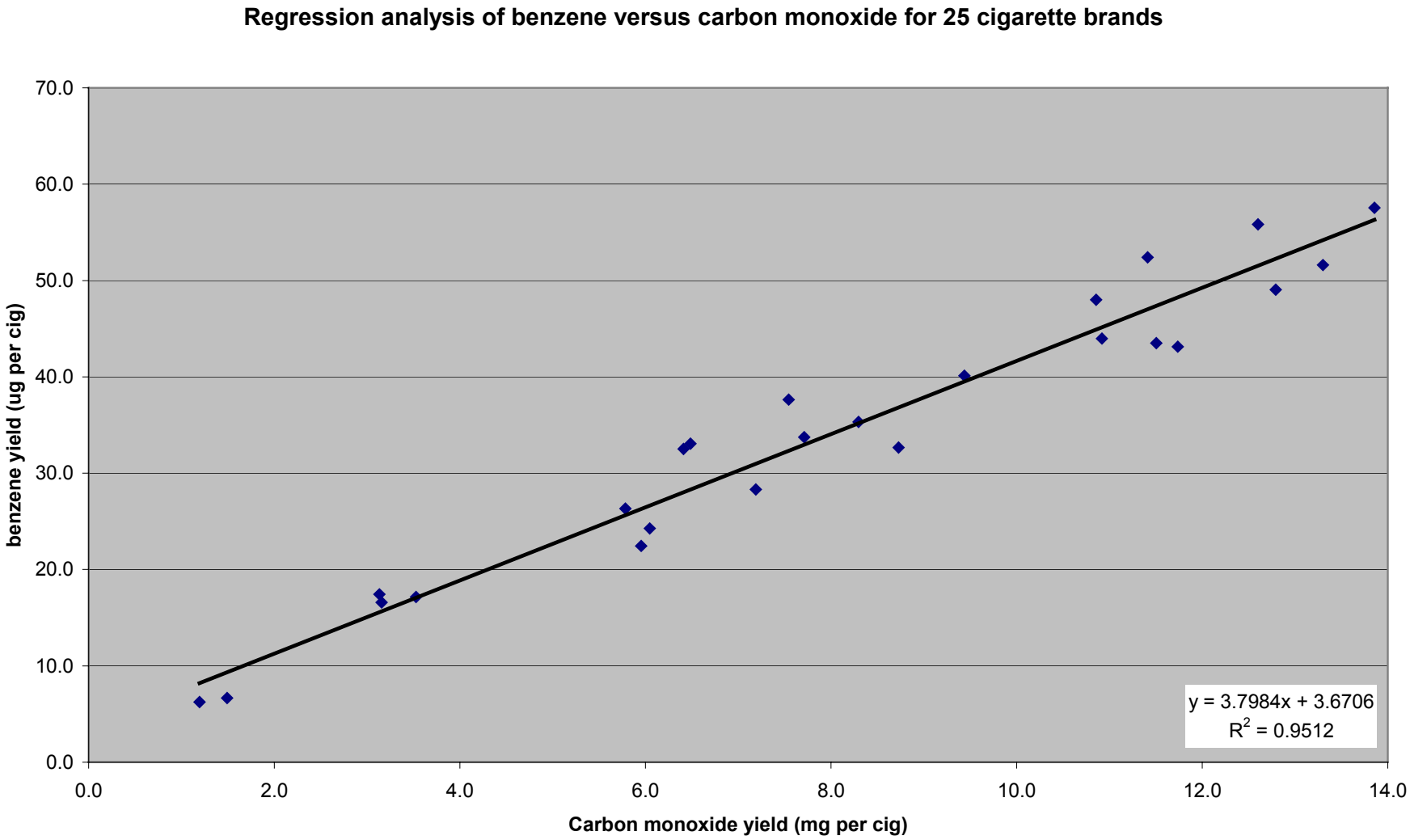
The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of acrylonitrile versus carbon monoxide



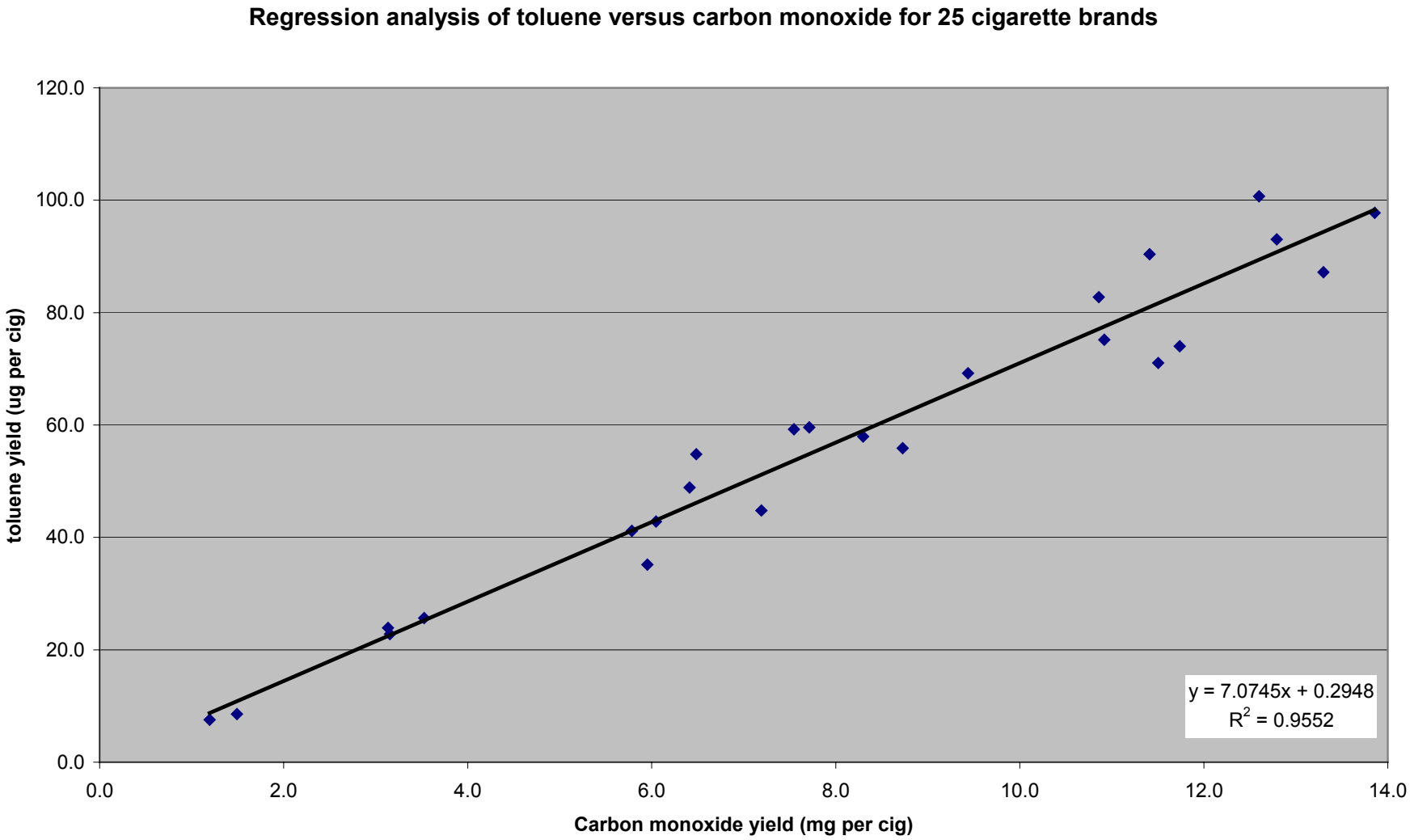
The regression analysis trend line has been calculate on the basis of a linear relationship (y =mx + c)

Regression analysis of benzene versus carbon monoxide



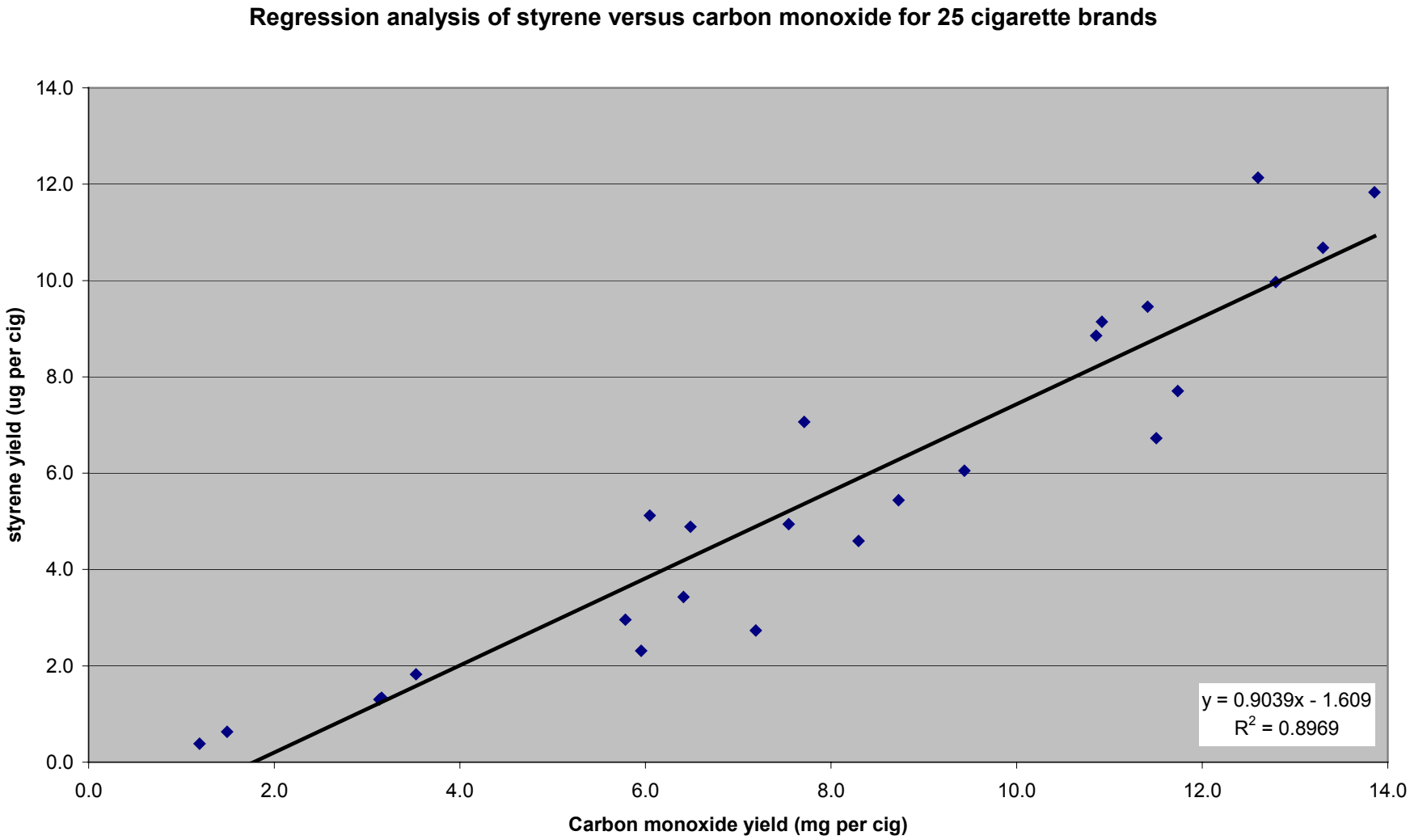
The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of toluene versus carbon monoxide



