

CONFIDENTIAL

UK SMOKE CONSTITUENTS STUDY

Part 2 : Determination of Eight Carbonyl Yields in Cigarette Smoke

COMMISSIONED BY :

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*Setting standards
in analytical science*

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UK SMOKE CONSTITUENTS STUDY

Determination of Eight Carbonyl Yields in Cigarette Smoke

1. Introduction

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

2. Summary

The objective of this study is to determine the yield ratings of selected smoke constituents (Appendix 1) 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 a Kentucky reference cigarette 1R4F has been smoked as part of the study.

This report details the results for formaldehyde (methanal), acetaldehyde (ethanal), acetone (2-propanone), acrolein (2-propenal), propionaldehyde (propanal), crotonaldehyde (2 - butenal), methyl ethyl ketone (2 - butanone), butyraldehyde (butanal).

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 cigarette 1R4F was also included in the study and for some determinations Kentucky 1R5F has been included.

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 conditioned¹ at a temperature* of $22 \pm 1^\circ\text{C}$ and $60 \pm 2\%$ relative humidity* 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 a 20 channel Filtrona SM350 smoking machine or a Filtrona SM400 smoking machine.

* The parameter is slightly more stringent than that specified in ISO

2 cigarettes were sub-sampled from packets chosen on a random basis and smoked to determine the yields of eight carbonyls using the method given below (see section 5) Five determinations were performed for each of the 25 brands & 1R4F. In addition the Kentucky Reference cigarette 1R5F was also tested. As far as was practicable brands were smoked on different channels on different smoking runs.

ISO conditions³ for smoking cigarettes were used. The smoking machine puffing parameters was $35 \pm 0.2 \text{ cm}^3$ puff volume* with 2.0 ± 0.02 second puff duration once every 60.0 ± 0.5 seconds.

As a check that cigarettes have been smoked in accordance with ISO standard conditions, carbon monoxide concentration was determined in the vapour phase using a non-dispersive infrared analyser using the method described in ISO 8454: 1995⁴.

5. Method and Validation

The method used is applicable to the extraction and determination of eight carbonyl compounds in mainstream tobacco smoke by High Performance Liquid Chromatography (HPLC). For each sample, two conditioned cigarettes were smoked on a 20 channel linear smoking machine. The mainstream smoke was collected (and reacted) in a sintered bubbler containing a solution of acidified 2,4-dinitrophenylhydrazine (DNPH) in acetonitrile. After smoking, the derivatised carbonyls were stabilised by the addition of pyridine. If appropriate, the solutions were diluted by 50% with acetonitrile to reduce the carbonyl concentration so that it was within the calibration range. The solutions were analysed by high performance liquid chromatography with diode array detection. Individual carbonyl concentrations were determined by an external standard calibration method. A blank solution was analysed with each batch of samples. The full method is given in an Annex to this report.

Before use, the method was validated to show that it was suitable for carrying out the bench mark study. The validation data is given in an Annex to this report.

6. Results & Discussion

The results were tabulated for each brand (Page 23 to 48). The mean, standard deviation and relative standard deviation were determined for the sets of results for each brand.

A summary of the results is included at the beginning (Page 6). Linear least squares regression analysis has been carried out for each carbonyl yield versus NFDPM (Page 7) and carbonyl yield versus carbon monoxide (Page 15) for the twenty five cigarette brands (excluding 1R4F & 1R5F).

Acetone was detected at varying concentrations in the blank DNPH solution. The concentration of acetone measured was generally much lower than that found in the cigarette smoke solutions. Therefore, the results have not been blank corrected. During the study, the levels of acetone ranged from $5 \mu\text{g cig}^{-1}$ to $10 \mu\text{g cig}^{-1}$.

Repeat analyses were only performed where a problem had been identified. In this study there were four results with suspect yields for most of the eight analytes (results outside 3 standard deviation). The CO yields were checked and found to be also outside 3 standard deviation. Therefore, the original results were discarded and the analysis repeated – denoted by an “r” at the end of the data.

Two brands gave higher results than expected for some analytes, significantly exceeding the top standard. The original results have been reported but as a check, four samples for each

brand were re-smoked and analysed (diluted by 50%). The repeat results are reported at the bottom of the table. In our opinion there is no significant difference between the original and the repeat results.

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.⁵

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 carbonyl 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: 2000 - 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 ISO 8454:1995 – Chemical analysis of tobacco and tobacco products: Determination of carbon monoxide in the vapour phase cigarette smoke (NDIR method)

