

CONFIDENTIAL

UK SMOKE CONSTITUENTS STUDY

Part 12: Determination of Polycyclic Aromatic Amines Yields in Cigarette Smoke

Commissioned by:
Tobacco Manufacturers Association
55 Tufton Street
London SW1P 3QL

Report Number 012/2003

March 2003

Prepared by Pete Houlgate
Arista Laboratories Europe

Contact Point: Pete Houlgate

Tel: 020 8943 7375

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UK SMOKE CONSTITUENTS TESTING STUDY PROTOCOL

Determination of Polycyclic Aromatic Amines 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, polycyclic aromatic amines 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 polycyclic aromatic amines: 1-naphthylamine, 2-naphthylamine, 3-aminobiphenyl, 4-aminobiphenyl.

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 $22 \pm 1^\circ\text{C}$ and $60 \pm 3\%$ relative humidity¹ for a minimum of 48 hours but not exceeding 10 days.

Butt marking was done in accordance with ISO butt length specifications². 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 $22 \pm 2^\circ\text{C}$ and $60 \pm 5\%$ relative humidity¹.

4. Smoking

The cigarettes were smoked on 20 channel linear smoking machines.

5 cigarettes were sub-sampled from packets chosen on a random basis and smoked to determine the yield of PAAs 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 conditions³ for smoking cigarettes were used. The smoking machine puffing parameters were $35 \pm 0.3 \text{ cm}^3$ 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 PAAs in mainstream tobacco smoke by GC-MS. For each sample, five conditioned cigarettes are smoked on a linear 20 channel smoking machine. The total particulate matter in the mainstream smoke is trapped on a Cambridge filter pad. Each pad is transferred to conical flasks and 25 mL of 5% HCl added along with an internal standard. The flasks are shaken for half an hour to extract the PAAs. The extract solutions are filtered into separating funnels. Dichlormethane is added to each flask, the contents shaken, the layers allowed to separate and the DCM layer discarded. Sodium hydroxide solution is added to make the solution basic and the PAAs back extracted into DCM. The extract is derivatised with pentafluoropropionic acid anhydride and the sample 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 PAA yield versus carbon monoxide (Page 7 to 10) and each PAA yield versus NFDPM (Page 11 to 14) 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 (0.14 to 0.02 ng cig^{-1} depending on the PAA).

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 PAAs 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.

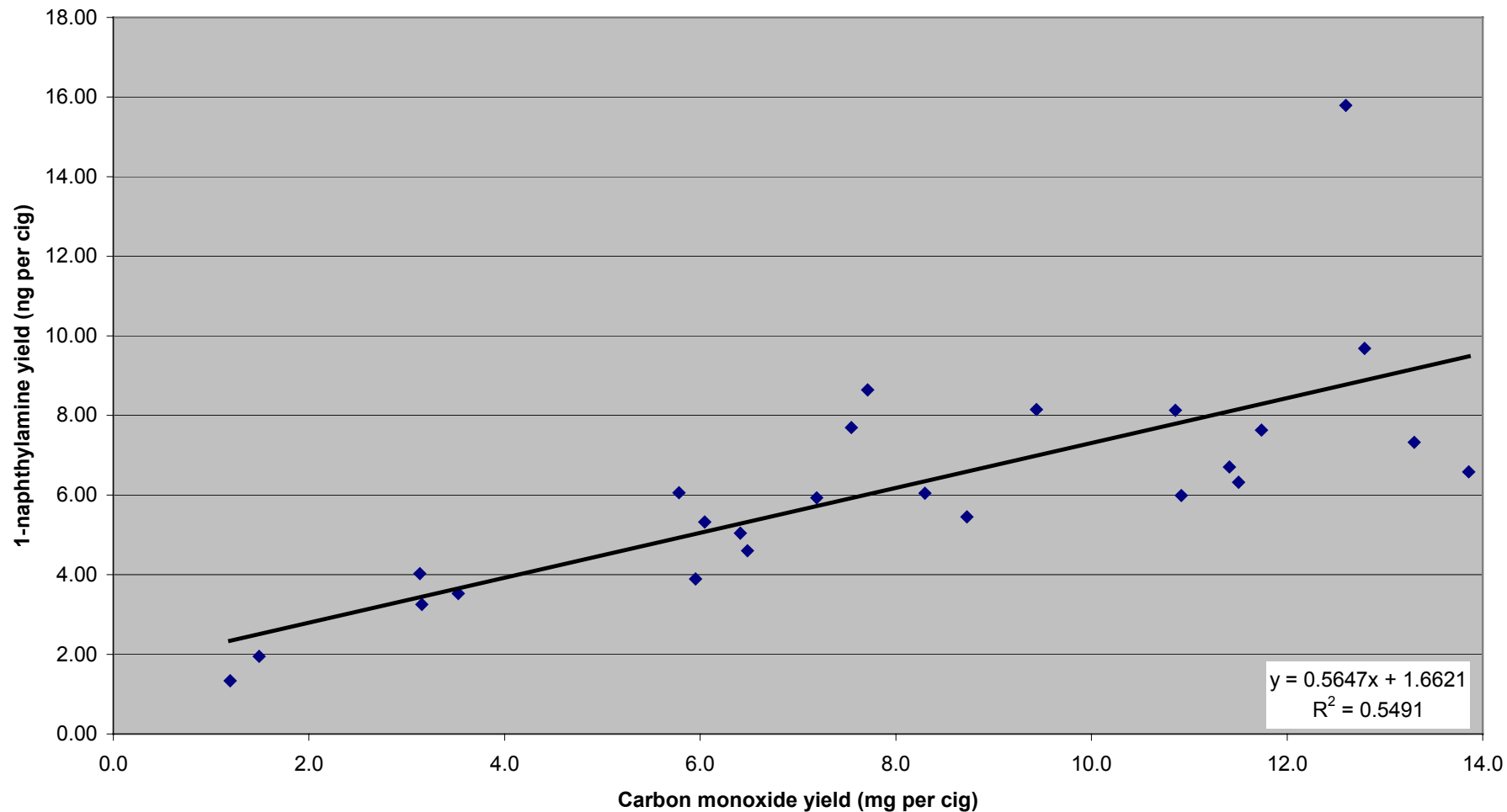
Tables

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

	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl	NFDPM	Carbon Monoxide
	ng/cig	ng/cig	ng/cig	ng/cig	mg/cig	mg/cig
1R4F	8.74	6.71	1.66	1.30	9.06	12.26
1R5F	2.04	1.57	0.50	0.42	1.92	3.36
Benson & Hedges King Size	7.63	5.15	1.11	0.86	10.30	11.74
Berkely Superkings	6.32	4.56	1.01	0.80	9.69	11.50
Camel Ultra Lights	4.03	2.24	0.58	0.51	3.09	3.13
Consulate Menthol	6.05	3.50	0.85	0.63	7.06	8.30
Gitanes Caporal Filter	15.8	10.3	2.87	2.06	12.00	12.60
Lambert & Butler King Size	7.33	3.81	0.99	0.71	11.93	13.30
Lambert & Butler Lights King Size	4.60	2.77	0.72	0.54	5.24	6.48
Lambert & Butler Ultra Lights	1.95	1.36	0.33	0.28	1.61	1.49
Marlboro King Size	9.69	5.55	1.54	1.21	12.69	12.79
Marlboro Lights King Size	5.93	4.22	0.90	0.73	6.10	7.19
Mayfair Lights King Size	5.45	3.94	0.92	0.74	7.23	8.73
Mayfair Menthol King Size	3.89	2.65	0.62	0.49	4.65	5.95
Red Band Lights King Size	5.04	2.85	0.71	0.57	5.55	6.41
Regal Filter	5.99	3.26	0.81	0.59	10.65	10.92
Regal King Size	6.58	3.38	0.84	0.63	11.96	13.86
Rothman Royals 120s	8.15	4.79	1.16	0.87	10.39	9.44
Rothman Royals King Size	8.13	5.05	1.08	0.81	11.00	10.86
Senior Service	8.64	4.93	1.05	0.88	11.92	7.71
Silk Cut Extra Mild	3.25	1.89	0.52	0.41	2.67	3.16
Silk Cut King Size	6.06	3.16	0.89	0.71	5.62	5.78
Silk Cut Ultra King Size	1.34	0.86	0.22	0.21	1.01	1.20
Superkings	6.70	4.02	0.92	0.77	10.71	11.41
Superkings Lights	7.70	4.58	0.97	0.78	8.09	7.54
Superkings Ultra Lights	3.53	2.05	0.57	0.47	3.08	3.53
Vogue Superslims	5.32	2.61	0.69	0.65	7.38	6.05