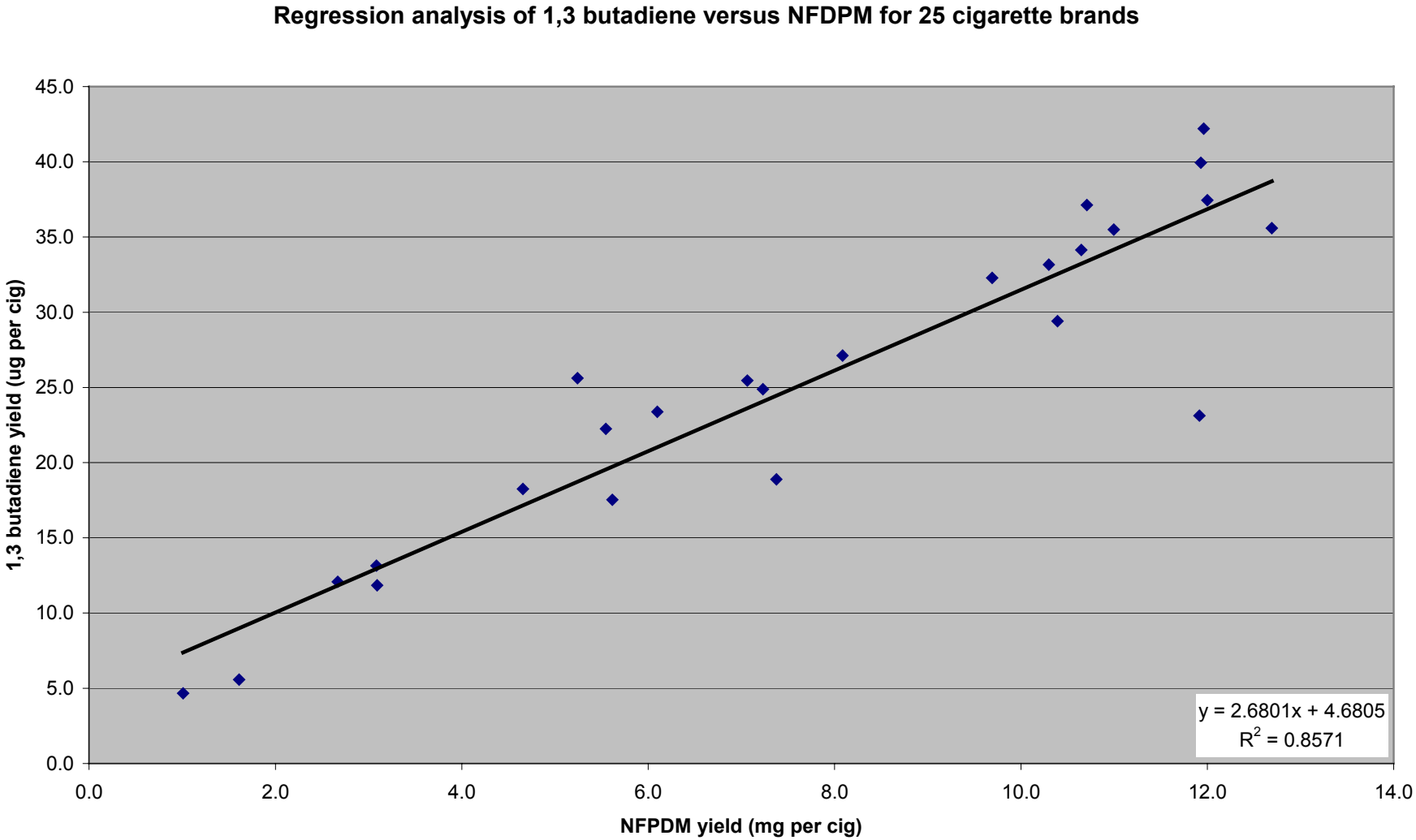
The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of styrene versus carbon monoxide



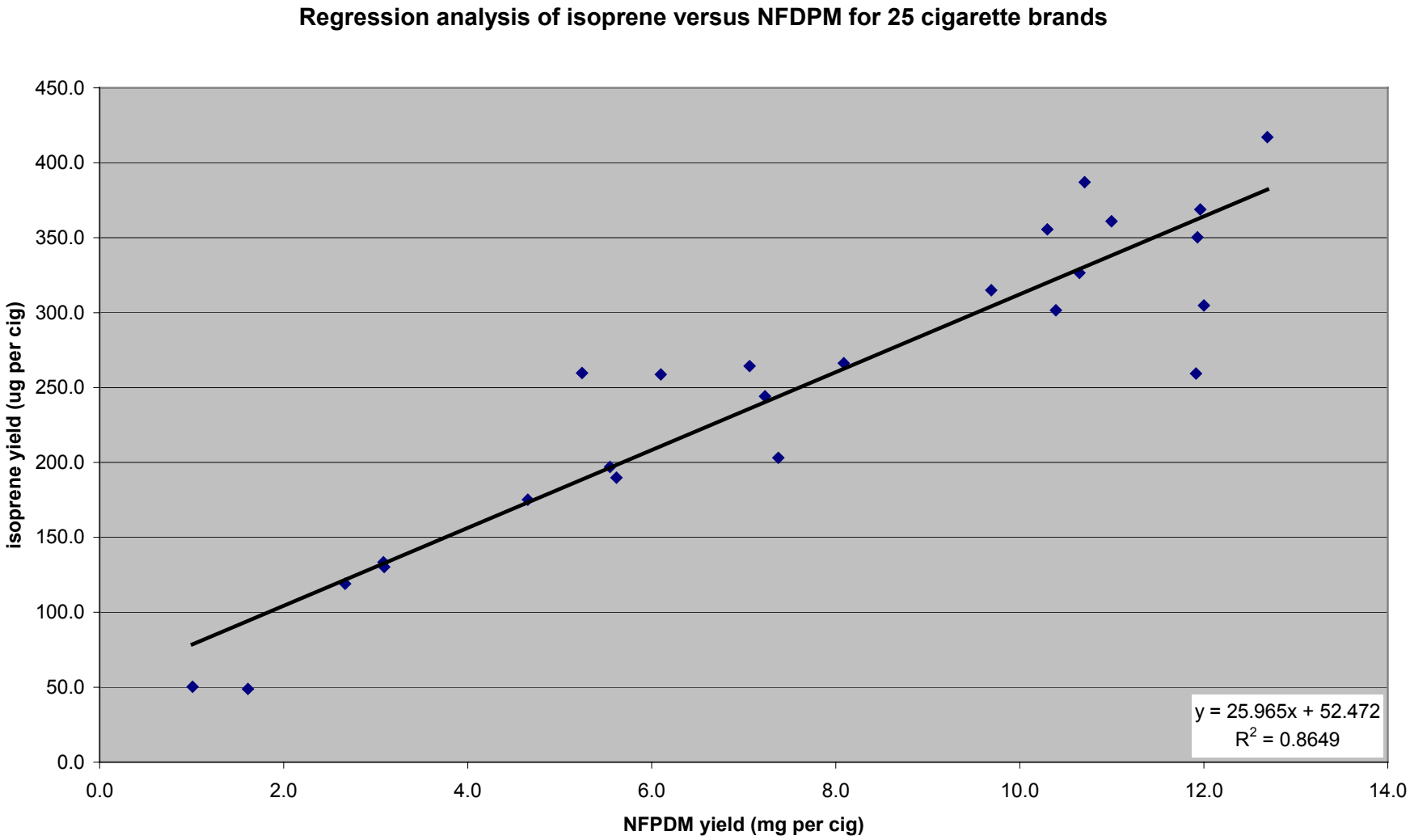
The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of 1,3-butadiene versus NFDPM