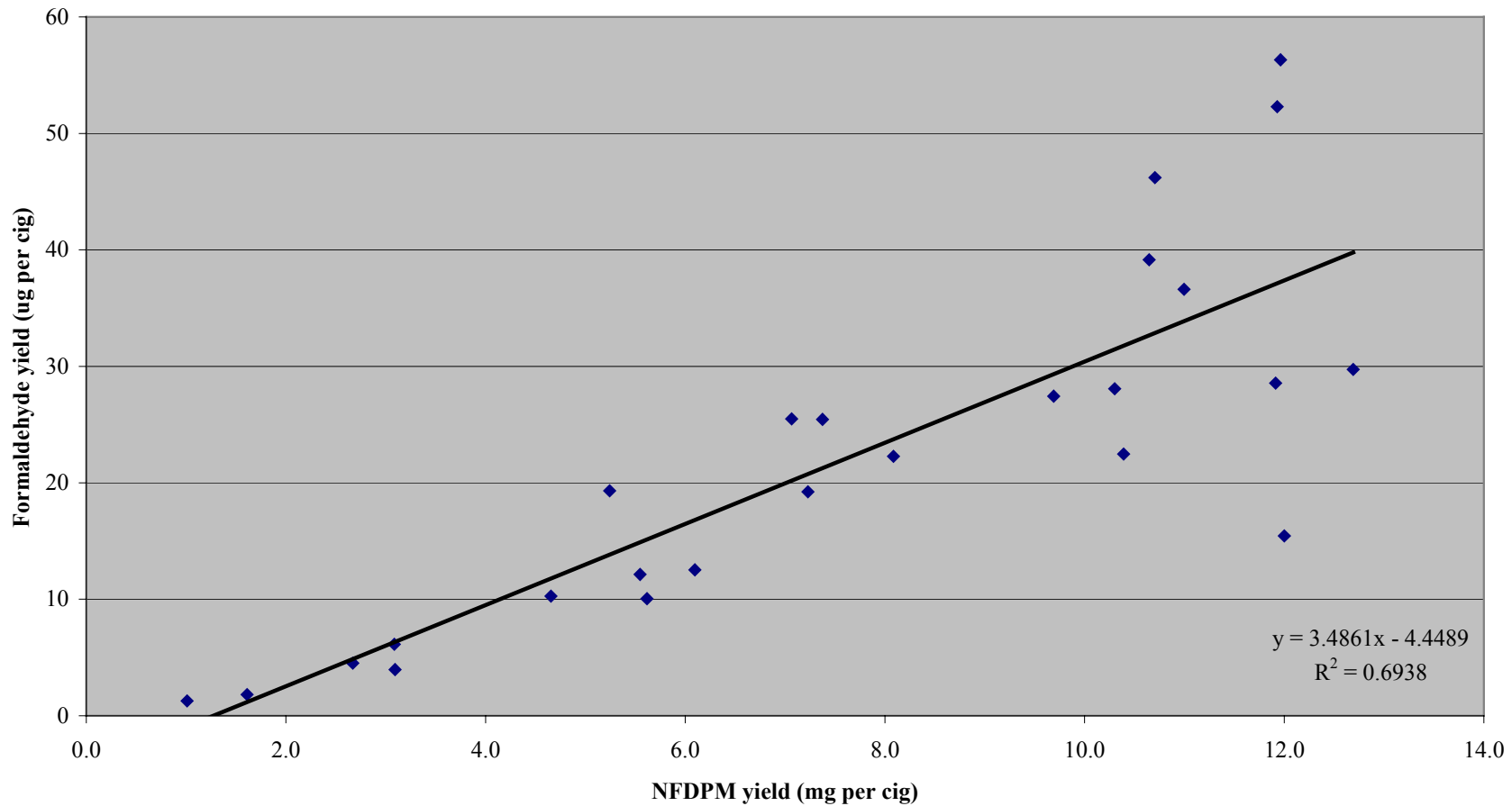
⁵ NB When evaluating a set of results obtained using a particular method it is important to put the results in context and this is what we have set out to do in this Appendix.

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

| Brand | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde | NFDPM | Carbon Monoxide |
|--|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|--------|-----------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | mg/cig | mg/cig |
| 1R4F | 18.3 | 709 | 299 | 55.0 | 52.8 | 16.8 | 76.5 | 40.3 | 9.06 | 12.26 |
| 1R5F | 3.1 | 183 | 87.4 | 12.6 | 13.7 | 2.77 | 18.4 | 9.57 | 1.92 | 3.36 |
| Benson & Hedges King Size | 28.1 | 720 | 307 | 59.9 | 52.6 | 24.4 | 83.3 | 44.3 | 10.30 | 11.74 |
| Berkely Superkings | 27.4 | 705 | 303 | 59.6 | 50.8 | 23.9 | 80.9 | 40.9 | 9.69 | 11.50 |
| Camel Ultra Lights | 3.97 | 167 | 83.1 | 12.4 | 12.8 | 3.15 | 18.7 | 9.61 | 3.09 | 3.13 |
| Consulate Menthol | 25.5 | 514 | 217 | 46.0 | 37.6 | 16.6 | 56.8 | 30.5 | 7.06 | 8.30 |
| Gitanes Caporal Filter | 15.4 | 687 | 303 | 45.8 | 46.7 | 22.2 | 83.2 | 36.6 | 12.00 | 12.60 |
| Lambert & Butler King Size | 52.3 | 758 | 318 | 69.1 | 54.4 | 29.1 | 88.8 | 46.0 | 11.93 | 13.30 |
| Lambert & Butler Lights King Size | 19.3 | 463 | 202 | 39.1 | 33.7 | 14.2 | 55.1 | 26.3 | 5.24 | 6.48 |
| Lambert & Butler Ultra Lights | <2 | 108 | 55.9 | 6.4 | 8.2 | 2.1 | 13.1 | 8.3 | 1.61 | 1.49 |
| Marlboro King Size | 29.7 | 716 | 311 | 61.7 | 52.9 | 22.7 | 82.4 | 42.5 | 12.69 | 12.79 |
| Marlboro Lights King Size | 12.5 | 402 | 175 | 34.4 | 29.6 | 8.85 | 41.8 | 19.3 | 6.10 | 7.19 |
| Mayfair Lights King Size | 19.2 | 520 | 229 | 44.3 | 37.0 | 17.6 | 61.9 | 32.3 | 7.23 | 8.73 |
| Mayfair Menthol King Size | 10.3 | 349 | 160 | 27.3 | 25.5 | 8.66 | 40.3 | 19.0 | 4.65 | 5.95 |
| Red Band Lights King Size | 12.1 | 351 | 154 | 28.3 | 25.2 | 8.75 | 38.2 | 24.0 | 5.55 | 6.41 |
| Regal Filter | 39.2 | 631 | 266 | 57.4 | 45.1 | 24.0 | 75.0 | 39.1 | 10.65 | 10.92 |
| Regal King Size | 56.3 | 872 | 360 | 87.8 | 62.1 | 33.3 | 98.5 | 51.2 | 11.96 | 13.86 |
| Rothman Royals 120s | 22.5 | 567 | 250 | 50.8 | 42.2 | 19.2 | 65.1 | 37.6 | 10.39 | 9.44 |
| Rothman Royals King Size | 36.6 | 661 | 289 | 62.4 | 48.6 | 25.8 | 76.9 | 42.5 | 11.00 | 10.86 |
| Senior Service | 28.6 | 523 | 237 | 46.0 | 40.6 | 24.3 | 69.1 | 36.9 | 11.92 | 7.71 |
| Silk Cut Extra Mild | 4.51 | 183 | 88.0 | 12.8 | 13.3 | 3.80 | 21.2 | 10.6 | 2.67 | 3.16 |
| Silk Cut King Size | 10.1 | 367 | 171 | 28.7 | 27.1 | 10.5 | 44.7 | 23.1 | 5.62 | 5.78 |
| Silk Cut Ultra King Size | <2 | 73.0 | 39.1 | 4.3 | 5.7 | <2 | 8.2 | 5.5 | 1.01 | 1.20 |
| Superkings | 46.2 | 778 | 328 | 69.0 | 56.9 | 27.9 | 90.7 | 45.8 | 10.71 | 11.41 |
| Superkings Lights | 22.3 | 505 | 218 | 43.4 | 37.6 | 14.9 | 58.0 | 31.5 | 8.09 | 7.54 |
| Superkings Ultra Lights | 6.1 | 268 | 118 | 20.1 | 19.6 | 6.6 | 29.2 | 16.8 | 3.08 | 3.53 |
| Vogue Superslims | 25.5 | 346 | 152 | 35.1 | 25.3 | 14.2 | 38.4 | 18.3 | 7.38 | 6.05 |