Regression analysis of 1-naphthylamine versus carbon monoxide

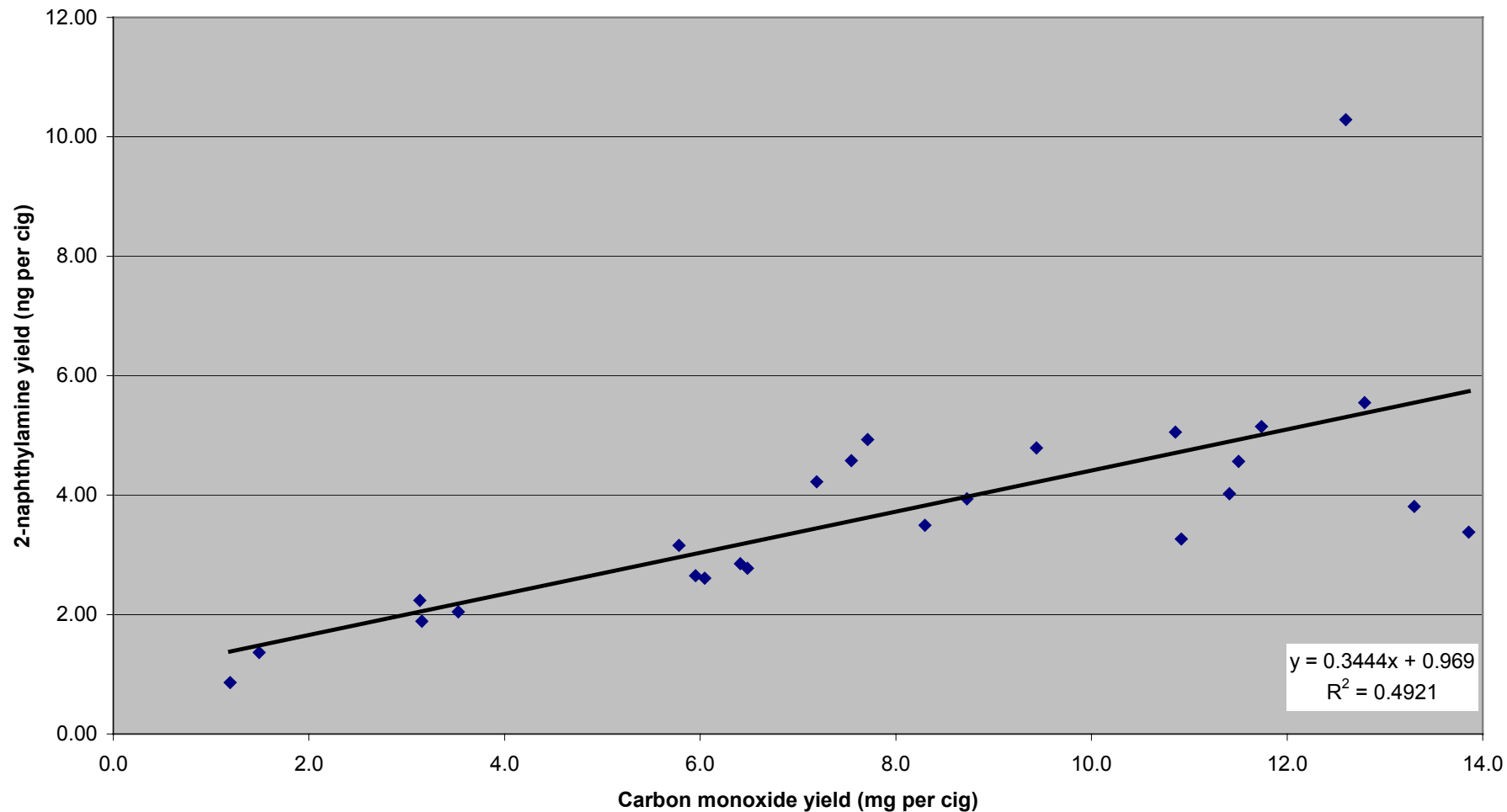
Regression analysis of 1-naphthylamine versus carbon monoxide for 25 cigarette brands



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

Regression analysis of 2-naphthylamine versus carbon monoxide

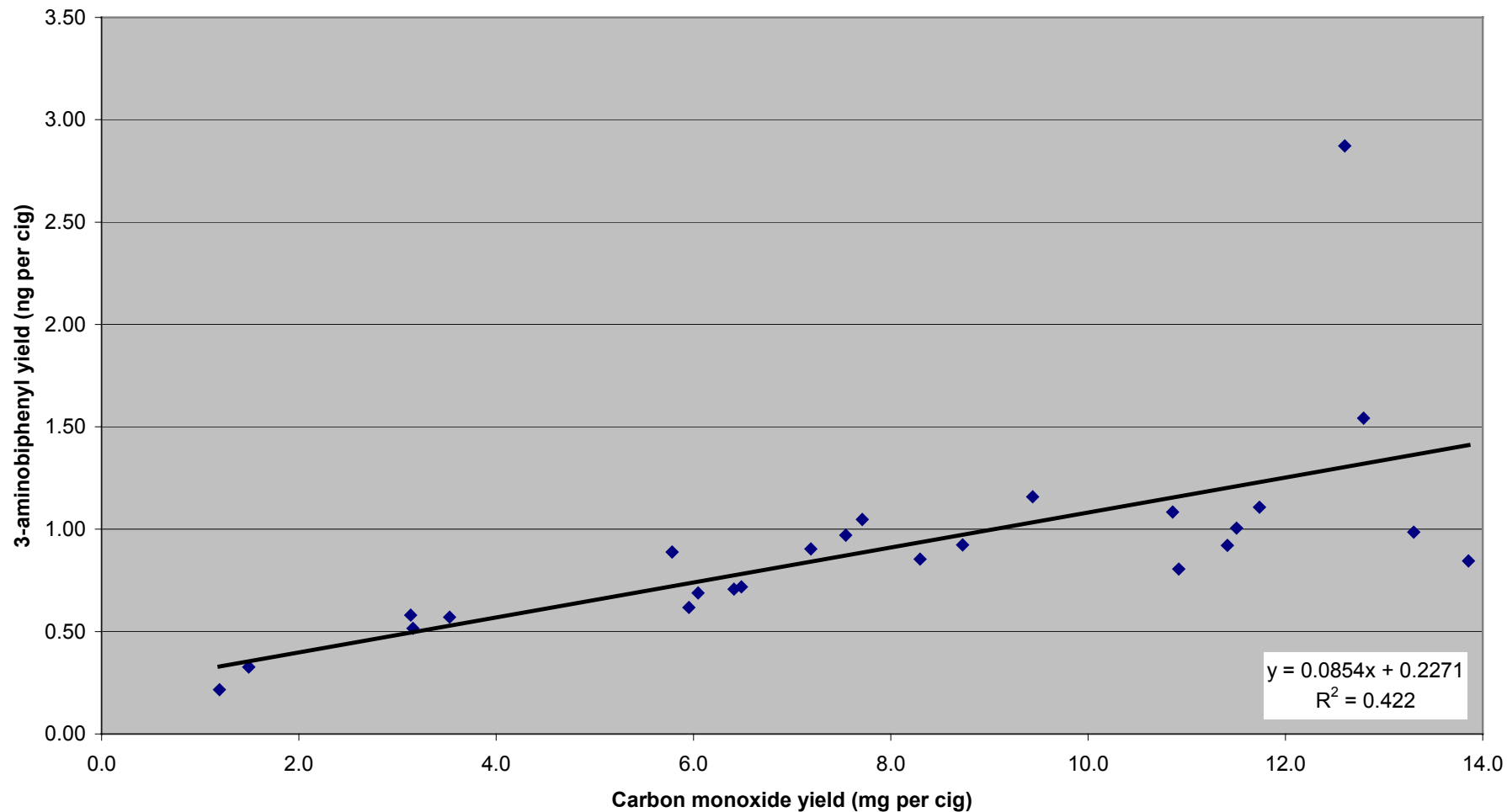
Regression analysis of 2-naphthylamine versus carbon monoxide for 25 cigarette brands