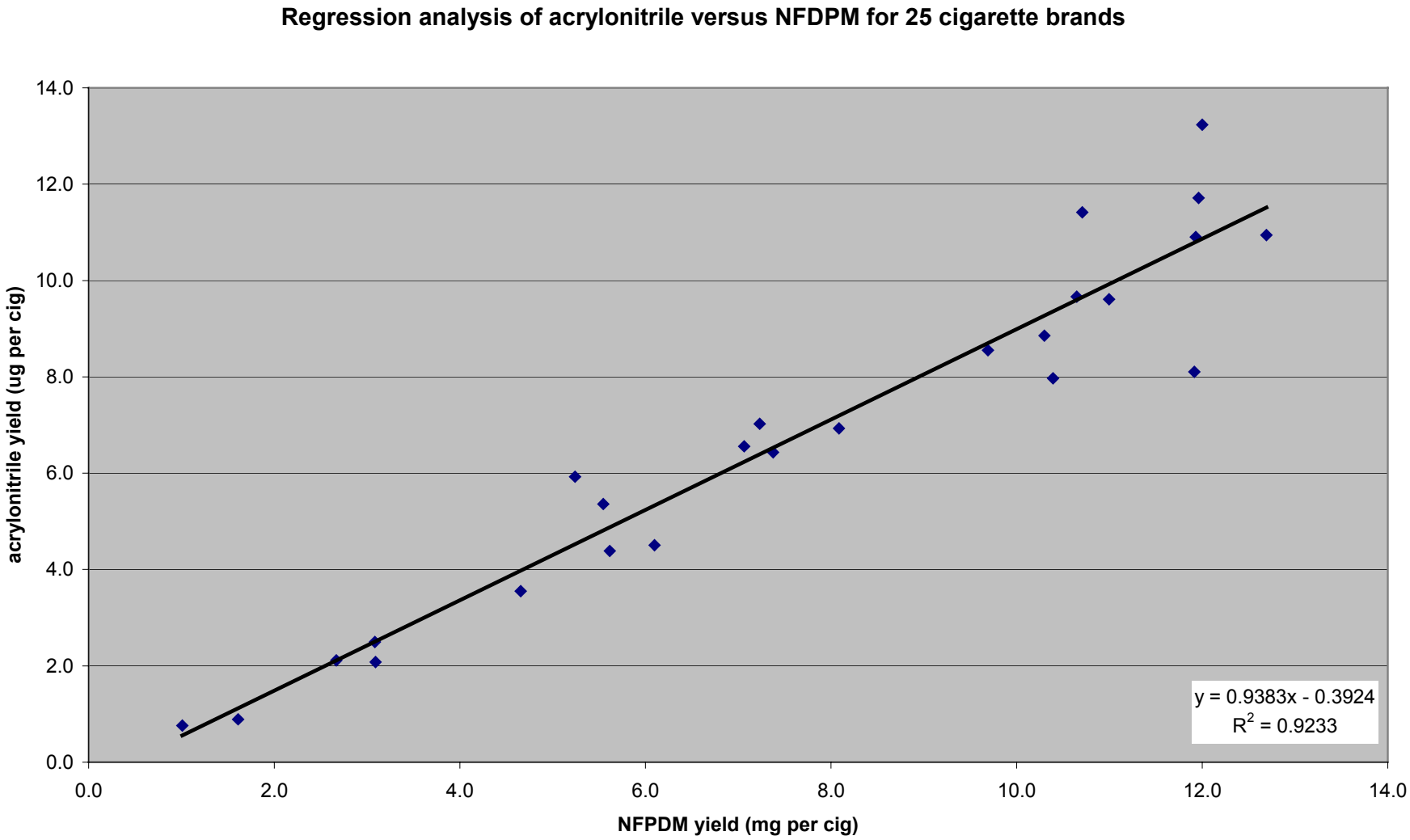
The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of isoprene versus NFDPM



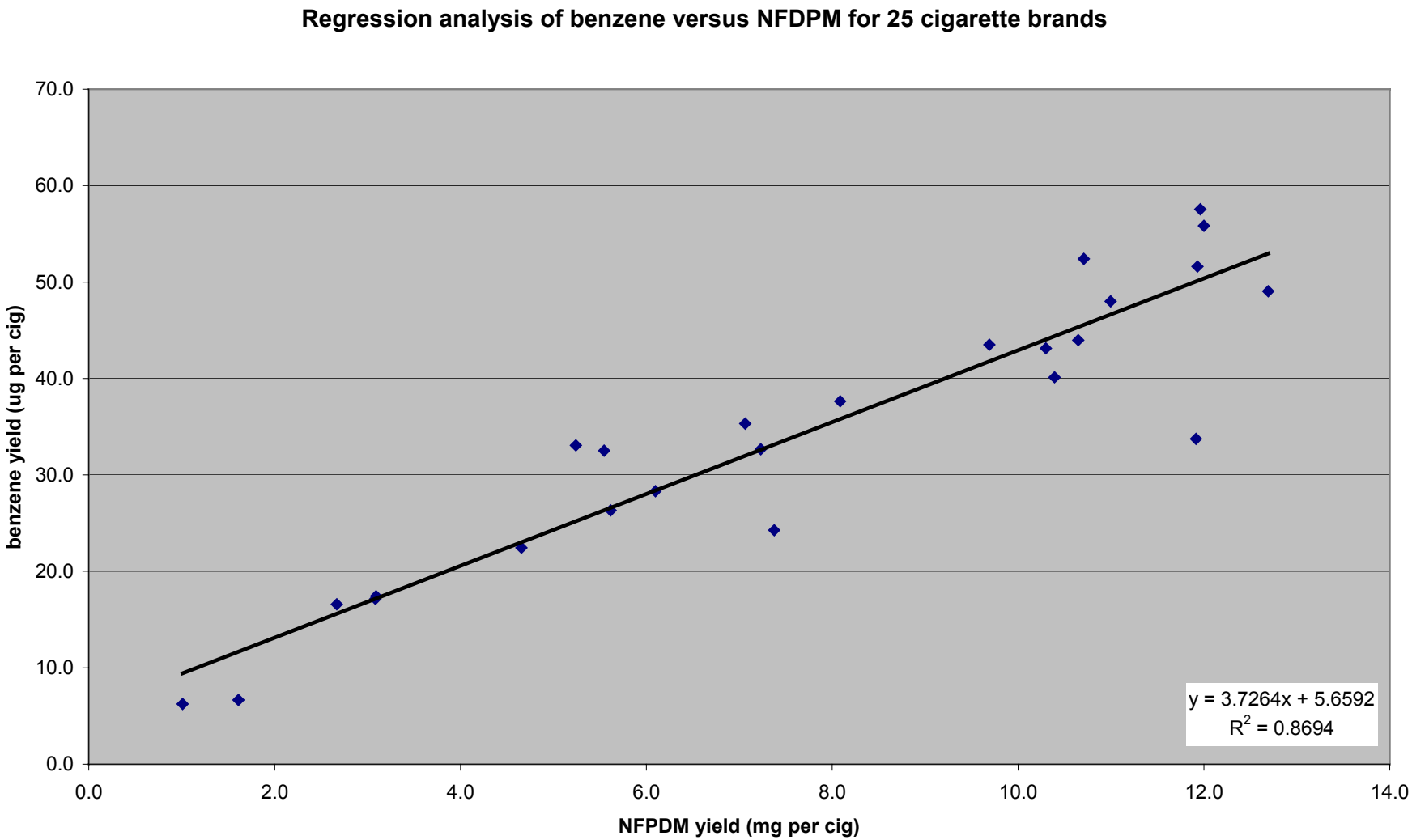
The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of acrylonitrile versus NFDPM



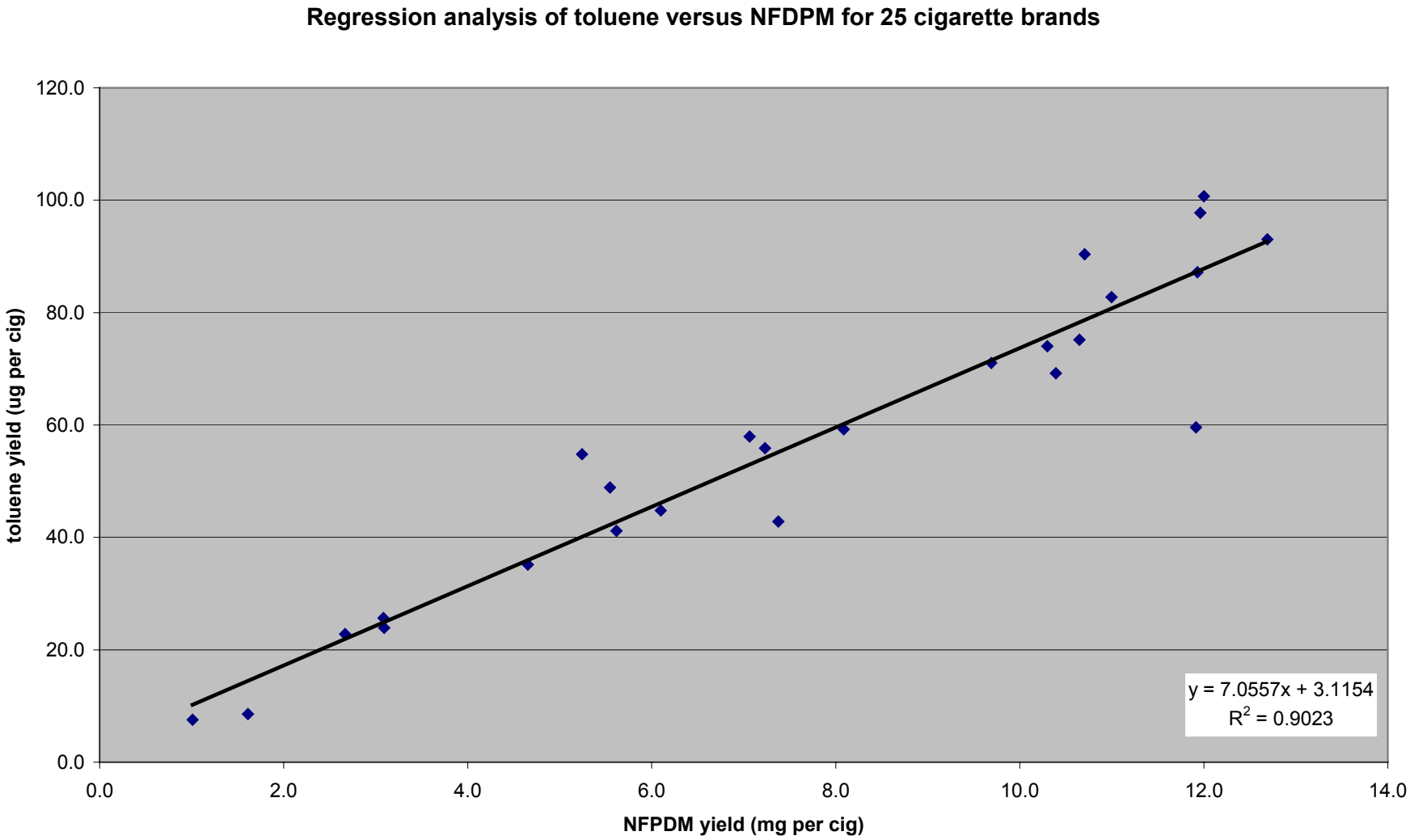
The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of benzene versus NFDPM