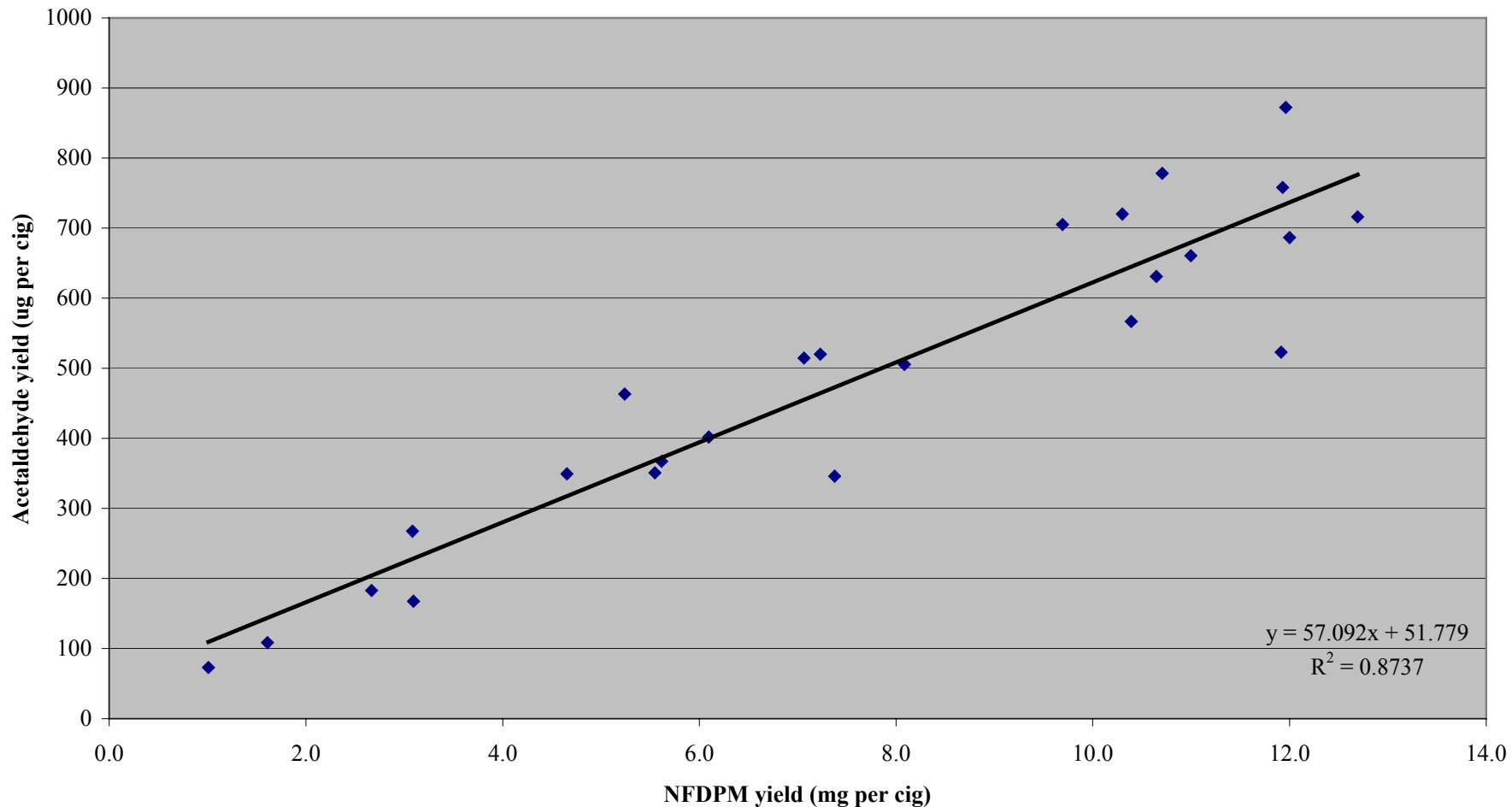
Figures 1 to 8 - regression analysis of each carbonyl versus NFDPM