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

Regression analysis of 3-aminobiphenyl versus carbon monoxide

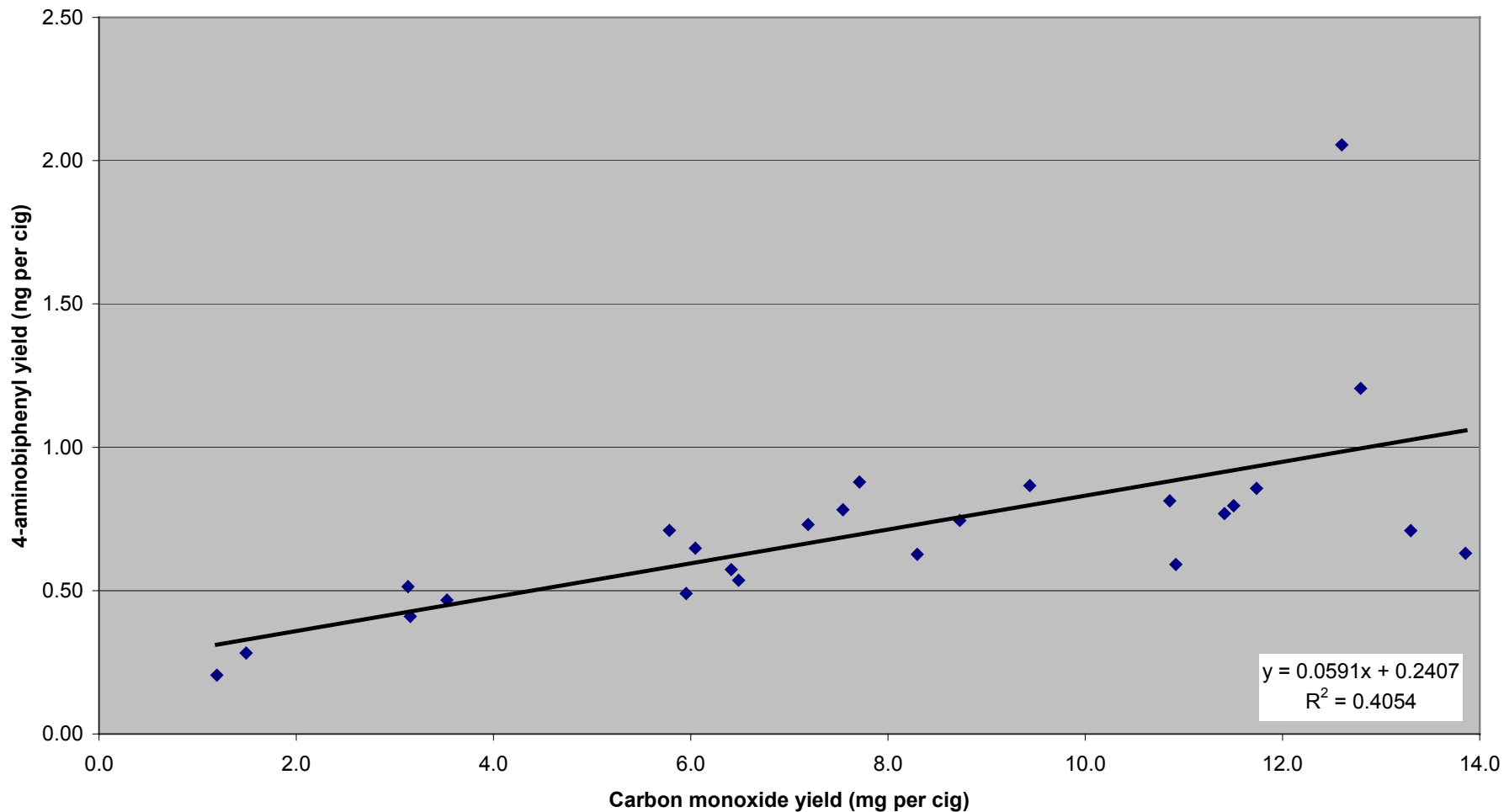
Regression analysis of 3-aminobiphenyl versus carbon monoxide for 25 cigarette brands



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

Regression analysis of 4-aminobiphenyl versus carbon monoxide

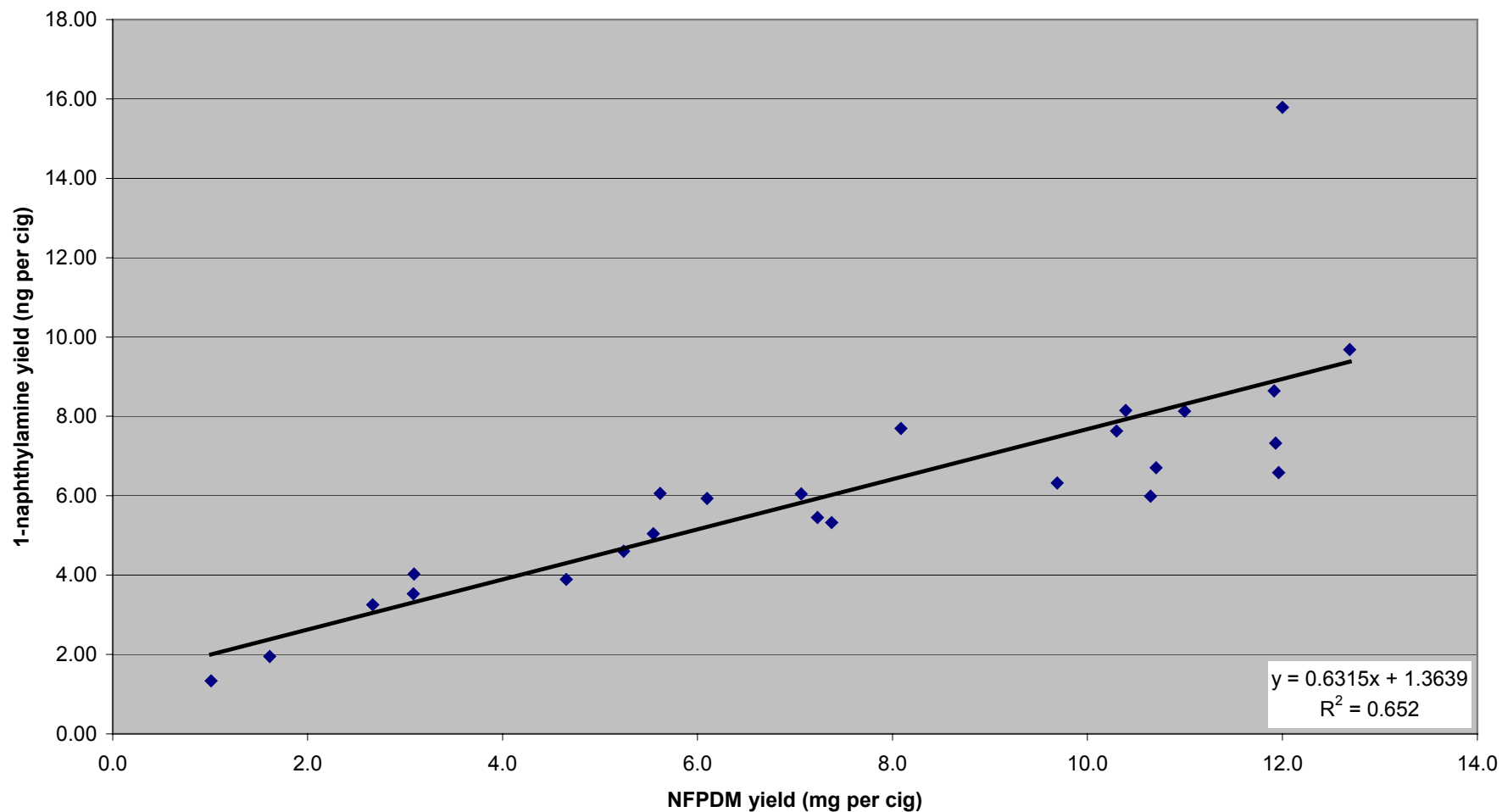
Regression analysis of 4-aminobiphenyl versus carbon monoxide for 25 cigarette brands