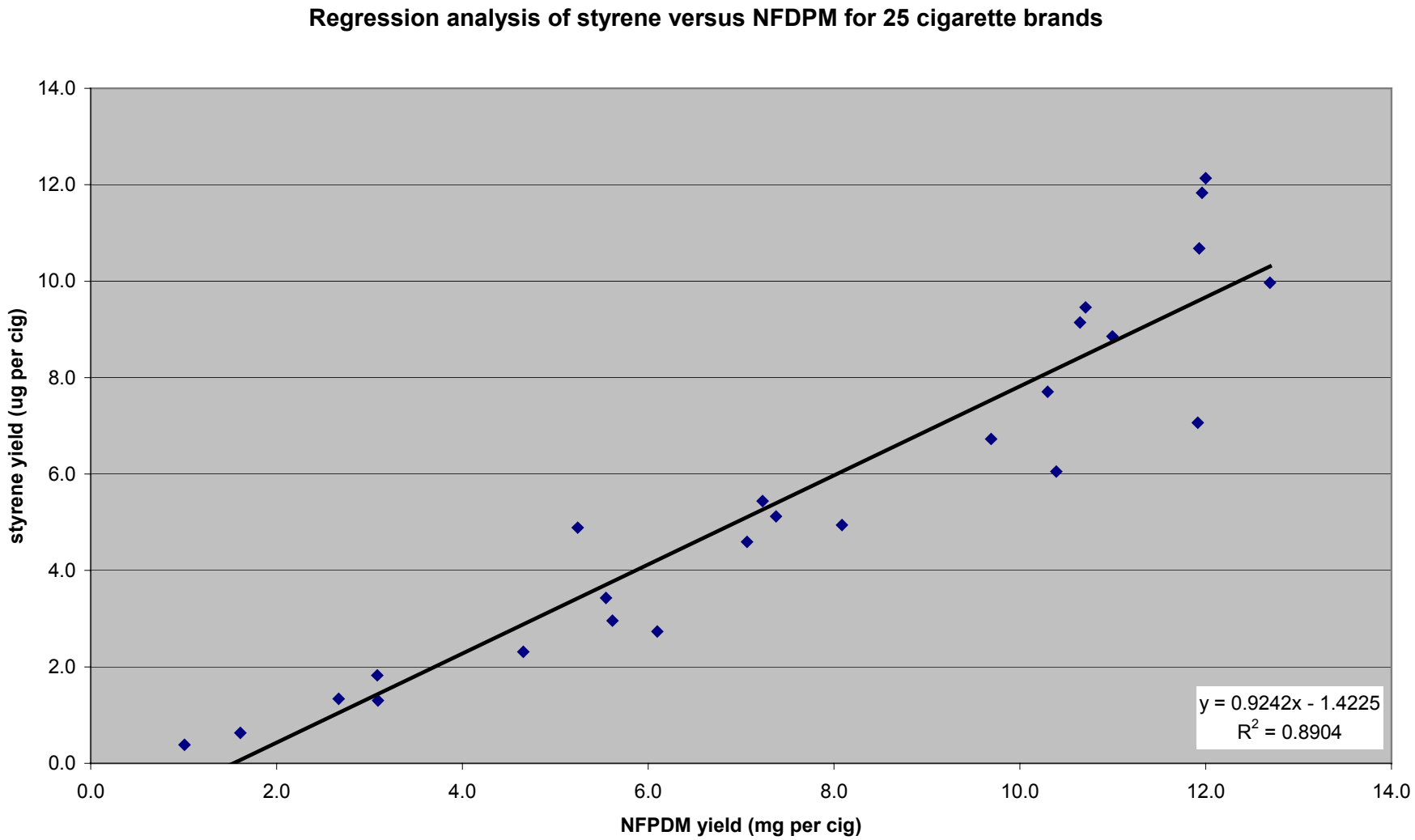
The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of toluene versus NFDPM



The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

Regression analysis of styrene versus NFDPM



The regression analysis trend line has been calculated on the basis of a linear relationship (y =mx + c)

1R4F

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
1R4F	29.5	322	7.16	37.3	65.8	4.72
1R4F	30.4	348	8.40	41.6	74.6	5.52
1R4F	33.7	385	8.28	43.6	78.2	5.80
1R4F	30.7	344	8.88	41.8	75.0	5.52
1R4F	30.4	319	7.64	38.9	67.9	4.88
Mean (µg/cig)	31.0	343	8.07	40.6	72.3	5.29
Standard Deviation	1.61	26.3	0.67	2.52	5.23	0.46
CV (%)	5.2	7.7	8.4	6.2	7.2	8.8

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	29.520	319.200	7.160	37.280	65.800	4.720
	30.400	321.640	7.640	38.880	67.880	4.880
	30.440	343.960	8.280	41.600	74.560	5.520
	30.680	347.800	8.400	41.800	75.000	5.520
	33.720	384.520	8.880	43.600	78.240	5.800
Statistical test applied						
Dixons low end test	0.210	0.037	0.279	0.253	0.167	0.148
Outlier detected at 95%						
Dixons high end test	0.724	0.562	0.279	0.285	0.260	0.259
Outlier detected at 95%	95%					

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	30.3	343	8.07	40.6	72.3	5.29
Standard Deviation	0.51	26.3	0.67	2.52	5.23	0.46
CV (%)	1.7	7.7	8.4	6.2	7.2	8.8

1R5F

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
1R5F	11.4	119	1.72	13.9	19.4	1.24
1R5F	12.2	131	2.16	15.2	21.6	1.48
1R5F	12.6	143	2.44	16.3	24.9	1.56
1R5F	15.6	152	2.72	17.9	27.4	1.96
1R5F	11.3	134	1.80	15.3	21.8	1.32
Mean (µg/cig)	12.6	136	2.17	15.7	23.0	1.51
Standard Deviation	1.76	12.3	0.42	1.47	3.16	0.28
CV (%)	13.9	9.1	19.5	9.4	13.7	18.6

Outlier Test
Dixons outlier test was applied to the above data

Data sorted	11.320	119.080	1.720	13.920	19.360	1.240
	11.400	131.240	1.800	15.200	21.560	1.320
	12.240	133.560	2.160	15.320	21.840	1.480
	12.640	143.040	2.440	16.320	24.920	1.560
	15.640	151.520	2.720	17.880	27.440	1.960
Statistical test applied						
Dixons low end test	0.019	0.375	0.080	0.323	0.272	0.111
Outlier detected at 95%						
Dixons high end test	0.694	0.261	0.280	0.394	0.312	0.556
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	12.6	136	2.17	15.7	23.0	1.51
Standard Deviation	1.76	12.3	0.42	1.47	3.16	0.28
CV (%)	13.9	9.1	19.5	9.4	13.7	18.6

Benson & Hedges King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Benson & Hedges King Size	30.9	334	8.64	41.3	70.5	7.88
Benson & Hedges King Size	29.4	324	8.48	39.9	71.3	7.20
Benson & Hedges King Size	36.7	374	10.0	47.2	78.2	8.32
Benson & Hedges King Size	33.0	370	8.08	41.8	72.1	7.16
Benson & Hedges King Size	35.9	374	9.04	45.4	77.9	7.96
Mean (ug/cig)	33.2	356	8.86	43.1	74.0	7.70
Standard Deviation	3.14	24.3	0.75	3.07	3.74	0.51
CV (%)	9.5	6.8	8.4	7.1	5.0	6.6

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	29.360	324.280	8.080	39.920	70.480	7.160
	30.880	334.240	8.480	41.280	71.320	7.200
	32.960	370.480	8.640	41.800	72.120	7.880
	35.880	374.240	9.040	45.440	77.880	7.960
	36.680	374.360	10.040	47.240	78.200	8.320
Statistical test applied						
Dixons low end test	0.208	0.199	0.204	0.186	0.109	0.034
Outlier detected at 95%						
Dixons high end test	0.109	0.002	0.510	0.246	0.041	0.310
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	33.2	356	8.86	43.1	74.0	7.70
Standard Deviation	3.14	24.3	0.75	3.07	3.74	0.51
CV (%)	9.5	6.8	8.4	7.1	5.0	6.6

Berkely Superkings

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Berkely Superkings	33.4	318	9.40	44.1	72.6	7.16
Berkely Superkings	29.1	281	7.08	37.2	62.3	5.64
Berkely Superkings	28.0	286	7.84	40.0	62.9	5.64
Berkely Superkings	33.7	339	8.80	46.0	78.0	8.12
Berkely Superkings	37.2	350	9.64	50.2	79.3	7.08
Mean (µg/cig)	32.3	315	8.55	43.5	71.0	6.73
Standard Deviation	3.75	30.9	1.08	5.08	8.09	1.07
CV (%)	11.6	9.8	12.6	11.7	11.4	16.0