Figure 1 - Regression analysis of formaldehyde versus NFDPM for 25 cigarette brands



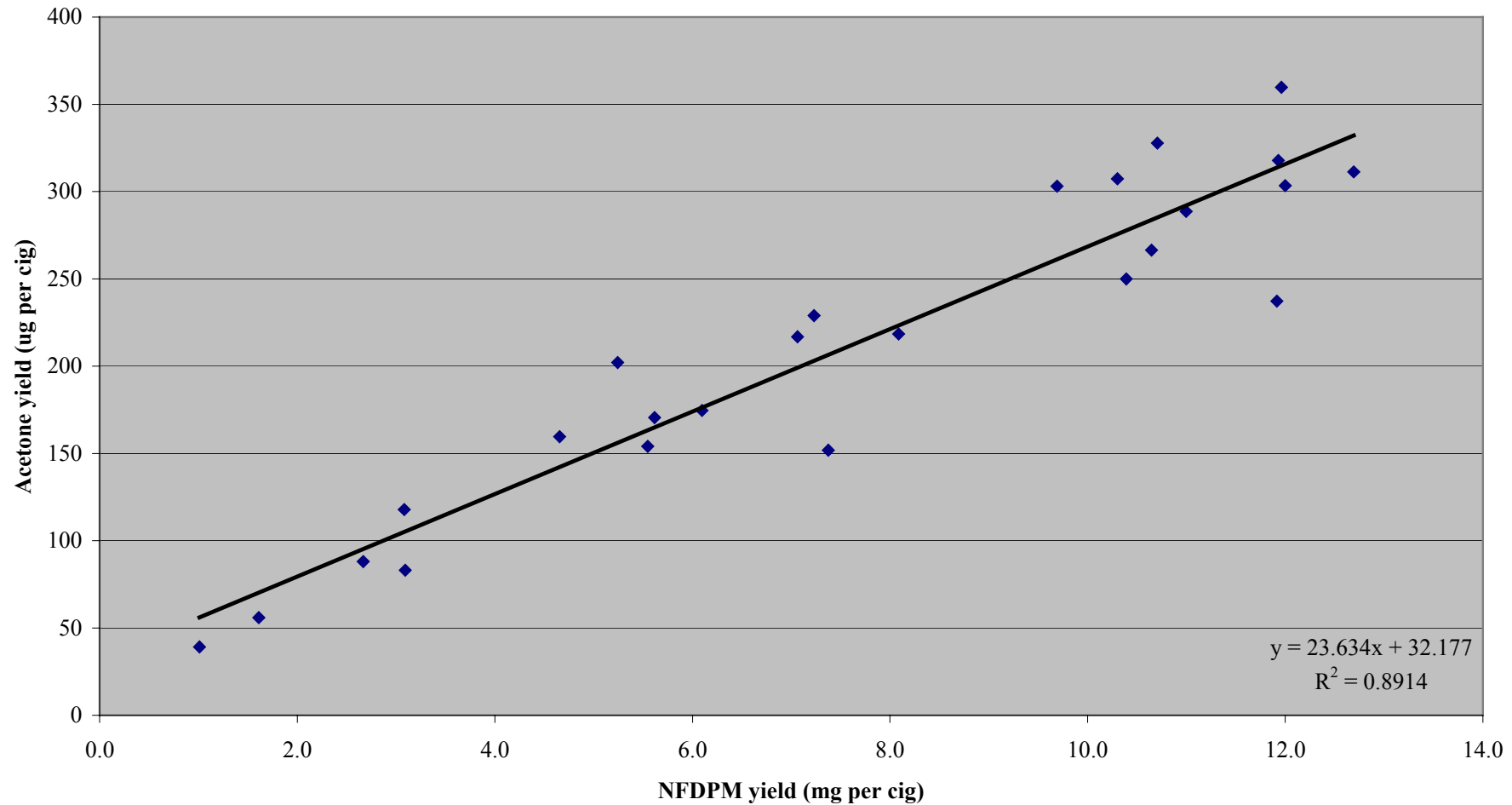
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 2 - Regression analysis of acetaldehyde versus NFDPM for 25 cigarette brands