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

Regression analysis of 1-naphthylamine versus NFDPM

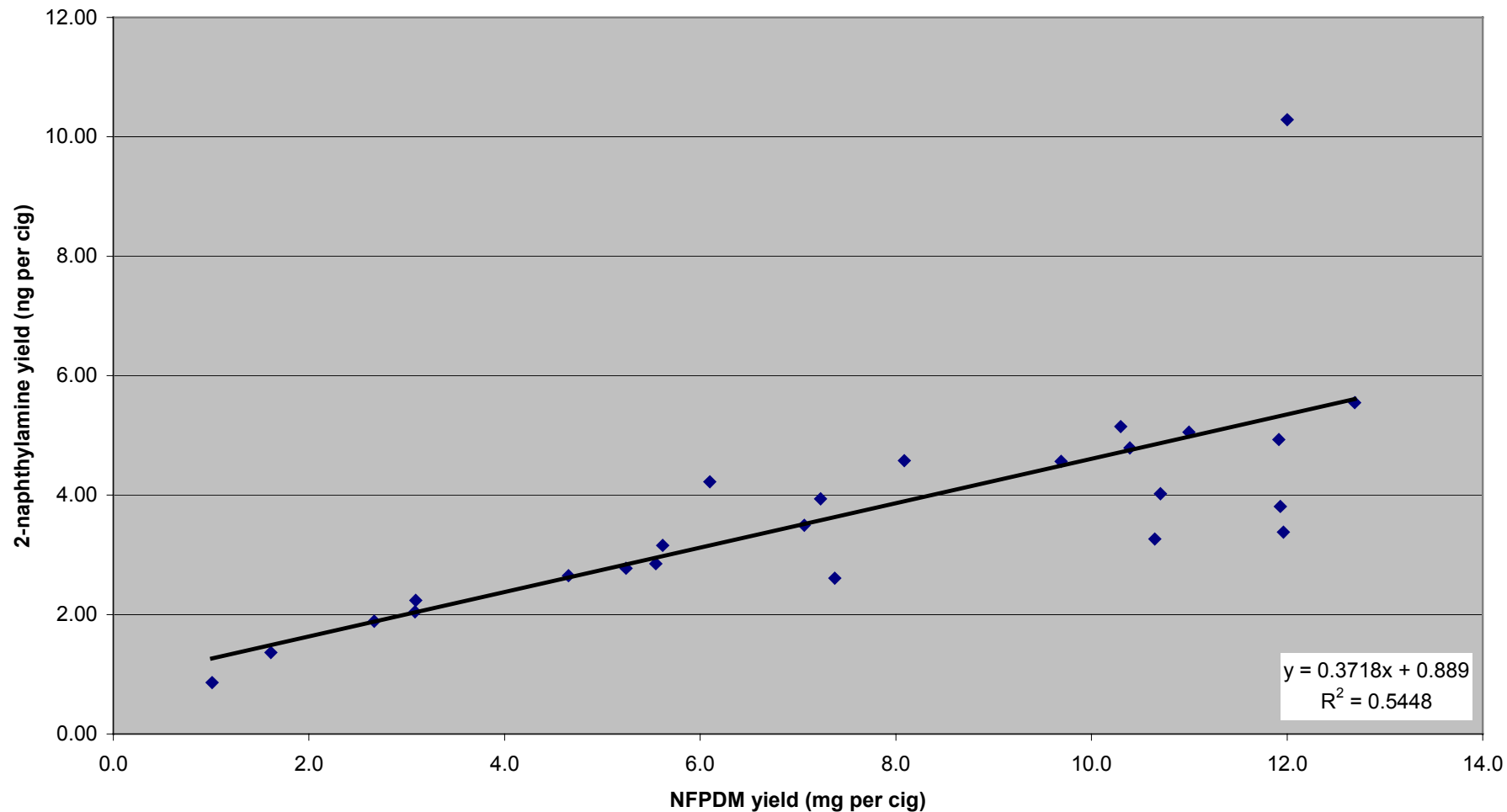
Regression analysis of 1-naphthylamine versus NFDPM for 25 cigarette brands



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

Regression analysis of 2-naphthylamine versus NFDPM

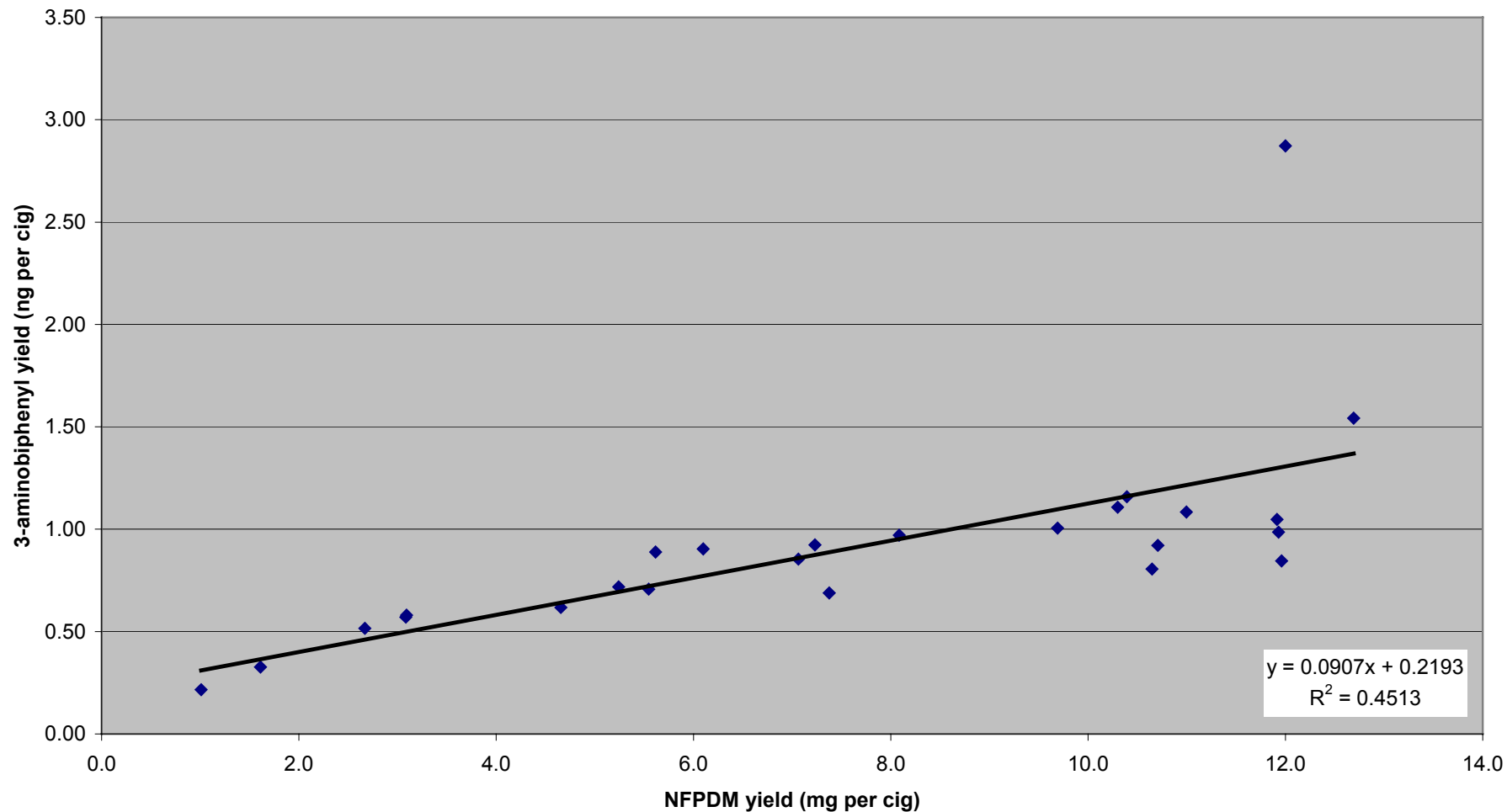
Regression analysis of 2-naphthylamine versus NFDPM for 25 cigarette brands