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	28.000	281.040	7.080	37.240	62.320	5.640
	29.080	286.040	7.840	40.000	62.880	5.640
	33.400	318.320	8.800	44.080	72.640	7.080
	33.680	338.880	9.400	45.960	78.000	7.160
	37.240	350.400	9.640	50.240	79.280	8.120
Statistical test applied						
Dixons low end test	0.117	0.072	0.297	0.212	0.033	0.000
Outlier detected at 95%						
Dixons high end test	0.385	0.166	0.094	0.329	0.075	0.387
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	32.3	315	8.55	43.5	71.0	6.73
Standard Deviation	3.75	30.9	1.08	5.08	8.09	1.07
CV (%)	11.6	9.8	12.6	11.7	11.4	16.0

Camel Ultra Lights

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Camel Ultra Lights	12.2	125	1.88	17.2	22.2	1.24
Camel Ultra Lights	11.0	127	1.76	16.8	22.6	1.24
Camel Ultra Lights	13.1	143	2.40	18.9	25.2	1.40
Camel Ultra Lights	12.0	137	2.36	17.9	27.2	1.44
Camel Ultra Lights	10.9	119	2.00	16.3	22.2	1.20
Mean (ug/cig)	11.8	130	2.08	17.4	23.9	1.30
Standard Deviation	0.91	9.30	0.29	0.99	2.24	0.11
CV (%)	7.7	7.1	13.8	5.7	9.4	8.3

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	10.880	119.400	1.760	16.320	22.200	1.200
	11.040	125.320	1.880	16.840	22.200	1.240
	12.040	127.240	2.000	17.240	22.600	1.240
	12.160	136.880	2.360	17.880	25.240	1.400
	13.120	142.520	2.400	18.880	27.200	1.440
Statistical test applied						
Dixons low end test	0.071	0.256	0.188	0.203	0.000	0.167
Outlier detected at 95%						
Dixons high end test	0.429	0.244	0.063	0.391	0.392	0.167
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	11.8	130	2.08	17.4	23.9	1.30
Standard Deviation	0.91	9.30	0.29	0.99	2.24	0.11
CV (%)	7.7	7.1	13.8	5.7	9.4	8.3

Consulate Menthol

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Consulate Menthol	24.5	251	5.84	33.1	54.0	3.96
Consulate Menthol	24.2	268	6.80	37.2	63.0	5.32
Consulate Menthol	27.7	278	6.92	38.9	62.2	4.92
Consulate Menthol	26.5	274	7.28	35.9	59.7	4.96
Consulate Menthol	24.4	251	5.96	31.5	50.9	3.80
Mean (ug/cig)	25.5	264	6.56	35.3	58.0	4.59
Standard Deviation	1.57	12.79	0.63	3.02	5.30	0.67
CV (%)	6.2	4.8	9.6	8.6	9.1	14.6

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	24.200	250.640	5.840	31.480	50.920	3.800
	24.400	251.240	5.960	33.080	53.960	3.960
	24.480	267.840	6.800	35.920	59.680	4.920
	26.480	273.960	6.920	37.160	62.200	4.960
	27.720	278.120	7.280	38.920	63.040	5.320
Statistical test applied						
Dixons low end test	0.057	0.022	0.083	0.215	0.251	0.105
Outlier detected at 95%						
Dixons high end test	0.352	0.151	0.250	0.237	0.069	0.237
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	25.5	264	6.56	35.3	58.0	4.59
Standard Deviation	1.57	12.8	0.63	3.02	5.30	0.67
CV (%)	6.2	4.8	9.6	8.6	9.1	14.6

Gitanes Caporal Filter

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Gitanes Caporal Filter	41.0	319	14.2	60.3	109	13.5
Gitanes Caporal Filter	36.6	296	12.7	54.8	100	12.3
Gitanes Caporal Filter	36.2	283	12.9	52.7	94.8	11.4
Gitanes Caporal Filter	37.3	307	14.0	58.3	104	12.8
Gitanes Caporal Filter	36.1	319	12.4	53.0	95.0	10.8
Mean (ug/cig)	37.4	305	13.2	55.8	101	12.1
Standard Deviation	2.03	15.2	0.78	3.36	6.06	1.07
CV (%)	5.4	5.0	5.9	6.0	6.0	8.8

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	36.120	283.440	12.440	52.680	94.840	10.800
	36.160	296.040	12.680	53.040	95.040	11.360
	36.640	306.800	12.920	54.840	100.400	12.280
	37.320	318.680	13.960	58.320	104.160	12.760
	40.960	318.960	14.160	60.320	108.960	13.480
Statistical test applied						
Dixons low end test	0.008	0.355	0.140	0.047	0.014	0.209
Outlier detected at 95%						
Dixons high end test	0.752	0.008	0.116	0.262	0.340	0.269
Outlier detected at 95%	95%					

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	36.6	305	13.2	55.8	101	12.1
Standard Deviation	0.56	15.2	0.78	3.36	6.06	1.07
CV (%)	1.5	5.0	5.9	6.0	6.0	8.8

Lambert & Butler King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Lambert & Butler King Size	39.5	374	11.4	55.2	95.6	11.8
Lambert & Butler King Size	39.8	350	11.4	52.6	87.2	10.5
Lambert & Butler King Size	41.4	334	11.0	48.6	79.9	9.64
Lambert & Butler King Size	40.2	338	10.9	52.3	88.8	11.5
Lambert & Butler King Size	38.7	356	9.84	49.3	84.5	10.0
Mean (ug/cig)	39.9	350	10.9	51.6	87.2	10.7
Standard Deviation	1.00	16.2	0.64	2.67	5.77	0.92
CV (%)	2.5	4.6	5.9	5.2	6.6	8.6

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	38.720	333.560	9.840	48.640	79.880	9.640
	39.520	337.680	10.920	49.320	84.520	10.000
	39.800	349.800	10.960	52.280	87.240	10.520
	40.160	356.040	11.360	52.640	88.800	11.480
	41.440	374.240	11.440	55.200	95.560	11.760
Statistical test applied						
Dixons low end test	0.294	0.101	0.675	0.104	0.296	0.170
Outlier detected at 95%						
Dixons high end test	0.471	0.447	0.050	0.390	0.431	0.132
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	39.9	350	10.9	51.6	87.2	10.7
Standard Deviation	1.00	16.2	0.64	2.67	5.77	0.92
CV (%)	2.5	4.6	5.9	5.2	6.6	8.6

Lambert & Butler Lights King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Lambert & Butler Lights King Size	24.3	259	5.80	32.9	56.0	4.84
Lambert & Butler Lights King Size	26.0	264	6.04	33.6	56.5	5.20
Lambert & Butler Lights King Size	29.4	299	7.12	39.8	65.2	6.64
Lambert & Butler Lights King Size	25.3	254	5.92	31.8	50.9	4.04
Lambert & Butler Lights King Size	23.0	222	4.76	27.2	45.4	3.72
Mean (ug/cig)	25.6	260	5.93	33.1	54.8	4.89
Standard Deviation	2.41	27.5	0.84	4.52	7.37	1.15
CV (%)	9.4	10.6	14.1	13.7	13.4	23.4

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	23.040	222.080	4.760	27.200	45.360	3.720
	24.320	254.200	5.800	31.800	50.880	4.040
	25.280	259.360	5.920	32.880	56.000	4.840
	26.000	263.760	6.040	33.600	56.520	5.200
	29.440	299.160	7.120	39.800	65.200	6.640
Statistical test applied						
Dixons low end test	0.200	0.417	0.441	0.365	0.278	0.110
Outlier detected at 95%						
Dixons high end test	0.538	0.459	0.458	0.492	0.438	0.493
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	25.6	260	5.93	33.1	54.8	4.89
Standard Deviation	2.41	27.5	0.84	4.52	7.37	1.15
CV (%)	9.4	10.6	14.1	13.7	13.4	23.4

Lambert & Butler Ultra Lights

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Lambert & Butler Ultra Lights	5.04	45.1	<1.3	6.36	8.24	<0.8
Lambert & Butler Ultra Lights	5.84	50.7	<1.3	6.24	7.68	<0.8
Lambert & Butler Ultra Lights	6.52	51.0	<1.3	7.28	9.16	<0.8
Lambert & Butler Ultra Lights	5.40	53.8	<1.3	7.24	9.12	<0.8
Lambert & Butler Ultra Lights	5.12	43.6	<1.3	6.20	8.72	0.92
Mean (µg/cig)	5.58	48.9	<1.3	6.66	8.58	<0.8
Standard Deviation	0.61	4.33	n/a	0.55	0.63	n/a
CV (%)	10.9	8.9	n/a	8.2	7.3	n/a
Outlier Test						
Dixons outlier test was applied to the above data						
Data sorted	5.040	43.600	0.760	6.200	7.680	0.480
	5.120	45.080	0.840	6.240	8.240	0.560
	5.400	50.720	0.920	6.360	8.720	0.560
	5.840	51.040	0.920	7.240	9.120	0.640
	6.520	53.840	1.000	7.280	9.160	0.920
Statistical test applied						
Dixons low end test	0.054	0.145	0.333	0.037	0.378	0.182
Outlier detected at 95%						
Dixons high end test	0.459	0.273	0.333	0.037	0.027	0.636
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	5.58	48.9	<1.3	6.66	8.58	<0.8
Standard Deviation	0.61	4.33	n/a	0.55	0.63	n/a
CV (%)	10.9	8.9	n/a	8.2	7.3	n/a