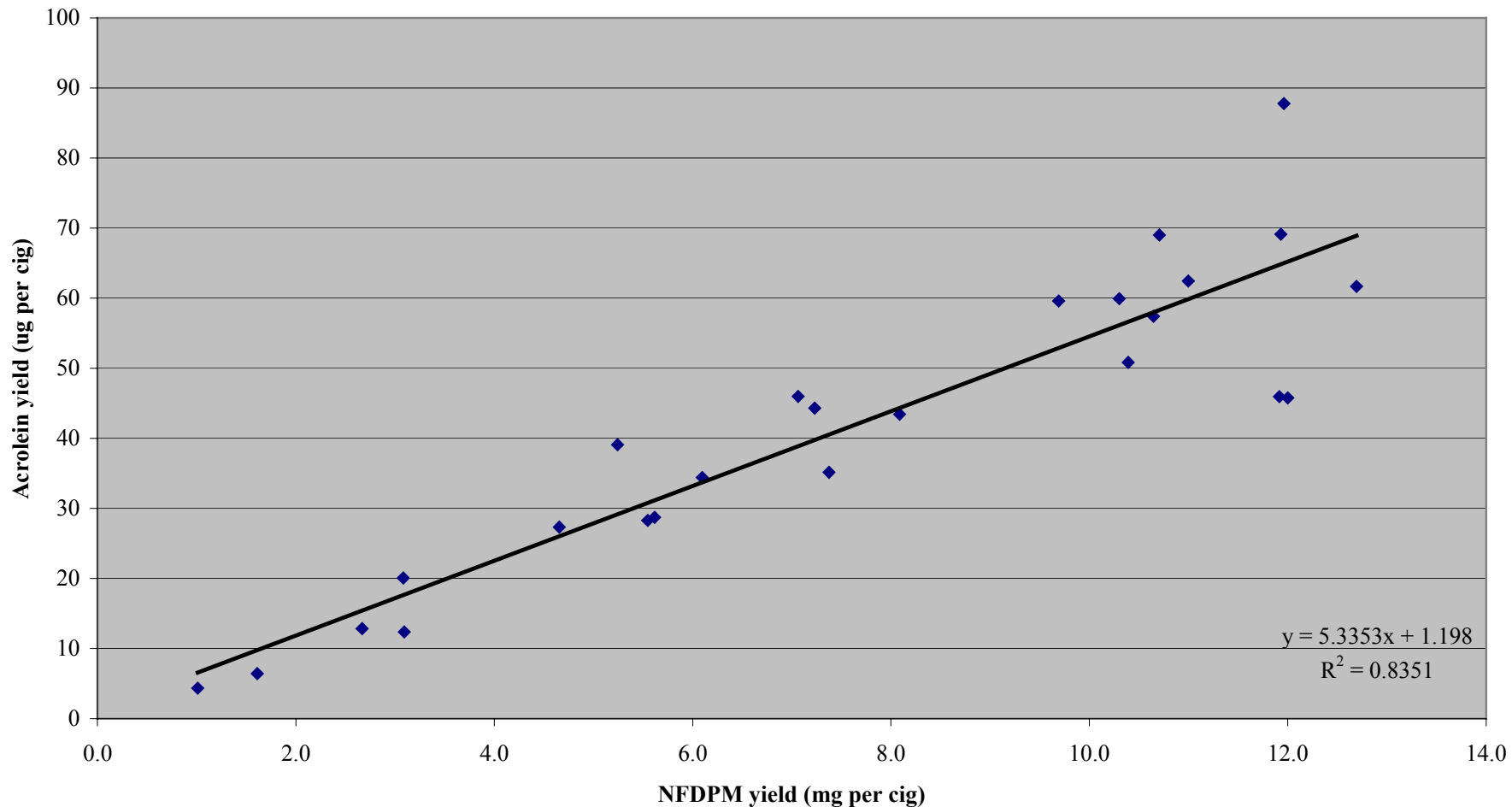
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 3 - Regression analysis of acetone versus NFDPM for 25 cigarette brands



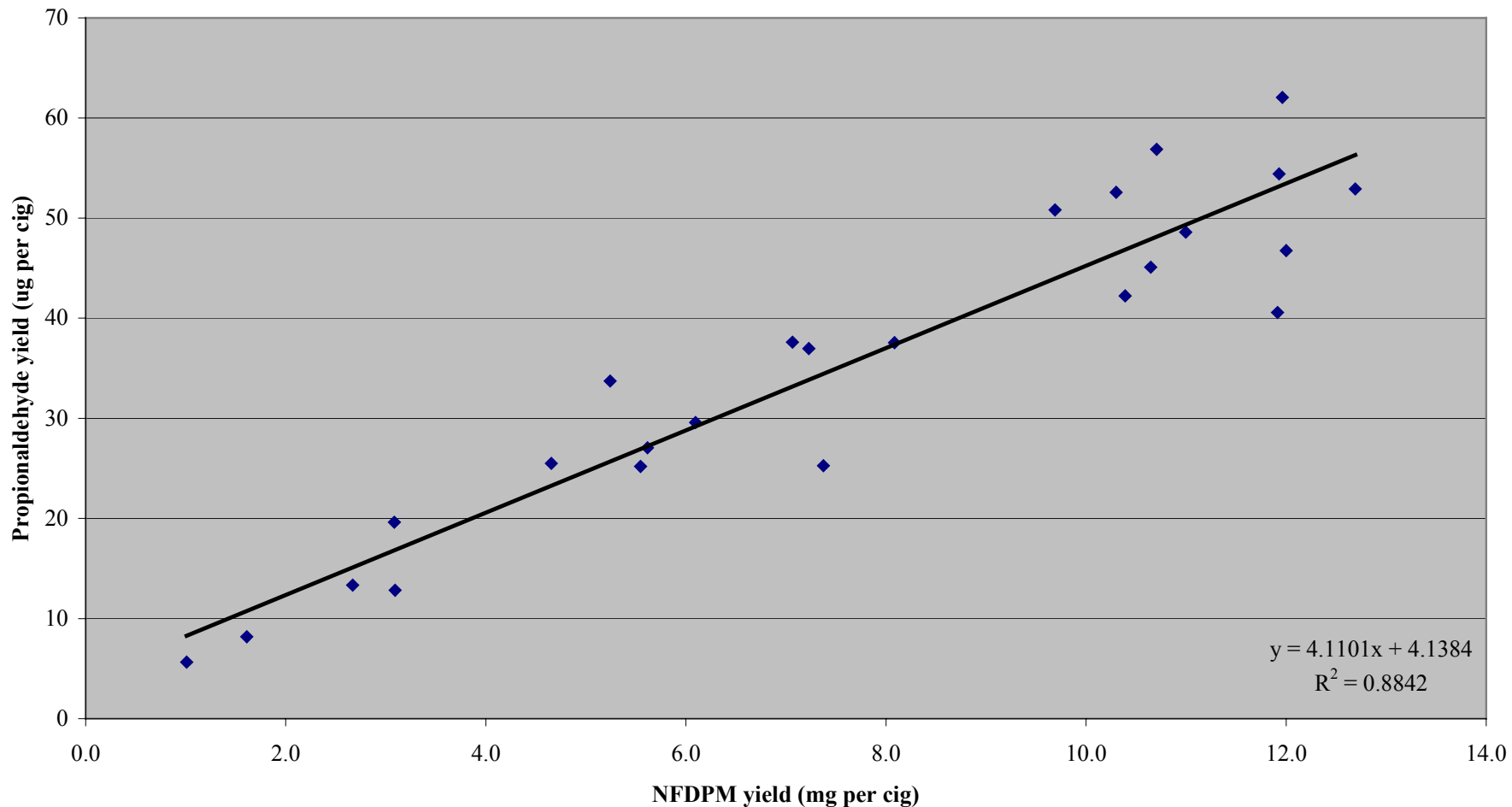
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 4 - Regression analysis of acrolein versus NFDPM for 25 cigarette brands