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

Regression analysis of 3-aminobiphenyl versus NFDPM

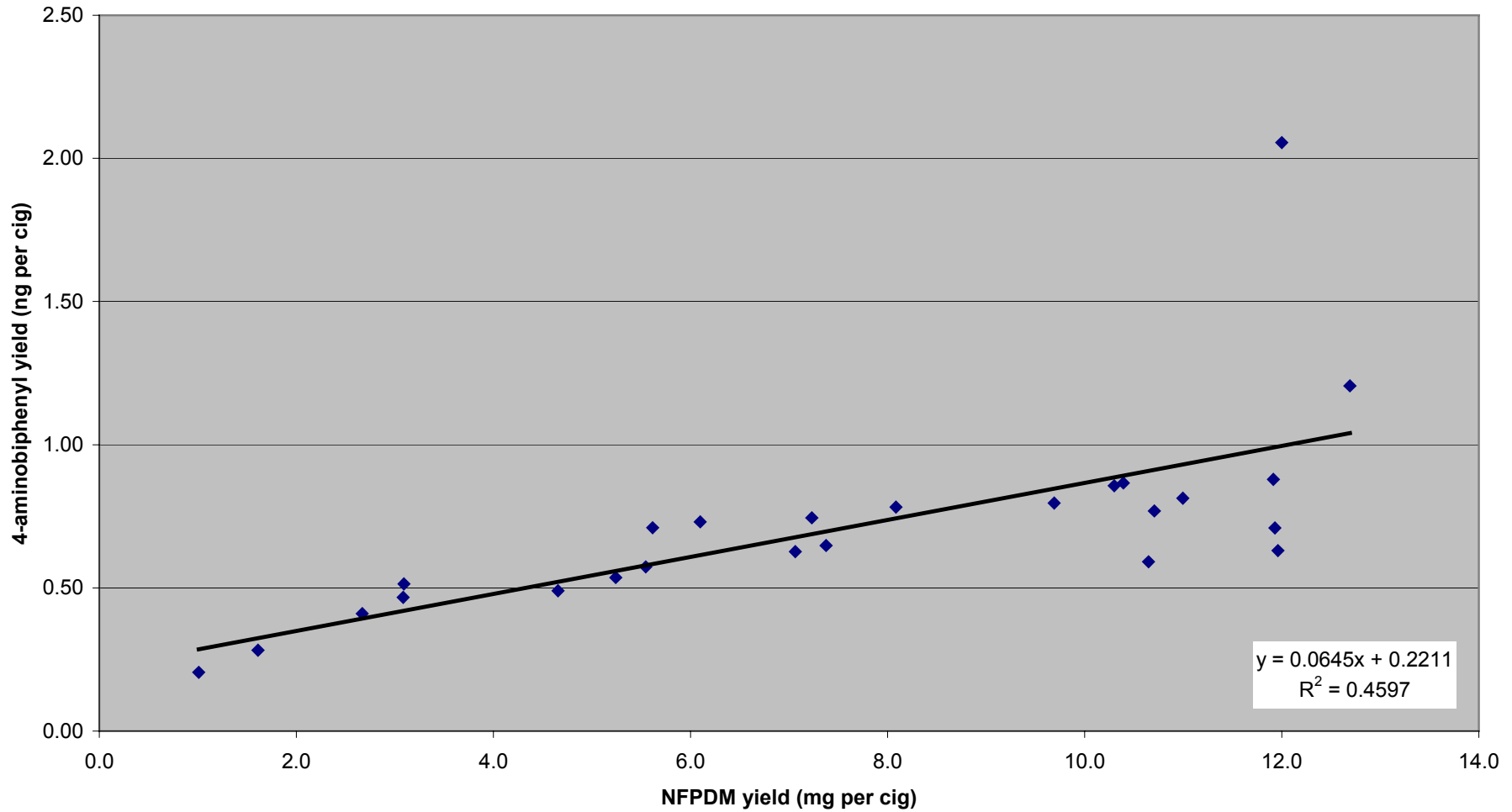
Regression analysis of 3-aminobiphenyl versus NFDPM for 25 cigarette brands



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

Regression analysis of 4-aminobiphenyl versus NFDPM

Regression analysis of 4-aminobiphenyl versus NFDPM for 25 cigarette brands



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

1R4F

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
1R4F	8.79	6.74	1.70	1.34
1R4F	8.99	7.10	1.81	1.37
1R4F	7.62	5.56	1.44	1.13
1R4F	10.3	7.41	1.71	1.41
1R4F	8.03	6.72	1.61	1.22
Mean (ng/cig)	8.74	6.71	1.66	1.30
Standard Deviation	1.01	0.7	0.14	0.12
CV (%)	11.6	10.4	8.3	8.9
Outlier Test				
Dixons outlier test was applied to the above data				
Data sorted	7.622	5.562	1.444	1.134
	8.034	6.724	1.614	1.220
	8.788	6.740	1.698	1.336
	8.994	7.096	1.708	1.374
	10.256	7.408	1.812	1.412
Statistical test applied				
Dixons low end test	0.156	0.629	0.462	0.309
Outlier detected at 95%				
Dixons high end test	0.479	0.169	0.283	0.137
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	8.74	6.71	1.66	1.30
Standard Deviation	1.01	0.70	0.14	0.12
CV (%)	11.6	10.4	8.3	8.9

1R5F

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
1R5F	2.31	1.70	0.55	0.45
1R5F	1.97	1.57	0.46	0.41
1R5F	1.67	1.65	0.52	0.41
1R5F	2.35	1.50	0.44	0.41
1R5F	1.91	1.45	0.53	0.44
Mean (ng/cig)	2.04	1.57	0.50	0.42
Standard Deviation	0.29	0.10	0.05	0.02
CV (%)	14.1	6.6	9.5	4.3
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	1.670	1.446	0.440	0.410
	1.910	1.500	0.460	0.412
	1.972	1.570	0.522	0.414
	2.310	1.652	0.534	0.438
	2.354	1.698	0.546	0.450
Statistical test applied				
Dixons low end test	0.351	0.214	0.189	0.050
Outlier detected at 95%				
Dixons high end test	0.064	0.183	0.113	0.300
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	2.04	1.57	0.50	0.42
Standard Deviation	0.29	0.10	0.05	0.02
CV (%)	14.1	6.6	9.5	4.3

Benson & Hedges King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Benson & Hedges King Size	7.09	4.53	0.96	0.61
Benson & Hedges King Size	6.68	4.95	1.03	0.76
Benson & Hedges King Size	8.86	5.47	1.09	0.95
Benson & Hedges King Size	8.35	5.57	1.26	0.97
Benson & Hedges King Size	7.18	5.22	1.21	0.99
Mean (ng/cig)	7.63	5.15	1.11	0.86
Standard Deviation	0.93	0.42	0.13	0.16
CV (%)	12.2	8.2	11.4	19.1
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	6.676	4.530	0.956	0.612
	7.090	4.946	1.026	0.764
	7.182	5.220	1.088	0.948
	8.352	5.472	1.208	0.972
	8.864	5.572	1.260	0.986
Statistical test applied				
Dixons low end test	0.189	0.399	0.230	0.406
Outlier detected at 95%				
Dixons high end test	0.234	0.096	0.171	0.037
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	7.63	5.15	1.11	0.86
Standard Deviation	0.93	0.42	0.13	0.16
CV (%)	12.2	8.2	11.4	19.1

Berkely Superkings

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Berkely Superkings	5.79	3.74	0.80	0.63
Berkely Superkings	5.51	3.91	0.87	0.66
Berkely Superkings	7.19	5.49	1.20	0.97
Berkely Superkings	6.34	5.02	1.12	0.86
Berkely Superkings	6.76	4.65	1.05	0.86
Mean (ng/cig)	6.32	4.56	1.01	0.80
Standard Deviation	0.69	0.74	0.17	0.14
CV (%)	10.9	16.2	16.6	18.1
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	5.510	3.742	0.796	0.632
	5.792	3.910	0.874	0.662
	6.342	4.654	1.046	0.856
	6.758	5.020	1.116	0.864
	7.192	5.494	1.198	0.968
Statistical test applied				
Dixons low end test	0.168	0.096	0.194	0.089
Outlier detected at 95%				
Dixons high end test	0.258	0.271	0.204	0.310
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	6.32	4.56	1.01	0.80
Standard Deviation	0.69	0.74	0.17	0.14
CV (%)	10.9	16.2	16.6	18.1

Camel Ultra Lights

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Camel Ultra Lights	3.71	2.10	0.54	0.47
Camel Ultra Lights	3.70	2.23	0.59	0.52
Camel Ultra Lights	4.46	2.56	0.62	0.54
Camel Ultra Lights	4.13	2.19	0.56	0.54
Camel Ultra Lights	4.15	2.12	0.60	0.50
Mean (ng/cig)	4.03	2.24	0.58	0.51
Standard Deviation	0.32	0.19	0.03	0.03
CV (%)	8.0	8.3	4.9	5.9
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	3.702	2.100	0.542	0.468
	3.714	2.116	0.564	0.502
	4.128	2.188	0.586	0.518
	4.146	2.226	0.596	0.540
	4.458	2.558	0.616	0.542
Statistical test applied				
Dixons low end test	0.016	0.035	0.297	0.459
Outlier detected at 95%				
Dixons high end test	0.413	0.725	0.270	0.027
Outlier detected at 95%		95%		
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	4.03	2.16	0.58	0.51
Standard Deviation	0.32	0.06	0.03	0.03
CV (%)	8.0	2.8	4.9	5.9

Consulate Menthol

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Consulate Menthol	6.25	3.59	0.78	0.64
Consulate Menthol	5.08	3.64	0.81	0.62
Consulate Menthol	6.04	3.40	0.86	0.63
Consulate Menthol	6.36	3.58	0.74	0.57
Consulate Menthol	6.49	3.27	1.08	0.67
Mean (ng/cig)	6.05	3.50	0.85	0.63
Standard Deviation	0.56	0.15	0.13	0.04
CV (%)	9.3	4.4	15.5	5.7
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	5.084	3.270	0.744	0.572
	6.044	3.404	0.778	0.620
	6.252	3.578	0.812	0.632
	6.358	3.588	0.858	0.640
	6.492	3.640	1.078	0.670
Statistical test applied				
Dixons low end test	0.682	0.362	0.102	0.490
Outlier detected at 95%				
Dixons high end test	0.095	0.141	0.659	0.306
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	6.05	3.50	0.85	0.63
Standard Deviation	0.56	0.15	0.13	0.04
CV (%)	9.3	4.4	15.5	5.7