Marlboro King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Marlboro King Size	36.9	459	12.9	54.0	106	11.6
Marlboro King Size	32.2	388	10.1	46.4	89.3	9.56
Marlboro King Size	37.6	424	11.2	51.3	93.9	10.3
Marlboro King Size	36.6	410	10.8	47.2	87.0	8.96
Marlboro King Size	34.7	405	9.80	46.3	89.0	9.36
Mean (ug/cig)	35.6	417	10.9	49.0	93.0	10.0
Standard Deviation	2.15	26.7	1.21	3.41	7.64	1.06
CV (%)	6.0	6.4	11.1	7.0	8.2	10.6

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	32.240	387.680	9.800	46.320	87.000	8.960
	34.680	405.080	10.080	46.440	88.960	9.360
	36.560	409.880	10.760	47.240	89.320	9.560
	36.880	424.400	11.200	51.280	93.920	10.320
	37.560	458.680	12.880	53.960	105.920	11.640
Statistical test applied						
Dixons low end test	0.459	0.245	0.091	0.016	0.104	0.149
Outlier detected at 95%						
Dixons high end test	0.128	0.483	0.545	0.351	0.634	0.493
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	35.6	417	10.9	49.0	93.0	10.0
Standard Deviation	2.15	26.7	1.21	3.41	7.64	1.06
CV (%)	6.0	6.4	11.1	7.0	8.2	10.6

Marlboro Lights King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Marlboro Lights King Size	23.4	265	4.92	28.5	45.8	3.08
Marlboro Lights King Size	24.5	274	4.92	29.9	45.0	2.60
Marlboro Lights King Size	22.0	240	4.20	27.2	43.2	2.60
Marlboro Lights King Size	23.3	248	3.96	25.5	41.3	2.60
Marlboro Lights King Size	23.7	268	4.52	30.4	48.5	2.80
Mean (µg/cig)	23.4	259	4.50	28.3	44.8	2.74
Standard Deviation	0.92	14.3	0.43	2.01	2.73	0.21
CV (%)	4.0	5.5	9.5	7.1	6.1	7.7

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	21.960	239.600	3.960	25.480	41.280	2.600
	23.280	248.240	4.200	27.240	43.240	2.600
	23.440	264.600	4.520	28.520	45.000	2.600
	23.680	267.960	4.920	29.880	45.840	2.800
	24.520	273.520	4.920	30.440	48.520	3.080
Statistical test applied						
Dixons low end test	0.516	0.255	0.250	0.355	0.271	0.000
Outlier detected at 95%						
Dixons high end test	0.328	0.164	0.000	0.113	0.370	0.583
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	23.4	259	4.50	28.3	44.8	2.74
Standard Deviation	0.92	14.3	0.43	2.01	2.73	0.21
CV (%)	4.0	5.5	9.5	7.1	6.1	7.7

Mayfair Lights King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Mayfair Lights King Size	22.6	228	6.80	31.7	55.3	5.28
Mayfair Lights King Size	26.3	227	6.60	31.7	53.6	4.80
Mayfair Lights King Size	24.7	244	7.16	32.0	53.5	5.20
Mayfair Lights King Size	24.3	247	7.16	32.7	56.6	5.60
Mayfair Lights King Size	26.6	275	7.40	35.3	60.3	6.32
Mean (µg/cig)	24.9	244	7.02	32.7	55.9	5.44
Standard Deviation	1.65	19.6	0.32	1.52	2.81	0.57
CV (%)	6.6	8.0	4.5	4.7	5.0	10.5

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	22.560	226.720	6.600	31.680	53.480	4.800
	24.280	228.200	6.800	31.680	53.600	5.200
	24.680	243.880	7.160	31.960	55.320	5.280
	26.280	246.560	7.160	32.720	56.640	5.600
	26.640	275.360	7.400	35.280	60.320	6.320
Statistical test applied						
Dixons low end test	0.422	0.030	0.250	0.000	0.018	0.263
Outlier detected at 95%						
Dixons high end test	0.088	0.592	0.300	0.711	0.538	0.474
Outlier detected at 95%				95%		

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	24.9	244	7.02	32.0	55.9	5.44
Standard Deviation	1.65	19.6	0.32	0.49	2.81	0.57
CV (%)	6.6	8.0	4.5	1.5	5.0	10.5

Mayfair Menthol King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Mayfair Menthol King Size	19.1	173.3	3.64	23.5	35.7	2.32
Mayfair Menthol King Size	18.0	190.1	3.80	22.7	37.2	2.44
Mayfair Menthol King Size	19.5	182.5	3.76	23.6	36.7	2.56
Mayfair Menthol King Size	17.8	168.1	3.32	21.0	32.9	1.92
Mayfair Menthol King Size	16.9	161.5	3.24	21.4	33.2	2.32
Mean (µg/cig)	18.3	175	3.55	22.4	35.1	2.31
Standard Deviation	1.03	11.4	0.26	1.17	1.97	0.24
CV (%)	5.6	6.5	7.2	5.2	5.6	10.4

Outlier Test
Dixons outlier test was applied to the above data

Data sorted	16.920	161.480	3.240	21.040	32.920	1.920
	17.760	168.120	3.320	21.440	33.200	2.320
	18.040	173.320	3.640	22.680	35.720	2.320
	19.080	182.520	3.760	23.480	36.680	2.440
	19.480	190.080	3.800	23.600	37.160	2.560
Statistical test applied						
Dixons low end test	0.328	0.232	0.143	0.156	0.066	0.625
Outlier detected at 95%						
Dixons high end test	0.156	0.264	0.071	0.047	0.113	0.188
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	18.3	175	3.55	22.4	35.1	2.31
Standard Deviation	1.03	11.4	0.26	1.17	1.97	0.24
CV (%)	5.6	6.5	7.2	5.2	5.6	10.4

Red Band Lights King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Red Band Lights King Size	23.7	213	6.24	36.1	56.1	4.44
Red Band Lights King Size	21.0	191	4.56	31.8	46.2	2.72
Red Band Lights King Size	20.3	178	4.64	29.3	42.4	2.48
Red Band Lights King Size	26.1	218	6.60	36.3	56.0	4.96
Red Band Lights King Size	20.0	184	4.76	29.1	43.8	2.56
Mean (µg/cig)	22.2	197	5.36	32.5	48.9	3.43
Standard Deviation	2.61	17.8	0.98	3.52	6.68	1.18
CV (%)	11.7	9.0	18.3	10.8	13.7	34.2

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	20.040	178.200	4.560	29.080	42.360	2.480
	20.320	184.080	4.640	29.280	43.760	2.560
	21.040	191.440	4.760	31.800	46.160	2.720
	23.720	213.440	6.240	36.080	56.000	4.440
	26.120	218.000	6.600	36.280	56.080	4.960
Statistical test applied						
Dixons low end test	0.046	0.148	0.039	0.028	0.102	0.032
Outlier detected at 95%						
Dixons high end test	0.395	0.115	0.176	0.028	0.006	0.210
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	22.2	197	5.36	32.5	48.9	3.43
Standard Deviation	2.61	17.8	0.98	3.52	6.68	1.18
CV (%)	11.7	9.0	18.3	10.8	13.7	34.2

Regal Filter

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Regal Filter	33.3	326	9.80	44.9	75.2	9.16
Regal Filter	32.3	334	10.1	47.0	84.7	10.5
Regal Filter	34.0	319	9.92	45.0	77.3	9.68
Regal Filter	32.2	303	8.96	41.7	70.9	8.32
Regal Filter	38.8	350	9.52	41.2	67.8	8.04
Mean (ug/cig)	34.1	326	9.66	44.0	75.2	9.14
Standard Deviation	2.74	17.5	0.45	2.43	6.48	1.01
CV (%)	8.0	5.4	4.7	5.5	8.6	11.0

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	32.200	302.960	8.960	41.240	67.760	8.040
	32.320	319.080	9.520	41.720	70.920	8.320
	33.280	325.880	9.800	44.880	75.240	9.160
	34.000	334.000	9.920	45.040	77.280	9.680
	38.840	350.200	10.120	47.000	84.680	10.520
Statistical test applied						
Dixons low end test	0.018	0.341	0.483	0.083	0.187	0.113
Outlier detected at 95%						
Dixons high end test	0.729	0.343	0.172	0.340	0.437	0.339
Outlier detected at 95%	95%					

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	33.0	326	9.66	44.0	75.2	9.14
Standard Deviation	0.85	17.5	0.45	2.43	6.48	1.01
CV (%)	2.6	5.4	4.7	5.5	8.6	11.0

Regal King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Regal King Size	41.3	380	12.7	60.1	103	12.6
Regal King Size	41.5	385	13.1	60.4	105	12.8
Regal King Size	43.0	374	10.4	55.7	94.0	11.0
Regal King Size	42.9	368	11.4	55.6	92.8	11.2
Regal King Size	42.3	338	11.0	55.9	94.1	11.6
Mean (µg/cig)	42.2	369	11.7	57.5	97.7	11.8
Standard Deviation	0.76	18.6	1.15	2.48	5.69	0.81
CV (%)	1.8	5.0	9.8	4.3	5.8	6.9

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	41.320	337.640	10.400	55.640	92.760	10.960
	41.520	367.960	10.960	55.680	94.000	11.200
	42.320	373.680	11.400	55.880	94.080	11.640
	42.880	379.840	12.680	60.080	103.280	12.600
	42.960	385.120	13.120	60.440	104.560	12.760
Statistical test applied						
Dixons low end test	0.122	0.639	0.206	0.008	0.105	0.133
Outlier detected at 95%						
Dixons high end test	0.049	0.111	0.162	0.075	0.108	0.089
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	42.2	369	11.7	57.5	97.7	11.8
Standard Deviation	0.76	18.6	1.15	2.48	5.69	0.81
CV (%)	1.8	5.0	9.8	4.3	5.8	6.9