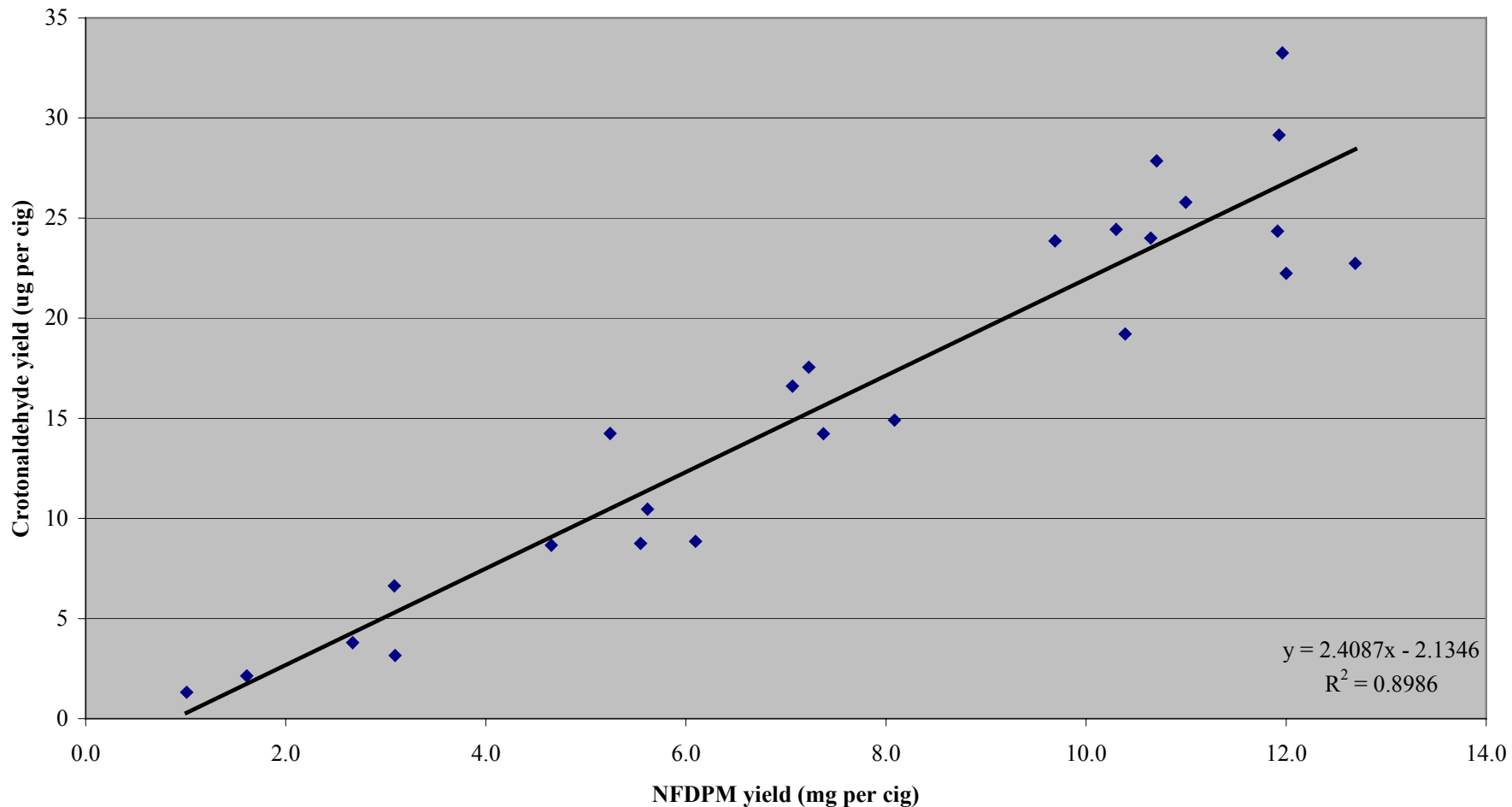
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 5 - Regression analysis of propionaldehyde versus NFDPM for 25 cigarette brands