Gitanes Caporal Filter

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Gitanes Caporal Filter	16.1	9.87	2.64	1.86
Gitanes Caporal Filter	16.4	9.52	2.74	1.83
Gitanes Caporal Filter	16.4	11.7	3.32	2.41
Gitanes Caporal Filter	14.8	10.4	2.91	2.11
Gitanes Caporal Filter	15.3	10.0	2.76	2.06
Mean (ng/cig)	15.8	10.3	2.87	2.06
Standard Deviation	0.72	0.83	0.27	0.23
CV (%)	4.6	8.0	9.4	11.3
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	14.750	9.516	2.636	1.832
	15.334	9.868	2.736	1.864
	16.088	10.030	2.760	2.062
	16.350	10.350	2.908	2.106
	16.404	11.664	3.322	2.412
Statistical test applied				
Dixons low end test	0.353	0.164	0.146	0.055
Outlier detected at 95%				
Dixons high end test	0.033	0.612	0.603	0.528
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	15.8	10.3	2.87	2.06
Standard Deviation	0.72	0.83	0.27	0.23
CV (%)	4.6	8.0	9.4	11.3

Lambert & Butler King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Lambert & Butler King Size	6.93	4.51	1.26	0.98
Lambert & Butler King Size	7.16	4.19	0.96	0.69
Lambert & Butler King Size	7.15	3.17	0.88	0.60
Lambert & Butler King Size	7.70	3.65	0.92	0.63
Lambert & Butler King Size	7.69	3.52	0.90	0.64
Mean (ng/cig)	7.33	3.81	0.99	0.71
Standard Deviation	0.35	0.54	0.16	0.15
CV (%)	4.8	14.1	15.8	21.8
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	6.930	3.172	0.880	0.604
	7.146	3.520	0.902	0.634
	7.162	3.648	0.922	0.636
	7.694	4.192	0.964	0.694
	7.700	4.514	1.258	0.980
Statistical test applied				
Dixons low end test	0.281	0.259	0.058	0.080
Outlier detected at 95%				
Dixons high end test	0.008	0.240	0.778	0.761
Outlier detected at 95%			95%	95%
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	7.33	3.81	0.92	0.64
Standard Deviation	0.35	0.54	0.04	0.04
CV (%)	4.8	14.1	3.9	5.9

Lambert & Butler Lights King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Lambert & Butler Lights King Size	5.65	3.01	0.82	0.55
Lambert & Butler Lights King Size	4.55	2.92	0.67	0.50
Lambert & Butler Lights King Size	4.51	2.79	0.67	0.47
Lambert & Butler Lights King Size	4.46	2.77	0.73	0.52
Lambert & Butler Lights King Size	3.84	2.38	0.70	0.64
Mean (ng/cig)	4.60	2.77	0.72	0.54
Standard Deviation	0.65	0.24	0.06	0.06
CV (%)	14.2	8.7	9.0	11.8
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	3.844	2.378	0.666	0.470
	4.460	2.770	0.672	0.504
	4.506	2.786	0.696	0.522
	4.550	2.918	0.734	0.548
	5.652	3.012	0.824	0.638
Statistical test applied				
Dixons low end test	0.341	0.618	0.038	0.202
Outlier detected at 95%				
Dixons high end test	0.610	0.148	0.570	0.536
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	4.60	2.77	0.72	0.54
Standard Deviation	0.65	0.24	0.06	0.06
CV (%)	14.2	8.7	9.0	11.8

Lambert & Butler Ultra Lights

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Lambert & Butler Ultra Lights	2.08	1.54	0.34	0.30
Lambert & Butler Ultra Lights	2.07	1.42	0.34	0.28
Lambert & Butler Ultra Lights	2.03	1.46	0.35	0.29
Lambert & Butler Ultra Lights	1.74	1.37	0.34	0.31
Lambert & Butler Ultra Lights	1.82	1.02	0.26	0.24
Mean (ng/cig)	1.95	1.36	0.33	0.28
Standard Deviation	0.16	0.20	0.04	0.03
CV (%)	8.0	14.6	10.9	9.5
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	1.740	1.024	0.264	0.238
	1.824	1.374	0.336	0.282
	2.028	1.424	0.338	0.286
	2.072	1.462	0.340	0.298
	2.082	1.538	0.354	0.308
Statistical test applied				
Dixons low end test	0.246	0.681	0.800	0.629
Outlier detected at 95%			95%	
Dixons high end test	0.029	0.148	0.156	0.143
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ug/cig)	1.95	1.36	0.34	0.28
Standard Deviation	0.16	0.20	0.01	0.03
CV (%)	8.0	14.6	2.4	9.5

Marlboro King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Marlboro King Size	9.38	6.50	1.65	1.41
Marlboro King Size	8.14	5.35	1.64	1.18
Marlboro King Size	9.87	5.43	1.59	1.33
Marlboro King Size	10.6	5.13	1.36	1.00
Marlboro King Size	10.4	5.34	1.48	1.10
Mean (ng/cig)	9.69	5.55	1.54	1.21
Standard Deviation	0.99	0.54	0.12	0.17
CV (%)	10.2	9.7	8.0	13.7
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	8.138	5.134	1.356	1.002
	9.382	5.336	1.482	1.104
	9.870	5.346	1.586	1.182
	10.444	5.432	1.642	1.332
	10.598	6.496	1.646	1.408
Statistical test applied				
Dixons low end test	0.506	0.148	0.434	0.251
Outlier detected at 95%				
Dixons high end test	0.063	0.781	0.014	0.187
Outlier detected at 95%				
95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	9.69	5.31	1.54	1.21
Standard Deviation	0.99	0.13	0.12	0.17
CV (%)	10.2	2.4	8.0	13.7

Marlboro Lights King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Marlboro Lights King Size	6.38	4.25	0.87	0.70
Marlboro Lights King Size	5.82	4.03	0.81	0.66
Marlboro Lights King Size	6.35	4.04	0.86	0.62
Marlboro Lights King Size	5.48	4.31	0.99	0.83
Marlboro Lights King Size	5.60	4.49	0.98	0.84
Mean (ng/cig)	5.93	4.22	0.90	0.73
Standard Deviation	0.42	0.20	0.08	0.10
CV (%)	7.1	4.6	9.0	13.3
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	5.484	4.028	0.810	0.624
	5.604	4.040	0.860	0.662
	5.822	4.254	0.872	0.702
	6.352	4.306	0.984	0.826
	6.384	4.494	0.994	0.840
Statistical test applied				
Dixons low end test	0.133	0.026	0.272	0.176
Outlier detected at 95%				
Dixons high end test	0.036	0.403	0.054	0.065
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	5.93	4.22	0.90	0.73
Standard Deviation	0.42	0.20	0.08	0.10
CV (%)	7.1	4.6	9.0	13.3

Mayfair Lights King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Mayfair Lights King Size	4.70	3.80	0.93	0.67
Mayfair Lights King Size	5.02	3.50	0.89	0.74
Mayfair Lights King Size	6.48	4.55	0.99	0.82
Mayfair Lights King Size	6.28	4.79	1.03	0.90
Mayfair Lights King Size	4.78	3.05	0.78	0.59
Mean (ng/cig)	5.45	3.94	0.92	0.74
Standard Deviation	0.86	0.72	0.10	0.12
CV (%)	15.7	18.4	10.3	16.5
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	4.704	3.052	0.782	0.592
	4.782	3.500	0.890	0.670
	5.016	3.798	0.930	0.736
	6.278	4.546	0.990	0.822
	6.480	4.794	1.028	0.904
Statistical test applied				
Dixons low end test	0.044	0.257	0.439	0.250
Outlier detected at 95%				
Dixons high end test	0.114	0.142	0.154	0.263
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	5.45	3.94	0.92	0.74
Standard Deviation	0.86	0.72	0.10	0.12
CV (%)	15.7	18.4	10.3	16.5