Rothman Royals 120s

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Rothman Royals 120s	27.5	306	7.96	40.8	70.9	6.00
Rothman Royals 120s	29.4	303	8.12	42.7	71.1	5.96
Rothman Royals 120s	27.0	289	8.08	37.4	65.8	5.64
Rothman Royals 120s	33.9	311	7.80	38.8	66.0	5.56
Rothman Royals 120s	29.2	299	7.88	40.8	72.1	7.08
Mean (µg/cig)	29.4	302	7.97	40.1	69.2	6.05
Standard Deviation	2.71	8.16	0.13	2.03	3.03	0.61
CV (%)	9.2	2.7	1.7	5.1	4.4	10.1
Outlier Test						
Dixons outlier test was applied to the above data						
Data sorted	27.000	289.160	7.800	37.440	65.840	5.560
	27.520	298.960	7.880	38.840	65.960	5.640
	29.200	303.400	7.960	40.760	70.920	5.960
	29.440	305.680	8.080	40.800	71.120	6.000
	33.880	310.800	8.120	42.720	72.080	7.080
Statistical test applied						
Dixons low end test	0.076	0.453	0.250	0.265	0.019	0.053
Outlier detected at 95%						
Dixons high end test	0.645	0.237	0.125	0.364	0.154	0.711
Outlier detected at 95%						95%

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	29.4	302	7.97	40.1	69.2	5.79
Standard Deviation	2.71	8.16	0.13	2.03	3.03	0.22
CV (%)	9.2	2.7	1.7	5.1	4.4	3.8

Rothman Royals King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Rothman Royals King Size	34.2	344	9.24	46.9	79.3	8.32
Rothman Royals King Size	32.7	354	9.68	48.6	85.0	8.72
Rothman Royals King Size	35.6	382	10.2	50.2	89.2	10.4
Rothman Royals King Size	38.4	352	9.52	45.8	76.2	7.72
Rothman Royals King Size	36.5	373	9.36	48.5	84.1	9.16
Mean (ug/cig)	35.5	361	9.61	48.0	82.8	8.86
Standard Deviation	2.18	15.8	0.39	1.70	5.08	0.99
CV (%)	6.1	4.4	4.1	3.5	6.1	11.2

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	32.720	344.240	9.240	45.800	76.240	7.720
	34.160	351.960	9.360	46.920	79.280	8.320
	35.640	353.880	9.520	48.480	84.080	8.720
	36.520	372.600	9.680	48.560	84.960	9.160
	38.400	382.280	10.240	50.240	89.240	10.360
Statistical test applied						
Dixons low end test	0.254	0.203	0.120	0.252	0.234	0.227
Outlier detected at 95%						
Dixons high end test	0.331	0.254	0.560	0.378	0.329	0.455
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	35.5	361	9.61	48.0	82.8	8.86
Standard Deviation	2.18	15.8	0.39	1.70	5.08	0.99
CV (%)	6.1	4.4	4.1	3.5	6.1	11.2

Senior Service

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Senior Service	23.0	242	7.68	32.1	55.4	6.52
Senior Service	23.0	259	8.08	33.3	61.0	7.04
Senior Service	22.6	260	8.00	34.6	62.3	7.48
Senior Service	21.1	254	7.52	33.9	59.6	7.00
Senior Service	26.0	281	9.24	34.7	59.5	7.28
Mean (ug/cig)	23.1	259	8.10	33.7	59.6	7.06
Standard Deviation	1.78	14.1	0.68	1.08	2.59	0.36
CV (%)	7.7	5.4	8.3	3.2	4.3	5.1

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	21.120	242.360	7.520	32.120	55.400	6.520
	22.560	254.120	7.680	33.280	59.520	7.000
	22.960	258.720	8.000	33.880	59.640	7.040
	23.000	260.000	8.080	34.640	61.000	7.280
	26.000	281.200	9.240	34.720	62.280	7.480
Statistical test applied						
Dixons low end test	0.295	0.303	0.093	0.446	0.599	0.500
Outlier detected at 95%						
Dixons high end test	0.615	0.546	0.674	0.031	0.186	0.208
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	23.1	259	8.10	33.7	59.6	7.06
Standard Deviation	1.78	14.1	0.68	1.08	2.59	0.36
CV (%)	7.7	5.4	8.3	3.2	4.3	5.1

Silk Cut Extra Mild

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Silk Cut Extra Mild	12.0	122	2.00	16.8	23.6	1.56
Silk Cut Extra Mild	11.8	114	1.96	17.4	23.2	1.20
Silk Cut Extra Mild	11.4	126	2.16	16.2	23.2	1.36
Silk Cut Extra Mild	11.4	117	2.12	15.8	21.4	1.28
Silk Cut Extra Mild	13.8	117	2.32	16.8	22.4	1.28
Mean (ug/cig)	12.1	119	2.11	16.6	22.8	1.34
Standard Deviation	1.01	4.70	0.14	0.60	0.86	0.14
CV (%)	8.4	3.9	6.7	3.6	3.8	10.3

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	11.360	114.240	1.960	15.800	21.440	1.200
	11.440	116.560	2.000	16.200	22.440	1.280
	11.800	116.720	2.120	16.760	23.240	1.280
	11.960	122.400	2.160	16.840	23.240	1.360
	13.840	125.560	2.320	17.360	23.560	1.560
Statistical test applied						
Dixons low end test	0.032	0.205	0.111	0.256	0.472	0.222
Outlier detected at 95%						
Dixons high end test	0.758	0.279	0.444	0.333	0.151	0.556
Outlier detected at 95%	95%					

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	11.6	119	2.11	16.6	22.8	1.34
Standard Deviation	0.29	4.70	0.14	0.60	0.86	0.14
CV (%)	2.5	3.9	6.7	3.6	3.8	10.3

Silk Cut King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Silk Cut King Size	17.4	192	3.92	24.2	38.6	2.68
Silk Cut King Size	14.2	161	3.60	21.8	35.8	2.32
Silk Cut King Size	20.2	211	4.92	29.3	45.2	3.08
Silk Cut King Size	16.9	189	4.52	27.4	43.0	3.16
Silk Cut King Size	19.0	196	4.96	28.9	43.3	3.56
Mean (ug/cig)	17.5	190	4.38	26.3	41.2	2.96
Standard Deviation	2.29	18.1	0.61	3.21	3.86	0.47
CV (%)	13.1	9.5	13.8	12.2	9.4	16.0

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	14.160	161.280	3.600	21.800	35.760	2.320
	16.880	188.760	3.920	24.240	38.600	2.680
	17.440	192.040	4.520	27.400	42.960	3.080
	18.960	195.680	4.920	28.880	43.320	3.160
	20.200	211.080	4.960	29.280	45.160	3.560
Statistical test applied						
Dixons low end test	0.450	0.552	0.235	0.326	0.302	0.290
Outlier detected at 95%						
Dixons high end test	0.205	0.309	0.029	0.053	0.196	0.323
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	17.5	190	4.38	26.3	41.2	2.96
Standard Deviation	2.29	18.1	0.61	3.21	3.86	0.47
CV (%)	13.1	9.5	13.8	12.2	9.4	16.0

Silk Cut Ultra King Size

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Silk Cut Ultra King Size	4.52	45.3	<1.3	5.84	6.92	<0.8
Silk Cut Ultra King Size	4.32	51.6	<1.3	6.36	7.56	<0.8
Silk Cut Ultra King Size	4.84	46.5	<1.3	6.16	7.48	<0.8
Silk Cut Ultra King Size	4.80	51.9	<1.3	6.28	7.68	<0.8
Silk Cut Ultra King Size	4.84	56.2	<1.3	6.60	8.16	<0.8
Mean (µg/cig)	4.66	50.3	<1.3	6.25	7.56	<0.8
Standard Deviation	0.23	4.42	n/a	0.28	0.44	n/a
CV (%)	5.0	8.8	n/a	4.5	5.9	n/a

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	4.320	45.280	0.600	5.840	6.920	0.360
	4.520	46.520	0.720	6.160	7.480	0.360
	4.800	51.640	0.760	6.280	7.560	0.400
	4.840	51.920	0.800	6.360	7.680	0.400
	4.840	56.160	0.920	6.600	8.160	0.400
Statistical test applied						
Dixons low end test	0.385	0.114	0.375	0.421	0.452	0.000
Outlier detected at 95%						
Dixons high end test	0.000	0.390	0.375	0.316	0.387	0.000
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (µg/cig)	4.66	50.3	<1.3	6.25	7.56	<0.8
Standard Deviation	0.23	4.42	n/a	0.28	0.44	n/a
CV (%)	5.0	8.8	n/a	4.5	5.9	n/a

Superkings

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Superkings	39.4	410	12.2	55.3	93.7	9.20
Superkings	36.8	385	10.7	50.3	86.3	8.96
Superkings	39.9	431	13.0	59.7	104.8	11.7
Superkings	35.4	358	11.8	53.4	94.5	10.4
Superkings	34.1	352	9.4	43.4	72.5	7.00
Mean (ug/cig)	37.1	387	11.4	52.4	90.4	9.46
Standard Deviation	2.52	33.67	1.43	6.08	11.97	1.76
CV (%)	6.8	8.7	12.5	11.6	13.2	18.6

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	34.120	351.880	9.360	43.400	72.520	7.000
	35.360	357.600	10.680	50.280	86.320	8.960
	36.760	384.920	11.800	53.360	93.720	9.200
	39.440	409.520	12.200	55.280	94.520	10.400
	39.920	430.880	13.040	59.680	104.840	11.720
Statistical test applied						
Dixons low end test	0.214	0.072	0.359	0.423	0.427	0.415
Outlier detected at 95%						
Dixons high end test	0.083	0.270	0.228	0.270	0.319	0.280
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	37.1	387	11.4	52.4	90.4	9.46
Standard Deviation	2.52	33.7	1.43	6.08	12.0	1.76
CV (%)	6.8	8.7	12.5	11.6	13.2	18.6