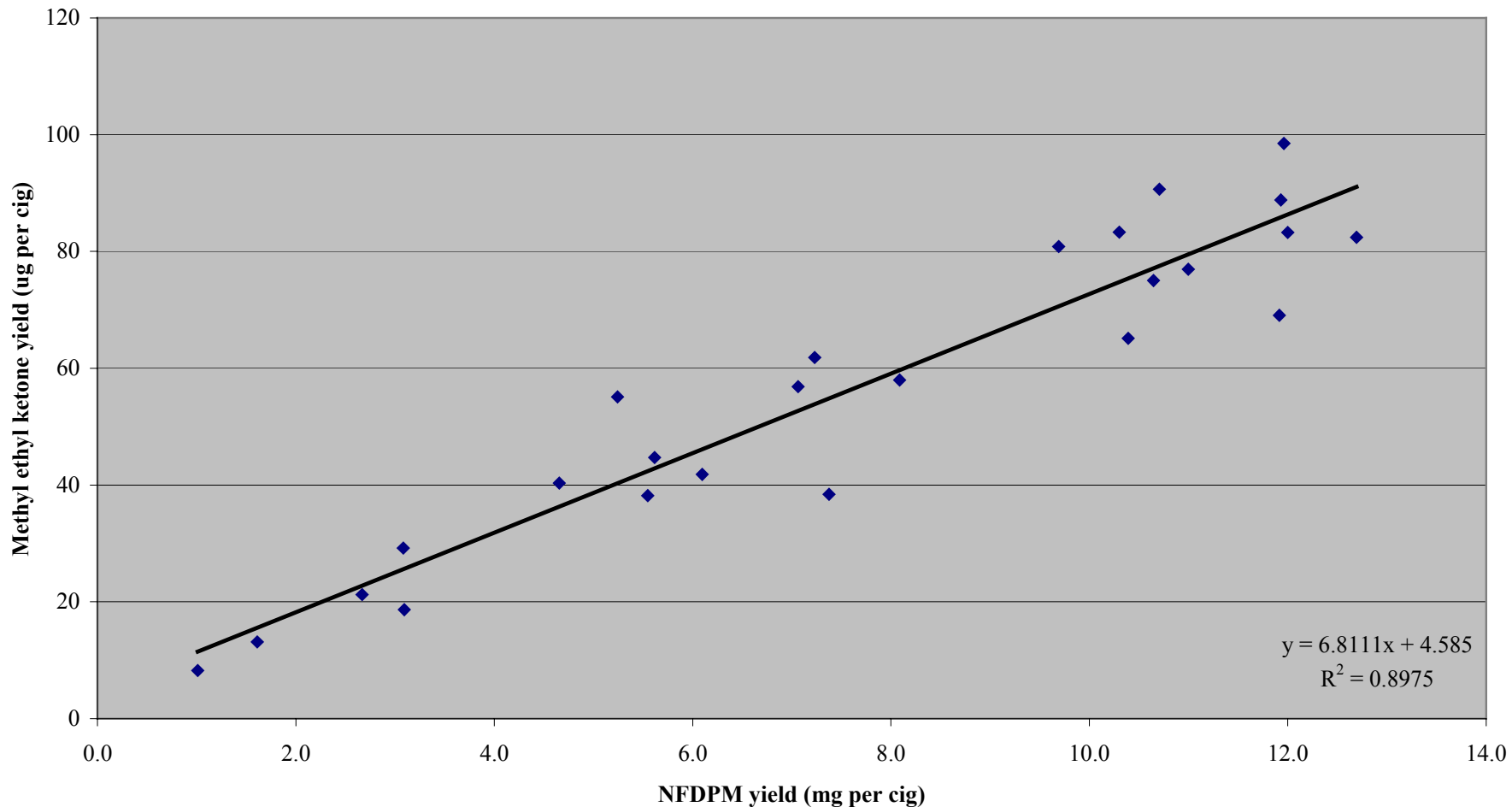
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 6 - Regression analysis of crotonaldehyde versus NFDPM for 25 cigarette brands



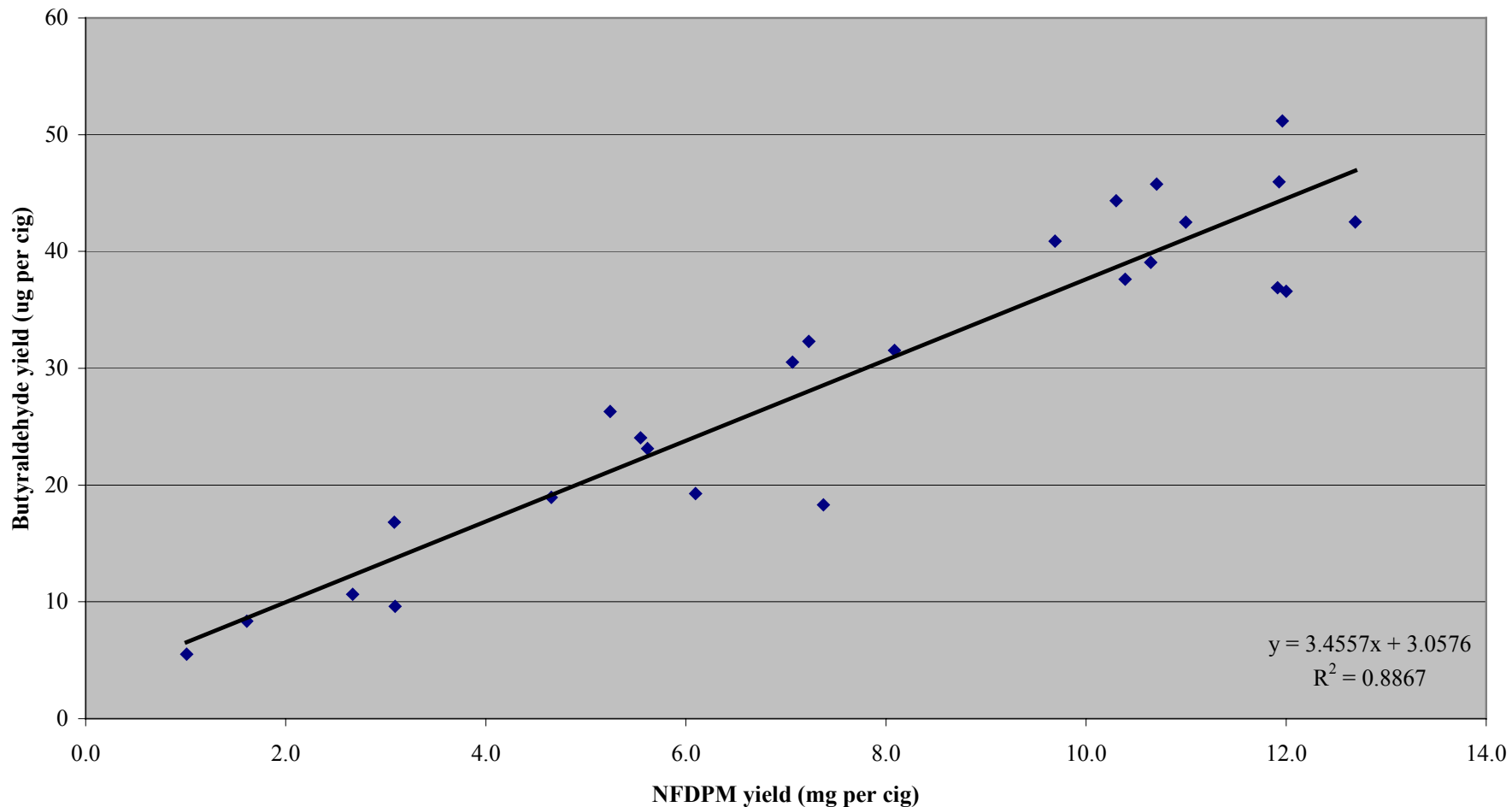
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 7 - Regression analysis of methyl ethyl ketone versus NFDPM for 25 cigarette brands