Mayfair Menthol King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Mayfair Menthol King Size	4.00	2.70	0.61	0.50
Mayfair Menthol King Size	3.90	2.74	0.64	0.48
Mayfair Menthol King Size	3.88	2.73	0.63	0.47
Mayfair Menthol King Size	4.23	2.94	0.68	0.59
Mayfair Menthol King Size	3.45	2.14	0.54	0.41
Mean (ng/cig)	3.89	2.65	0.62	0.49
Standard Deviation	0.28	0.30	0.05	0.07
CV (%)	7.2	11.4	8.3	13.6
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	3.454	2.138	0.536	0.406
	3.882	2.700	0.614	0.474
	3.904	2.730	0.626	0.484
	4.004	2.740	0.638	0.496
	4.228	2.942	0.676	0.592
Statistical test applied				
Dixons low end test	0.553	0.699	0.557	0.366
Outlier detected at 95%				
Dixons high end test	0.289	0.251	0.271	0.516
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	3.89	2.65	0.62	0.49
Standard Deviation	0.28	0.30	0.05	0.07
CV (%)	7.2	11.4	8.3	13.6

Red Band Lights King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Red Band Lights King Size	4.70	2.87	0.64	0.52
Red Band Lights King Size	6.36	3.58	0.74	0.57
Red Band Lights King Size	4.86	2.31	0.61	0.52
Red Band Lights King Size	5.09	2.94	0.91	0.64
Red Band Lights King Size	4.21	2.54	0.62	0.61
Mean (ng/cig)	5.04	2.85	0.71	0.57
Standard Deviation	0.80	0.48	0.13	0.05
CV (%)	15.9	16.8	17.9	9.6
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	4.210	2.314	0.614	0.518
	4.696	2.542	0.620	0.522
	4.856	2.872	0.644	0.572
	5.094	2.944	0.744	0.614
	6.358	3.578	0.914	0.642
Statistical test applied				
Dixons low end test	0.226	0.180	0.020	0.032
Outlier detected at 95%				
Dixons high end test	0.588	0.502	0.567	0.226
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	5.04	2.85	0.71	0.57
Standard Deviation	0.80	0.48	0.13	0.05
CV (%)	15.9	16.8	17.9	9.6

Regal Filter

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Regal Filter	5.63	3.41	0.74	0.55
Regal Filter	6.19	3.34	0.77	0.54
Regal Filter	6.55	3.52	0.94	0.67
Regal Filter	5.46	2.69	0.59	0.52
Regal Filter	6.11	3.36	0.99	0.68
Mean (ng/cig)	5.99	3.26	0.81	0.59
Standard Deviation	0.44	0.33	0.16	0.07
CV (%)	7.4	10.1	20.0	12.6
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	5.456	2.686	0.586	0.522
	5.626	3.340	0.744	0.538
	6.106	3.362	0.772	0.554
	6.194	3.410	0.938	0.668
	6.554	3.516	0.986	0.676
Statistical test applied				
Dixons low end test	0.155	0.788	0.395	0.104
Outlier detected at 95%		95%		
Dixons high end test	0.328	0.128	0.120	0.052
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	5.99	3.41	0.81	0.59
Standard Deviation	0.44	0.08	0.16	0.07
CV (%)	7.4	2.3	20.0	12.6

Regal King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Regal King Size	6.11	3.05	0.79	0.56
Regal King Size	7.47	3.24	0.81	0.54
Regal King Size	6.75	2.96	0.80	0.60
Regal King Size	7.31	3.81	0.76	0.71
Regal King Size	5.27	3.84	1.07	0.75
Mean (ng/cig)	6.58	3.38	0.84	0.63
Standard Deviation	0.91	0.42	0.13	0.09
CV (%)	13.8	12.3	14.8	14.6
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	5.266	2.962	0.760	0.538
	6.114	3.046	0.788	0.556
	6.748	3.244	0.796	0.604
	7.314	3.808	0.814	0.706
	7.472	3.836	1.066	0.746
Statistical test applied				
Dixons low end test	0.384	0.096	0.092	0.087
Outlier detected at 95%				
Dixons high end test	0.072	0.032	0.824	0.192
Outlier detected at 95%			95%	
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	6.58	3.38	0.79	0.63
Standard Deviation	0.91	0.42	0.02	0.09
CV (%)	13.8	12.3	2.8	14.6

Rothman Royals 120s

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Rothman Royals 120s	8.28	4.83	1.10	0.82
Rothman Royals 120s	9.60	5.89	1.33	1.04
Rothman Royals 120s	7.85	4.86	1.03	0.82
Rothman Royals 120s	7.64	4.39	1.22	0.96
Rothman Royals 120s	7.38	3.98	1.12	0.69
Mean (ng/cig)	8.15	4.79	1.16	0.87
Standard Deviation	0.87	0.71	0.12	0.14
CV (%)	10.7	14.9	10.0	15.8
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	7.380	3.980	1.030	0.686
	7.644	4.392	1.098	0.822
	7.854	4.826	1.122	0.824
	8.280	4.862	1.216	0.962
	9.602	5.894	1.328	1.038
Statistical test applied				
Dixons low end test	0.119	0.215	0.228	0.386
Outlier detected at 95%				
Dixons high end test	0.595	0.539	0.376	0.216
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	8.15	4.79	1.16	0.87
Standard Deviation	0.87	0.71	0.12	0.14
CV (%)	10.7	14.9	10.0	15.8

Rothman Royals King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Rothman Royals King Size	7.84	4.57	1.00	0.73
Rothman Royals King Size	7.76	5.33	1.17	0.83
Rothman Royals King Size	9.40	5.81	1.14	0.93
Rothman Royals King Size	7.81	4.79	1.10	0.76
Rothman Royals King Size	7.86	4.77	1.02	0.82
Mean (ng/cig)	8.13	5.05	1.08	0.81
Standard Deviation	0.71	0.51	0.07	0.08
CV (%)	8.7	10.0	6.9	9.6
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	7.756	4.572	0.996	0.730
	7.812	4.774	1.018	0.758
	7.836	4.788	1.096	0.816
	7.860	5.330	1.136	0.828
	9.402	5.808	1.170	0.932
Statistical test applied				
Dixons low end test	0.034	0.163	0.126	0.139
Outlier detected at 95%				
Dixons high end test	0.937	0.387	0.195	0.515
Outlier detected at 95%	95%			
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	7.82	5.05	1.08	0.81
Standard Deviation	0.04	0.51	0.07	0.08
CV (%)	0.6	10.0	6.9	9.6

Senior Service

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Senior Service	10.22	4.74	0.99	0.97
Senior Service	8.03	4.69	1.02	0.82
Senior Service	8.05	5.16	1.04	0.95
Senior Service	8.13	5.08	1.02	0.75
Senior Service	8.77	4.97	1.17	0.91
Mean (ng/cig)	8.64	4.93	1.05	0.88
Standard Deviation	0.94	0.21	0.07	0.09
CV (%)	10.8	4.2	6.8	10.6
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	8.028	4.690	0.988	0.748
	8.050	4.744	1.018	0.820
	8.128	4.974	1.020	0.906
	8.770	5.084	1.044	0.952
	10.222	5.164	1.170	0.970
Statistical test applied				
Dixons low end test	0.010	0.114	0.165	0.324
Outlier detected at 95%				
Dixons high end test	0.662	0.169	0.692	0.081
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	8.64	4.93	1.05	0.88
Standard Deviation	0.94	0.21	0.07	0.09
CV (%)	10.8	4.2	6.8	10.6

Silk Cut Extra Mild

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Silk Cut Extra Mild	2.97	1.27	0.48	0.43
Silk Cut Extra Mild	2.91	2.14	0.56	0.39
Silk Cut Extra Mild	4.05	2.15	0.55	0.42
Silk Cut Extra Mild	2.94	1.84	0.50	0.41
Silk Cut Extra Mild	3.40	2.03	0.50	0.40
Mean (ng/cig)	3.25	1.89	0.52	0.41
Standard Deviation	0.49	0.37	0.04	0.02
CV (%)	15.0	19.4	7.4	3.7
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	2.908	1.274	0.476	0.390
	2.944	1.838	0.496	0.400
	2.966	2.034	0.496	0.414
	3.396	2.142	0.552	0.418
	4.050	2.152	0.562	0.428
Statistical test applied				
Dixons low end test	0.032	0.642	0.233	0.263
Outlier detected at 95%				
Dixons high end test	0.573	0.011	0.116	0.263
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	3.05	1.89	0.52	0.41
Standard Deviation	0.23	0.37	0.04	0.02
CV (%)	7.5	19.4	7.4	3.7