Superkings Lights

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Superkings Lights	25.1	253	7.48	37.6	62.8	5.04
Superkings Lights	27.7	270	6.52	37.6	59.6	4.32
Superkings Lights	29.2	283	7.20	41.3	60.2	5.52
Superkings Lights	27.3	275	6.68	35.0	54.8	4.60
Superkings Lights	26.3	250	6.76	36.6	58.8	5.24
Mean (ug/cig)	27.1	266	6.93	37.6	59.2	4.94
Standard Deviation	1.55	14.1	0.40	2.33	2.89	0.48
CV (%)	5.7	5.3	5.8	6.2	4.9	9.8

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	25.080	250.160	6.520	34.960	54.800	4.320
	26.280	253.240	6.680	36.640	58.760	4.600
	27.320	269.760	6.760	37.600	59.600	5.040
	27.720	274.560	7.200	37.600	60.160	5.240
	29.200	283.040	7.480	41.320	62.760	5.520
Statistical test applied						
Dixons low end test	0.291	0.094	0.167	0.264	0.497	0.233
Outlier detected at 95%						
Dixons high end test	0.359	0.258	0.292	0.585	0.327	0.233
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	27.1	266	6.93	37.6	59.2	4.94
Standard Deviation	1.55	14.1	0.40	2.33	2.89	0.48
CV (%)	5.7	5.3	5.8	6.2	4.9	9.8

Superkings Ultra Lights

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Superkings Ultra Lights	15.2	154	2.76	19.9	28.6	2.04
Superkings Ultra Lights	14.1	149	2.88	18.2	27.4	1.92
Superkings Ultra Lights	12.8	121	2.40	16.1	22.4	1.40
Superkings Ultra Lights	13.7	137	2.44	17.2	26.8	2.08
Superkings Ultra Lights	9.9	108	2.00	14.4	23.0	1.68
Mean (ug/cig)	13.1	134	2.50	17.2	25.7	1.82
Standard Deviation	2.02	19.3	0.34	2.09	2.77	0.28
CV (%)	15.4	14.5	13.8	12.2	10.8	15.6

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	9.880	107.680	2.000	14.400	22.400	1.400
	12.800	120.680	2.400	16.120	23.040	1.680
	13.720	136.520	2.440	17.160	26.840	1.920
	14.080	148.640	2.760	18.200	27.360	2.040
	15.240	154.040	2.880	19.920	28.640	2.080
Statistical test applied						
Dixons low end test	0.545	0.280	0.455	0.312	0.103	0.412
Outlier detected at 95%						
Dixons high end test	0.216	0.116	0.136	0.312	0.205	0.059
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	13.1	134	2.50	17.2	25.7	1.82
Standard Deviation	2.02	19.3	0.34	2.09	2.77	0.28
CV (%)	15.4	14.5	13.8	12.2	10.8	15.6

Vogue Superslims

Brand	1,3-butadiene	Isoprene	Acrylonitrile	Benzene	Toluene	Styrene
Vogue Superslims	18.4	187	6.00	23.1	40.0	4.60
Vogue Superslims	19.3	210	6.44	25.1	44.1	5.36
Vogue Superslims	19.1	212	6.56	25.1	45.8	5.64
Vogue Superslims	19.6	210	6.68	24.9	43.0	5.12
Vogue Superslims	18.0	197	6.48	23.0	41.2	4.88
Mean (ug/cig)	18.9	203	6.43	24.3	42.8	5.12
Standard Deviation	0.65	10.7	0.26	1.08	2.30	0.40
CV (%)	3.5	5.3	4.0	4.4	5.4	7.9

Outlier Test

Dixons outlier test was applied to the above data

Data sorted	18.000	187.280	6.000	23.040	40.040	4.600
	18.440	196.880	6.440	23.120	41.160	4.880
	19.120	209.880	6.480	24.920	43.000	5.120
	19.280	210.200	6.560	25.080	44.080	5.360
	19.600	211.640	6.680	25.120	45.840	5.640
Statistical test applied						
Dixons low end test	0.275	0.394	0.647	0.038	0.193	0.269
Outlier detected at 95%						
Dixons high end test	0.200	0.059	0.176	0.019	0.303	0.269
Outlier detected at 95%						

If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier

Summary of Results						
Mean (ug/cig)	18.9	203	6.43	24.3	42.8	5.12
Standard Deviation	0.65	10.7	0.26	1.08	2.30	0.40
CV (%)	3.5	5.3	4.0	4.4	5.4	7.9

Appendix 1: Technical opinions and interpretations

The following comments are of a technical nature about the method, validation data and results obtained during the study. They are designed to help put the results in context.

Trapping system

The method used is designed to trap all the volatiles and also styrene. Styrene is somewhere between a volatile organic compound and a semi volatile compound. Therefore, to ensure 100% trapping efficiency for the styrene, the pad is added to the bubbler solution.

It was observed that toluene yields are slightly higher when analysing the 'combined trapping' solution compared to analysis of the bubbler solution. Investigations showed that a small amount of the toluene is being trapped by the pad. This is not unsurprising as toluene has a boiling point of 110°C [*] and is the 'volatile' with the highest boiling point.

As the trap consists of a standard Cambridge filter pad plus a Grade 0 sinter bubbler containing methanol at a temperature of ≈ - 70°C there will be a small effect on the puff profile.

Measurement uncertainty

Five of the six VOCS are liquids at room temperature. It is therefore relatively easy to prepare standard solutions with a reasonable degree of accuracy. 1,3-butadiene is a gas and the procedure to prepare the calibration standard is more complex which means that there will be a larger measurement uncertainty associated with this analyte concentration.

Acrylonitrile and styrene are present at much lower concentrations in the cigarette smoke than the other volatiles so there will be a larger measurement uncertainty associated with the yields for these two analytes.

[*] Aldrich catalogue

Appendix 2: Selected smoke constituents for UK study

Type	Specific analyte(s)
	Nicotine free dry particulate matter
	nicotine
	carbon monoxide
	ammonia
	hydrogen cyanide
	nitrogen monoxide
Aromatic amines	1-aminonaphthalene
	2-aminonaphthalene
	3-aminobiphenyl
	4-aminobiphenyl
Aldehydes & Ketones	formaldehyde
	acetaldehyde
	acetone
	acrolein
	propionaldehyde
	crotonaldehyde
	methyl ethyl ketone
	butyraldehyde
Nitrosamines	N-nitrosonornicotine (nnn)
	N-nitrosoanatabine (nat)
	N-nitrosanabasine (nab)
	4-(N-Methyl-N-nitrosamino)-1-(3-pyridinyl)-1-butanone (nnk)
Phenols	phenol
	catechol
	hydroquinone
	resorcinol
	ortho-cresol
	meta-cresol
	para-cresol
Polycyclic aromatic hydrocarbons	benzo[a]pyrene
Semi Volatile Compounds	pyridine
	quinoline
	styrene
Trace Metals	arsenic
	cadmium
	chromium
	lead
	mercury
	nickel
	selenium
Volatile Organic Compounds	benzene
	toluene
	1,3-butadiene
	isoprene
	acrylonitrile

Appendix 3: Selected abbreviations and terms used in this report

Term/Definition	Meaning
Channel	The channel of the smoking machine that the cigarette was smoked on
CO	Carbon Monoxide
CO(%v/v)	Percentage volume of carbon monoxide in the total volume of mainstream smoke corrected for any clearing puffs
Overwrap	The wrapper applied to the mouth end of the cigarette
Run	The smoking run that the cigarette was smoked in
TPM	Total Particulate Matter
Yield	The concentration of analyte measured in the smoke (normally per cigarette)
°C	Degree Celsius
ng	Nanogram
μg	Microgram
mg	Milligram
mL	Millilitre
L	Litre
mm	Millimetre
cig^{-1}	per cigarette
VOC	Volatile organic compound

Appendix 4: Description of brands (sold in the UK - Nov/Dec 2001) used in the benchmark study

Brand	Length (mm)	Butt length used for the study (mm)	Description
Benson & Hedges King Size	84	28	filter – typical UK blend
Berkeley Superkings	99	33	filter – typical UK blend
Camel Ultra Lights	84	35	filter – typical American blend
Consulate Menthol	84	35	filter – typical UK blend – menthol
Gitanes Caporal Filter	70	23	filter – dark air cured blend
Lambert & Butler King Size	84	30	filter – typical UK blend
Lambert & Butler Lights King Size	84	34 (overwrap + 3 mm)	filter – typical UK blend
Lambert & Butler Ultra Lights	84	34 (overwrap + 3 mm)	filter – typical UK blend
Marlboro King Size	84	29	filter – typical American blend
Marlboro Lights King Size	84	35	filter – typical American blend
Mayfair Lights King Size	84	28	filter – typical UK blend
Mayfair Menthol King Size	84	33	filter – typical UK blend – menthol
Red Band Lights King Size	84	33	filter – typical UK blend
Regal Filter	71	26	filter – typical UK blend
Regal King Size	84	30	filter – typical UK blend
Rothman Royals 120s	120	38	filter – typical UK blend
Rothman Royals King Size	84	30	filter – typical UK blend
Senior Service	69	23	plain - typical UK blend
Silk Cut Extra Mild	84	33	filter – typical UK blend
Silk Cut King Size	84	28	filter – typical UK blend
Silk Cut Ultra King Size	84	33 (overwrap + 3 mm)	filter – typical UK blend
Superkings	99	34	filter – typical UK blend
Superkings Lights	99	33	filter – typical UK blend
Superkings Ultra Lights	99	34	filter – typical UK blend
Vogue Superslims	99	38	filter – typical American blend