Silk Cut King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Silk Cut King Size	6.11	2.37	0.91	0.59
Silk Cut King Size	7.11	3.83	0.86	0.70
Silk Cut King Size	7.03	4.17	1.01	0.83
Silk Cut King Size	5.17	2.35	0.84	0.73
Silk Cut King Size	4.86	3.07	0.82	0.71
Mean (ng/cig)	6.06	3.16	0.89	0.71
Standard Deviation	1.03	0.83	0.08	0.09
CV (%)	17.1	26.4	8.7	12.2
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	4.862	2.346	0.822	0.586
	5.174	2.370	0.838	0.698
	6.108	3.072	0.856	0.710
	7.034	3.834	0.914	0.728
	7.108	4.174	1.012	0.828
Statistical test applied				
Dixons low end test	0.139	0.013	0.084	0.463
Outlier detected at 95%				
Dixons high end test	0.033	0.186	0.516	0.413
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	6.06	3.16	0.89	0.71
Standard Deviation	1.03	0.83	0.08	0.09
CV (%)	17.1	26.4	8.7	12.2

Silk Cut Ultra King Size

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Silk Cut Ultra King Size	1.34	0.98	0.19	0.19
Silk Cut Ultra King Size	1.69	0.97	0.27	0.24
Silk Cut Ultra King Size	1.27	0.66	0.22	0.21
Silk Cut Ultra King Size	1.25	0.91	0.19	0.20
Silk Cut Ultra King Size	1.13	0.79	0.21	0.18
Mean (ng/cig)	1.34	0.86	0.22	0.21
Standard Deviation	0.21	0.14	0.03	0.02
CV (%)	15.8	15.8	15.2	11.1
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	1.130	0.660	0.188	0.182
	1.254	0.792	0.192	0.194
	1.274	0.908	0.212	0.198
	1.344	0.974	0.220	0.210
	1.690	0.978	0.270	0.242
Statistical test applied				
Dixons low end test	0.221	0.415	0.049	0.200
Outlier detected at 95%				
Dixons high end test	0.618	0.013	0.610	0.533
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ug/cig)	1.34	0.86	0.22	0.21
Standard Deviation	0.21	0.14	0.03	0.02
CV (%)	15.8	15.8	15.2	11.1

Superkings

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Superkings	6.03	3.34	0.69	0.57
Superkings	6.73	4.14	0.88	0.64
Superkings	7.41	4.16	1.01	0.77
Superkings	6.41	3.91	0.97	0.79
Superkings	6.94	4.55	1.05	1.08
Mean (ng/cig)	6.70	4.02	0.92	0.77
Standard Deviation	0.53	0.44	0.14	0.20
CV (%)	7.8	11.1	15.4	25.7
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	6.026	3.340	0.692	0.568
	6.408	3.914	0.880	0.638
	6.732	4.142	0.970	0.768
	6.942	4.158	1.014	0.790
	7.412	4.552	1.046	1.082
Statistical test applied				
Dixons low end test	0.276	0.474	0.531	0.136
Outlier detected at 95%				
Dixons high end test	0.339	0.325	0.090	0.568
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	6.70	4.02	0.92	0.77
Standard Deviation	0.53	0.44	0.14	0.20
CV (%)	7.8	11.1	15.4	25.7

Superkings Lights

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Superkings Lights	8.45	4.54	0.89	0.76
Superkings Lights	8.53	4.77	0.97	0.85
Superkings Lights	6.88	4.10	0.90	0.74
Superkings Lights	7.91	4.97	1.09	0.81
Superkings Lights	6.73	4.50	1.00	0.75
Mean (ng/cig)	7.70	4.58	0.97	0.78
Standard Deviation	0.85	0.33	0.08	0.05
CV (%)	11.1	7.2	8.3	5.9
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	6.730	4.102	0.886	0.744
	6.880	4.504	0.904	0.748
	7.908	4.540	0.974	0.760
	8.446	4.774	1.000	0.806
	8.530	4.974	1.088	0.852
Statistical test applied				
Dixons low end test	0.083	0.461	0.089	0.037
Outlier detected at 95%				
Dixons high end test	0.047	0.229	0.436	0.426
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	7.70	4.58	0.97	0.78
Standard Deviation	0.85	0.33	0.08	0.05
CV (%)	11.1	7.2	8.3	5.9

Superkings Ultra Lights

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Superkings Ultra Lights	2.96	1.89	0.52	0.47
Superkings Ultra Lights	3.66	2.07	0.59	0.45
Superkings Ultra Lights	3.56	2.25	0.65	0.53
Superkings Ultra Lights	3.36	1.74	0.55	0.44
Superkings Ultra Lights	4.12	2.27	0.54	0.44
Mean (ng/cig)	3.53	2.05	0.57	0.47
Standard Deviation	0.42	0.23	0.05	0.04
CV (%)	12.0	11.2	9.0	7.8
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	2.958	1.744	0.520	0.442
	3.358	1.892	0.538	0.444
	3.560	2.068	0.554	0.454
	3.660	2.252	0.590	0.466
	4.116	2.272	0.650	0.530
Statistical test applied				
Dixons low end test	0.345	0.280	0.138	0.023
Outlier detected at 95%				
Dixons high end test	0.394	0.038	0.462	0.727
Outlier detected at 95%				95%
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	3.53	2.05	0.57	0.45
Standard Deviation	0.42	0.23	0.05	0.01
CV (%)	12.0	11.2	9.0	2.4

Vogue Superslims

Brand	1-naphthylamine	2-naphthylamine	3-aminobiphenyl	4-aminobiphenyl
Vogue Superslims	5.95	2.98	0.70	0.69
Vogue Superslims	5.32	2.64	0.63	0.55
Vogue Superslims	5.27	2.89	0.70	0.63
Vogue Superslims	4.40	2.26	0.68	0.66
Vogue Superslims	5.67	2.28	0.73	0.71
Mean (ng/cig)	5.32	2.61	0.69	0.65
Standard Deviation	0.58	0.34	0.04	0.06
CV (%)	11.0	12.9	5.7	9.5
<i>Outlier Test</i>				
Dixons outlier test was applied to the above data				
Data sorted	4.400	2.256	0.626	0.552
	5.270	2.284	0.682	0.634
	5.324	2.636	0.698	0.656
	5.670	2.890	0.702	0.686
	5.950	2.984	0.732	0.712
Statistical test applied				
Dixons low end test	0.561	0.038	0.528	0.513
Outlier detected at 95%				
Dixons high end test	0.181	0.129	0.283	0.162
Outlier detected at 95%				
<i>If an outlier is detected then the mean, standard deviation and CV have been recalculated excluding the outlier</i>				
Summary of Results				
Mean (ng/cig)	5.32	2.61	0.69	0.65
Standard Deviation	0.58	0.34	0.04	0.06
CV (%)	11.0	12.9	5.7	9.5

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.

Repeatability and reproducibility

This set of analytes is another case where the general point can be made that good repeatability within laboratories does not necessarily result in good reproducibility between labs. In a recent inter comparison exercise, the mean results reported from three laboratories for 2-naphthylamine ranged from 2.7 ng cig⁻¹ to 5.0 ng cig⁻¹ for one brand. Each laboratory employing their own favoured technique and analysed five samples. All the laboratories reported CoVs between 5 & 6.1%.

It was observed from the validation data that the polycyclic aromatic amines results obtained for the reference cigarette 2R4F were consistent with what had been previously achieved. However, it was also noticeable that the PAA results obtained were on the low side of what other laboratories have reported for 1R4F and Brand A and B. However, this possible 'difference' in results has been observed for many analytes present at low level concentrations in a range of matrices as described below.

The following information was obtained from the VAM (Valid Analytical Measurement) web site www.vam.org.uk – it relates to a paper by Horwitz et al who showed that CVs from inter-laboratory exercises increased as the levels of analytes being measured decreased:

“Inter-laboratory Coefficient of Variation as a Function of Concentration

The way in which accuracy varies with the concentration of analyte being determined was demonstrated graphically by Horwitz *et al*¹ who collected together data showing the coefficient of variation which can be achieved by interlaboratory studies at varying concentrations.

The coefficient of variation reported was typically 4% for a concentration of 100 mg kg⁻¹ and 32% for a concentration of 0.01 mg kg⁻¹.

Advances in analytical techniques have made the end determination of a method more sensitive so that smaller amounts of an analyte can be measured.

The perception of the analyst and the client is that lower and lower levels of analytes can be determined reliably because of advances in end measurement instrumentation, but caution needs to be exercised in the interpretation of the results of trace analysis at the lowest levels.

REFERENCE

1. Reprinted from the JAOAC, Volume 63, No 6, p. 1344-1354. Copyright 1980 by AOAC International”

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-nitrosornicotine (nnn)
	N-nitrosoanatabine (nat)
	N-nitrosanabasine (nab)
	4-(N-Methyl-N-nitrosamino)-1-(3-pyridinyl)-1-butanone
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
PAA	Polycyclic aromatic amines
DCM	Dichloromethane
SIM	Selective Ion Monitoring

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