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

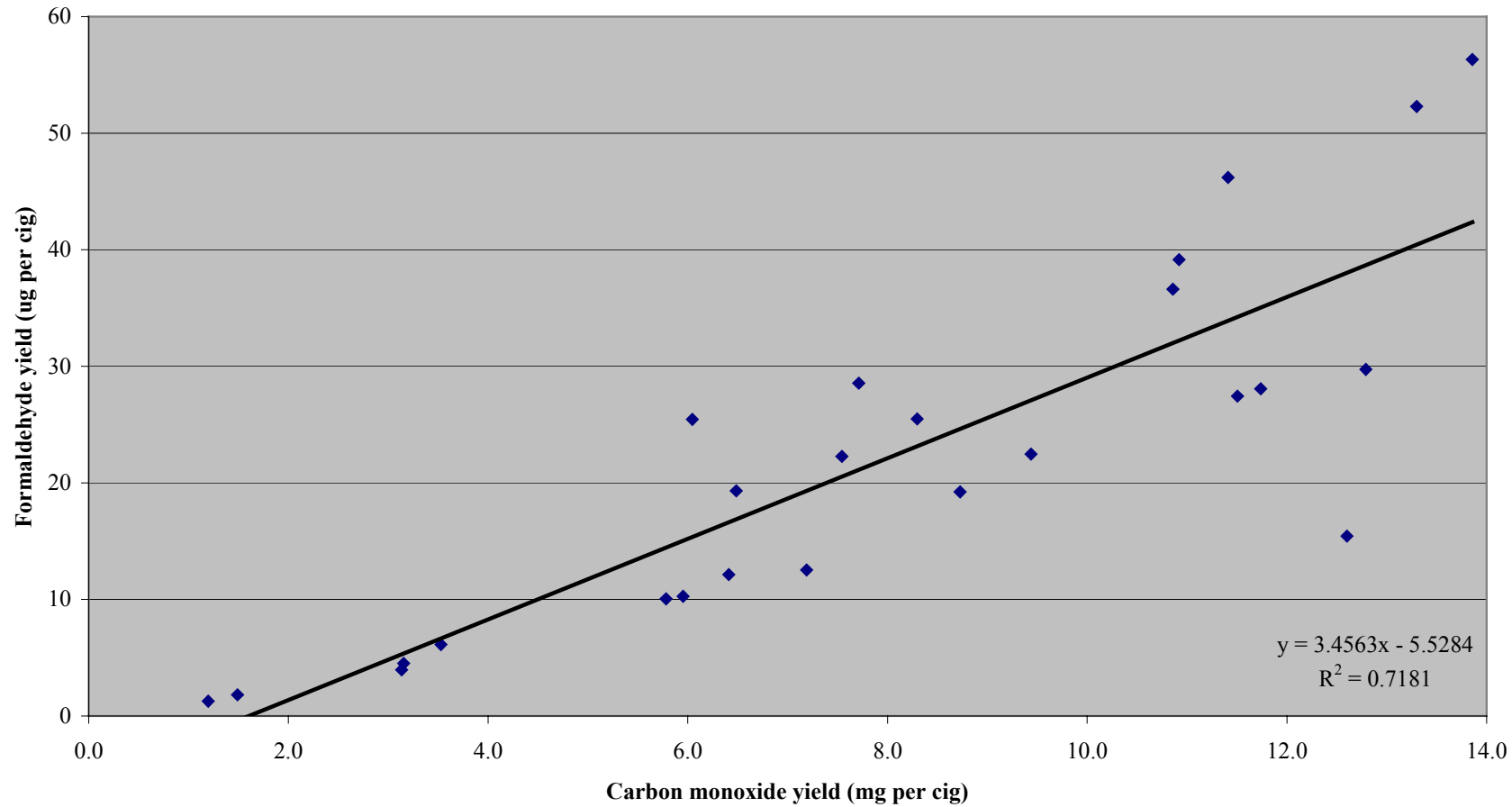
Figure 8 - Regression analysis of butyraldehyde versus NFDPM for 25 cigarette brands



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

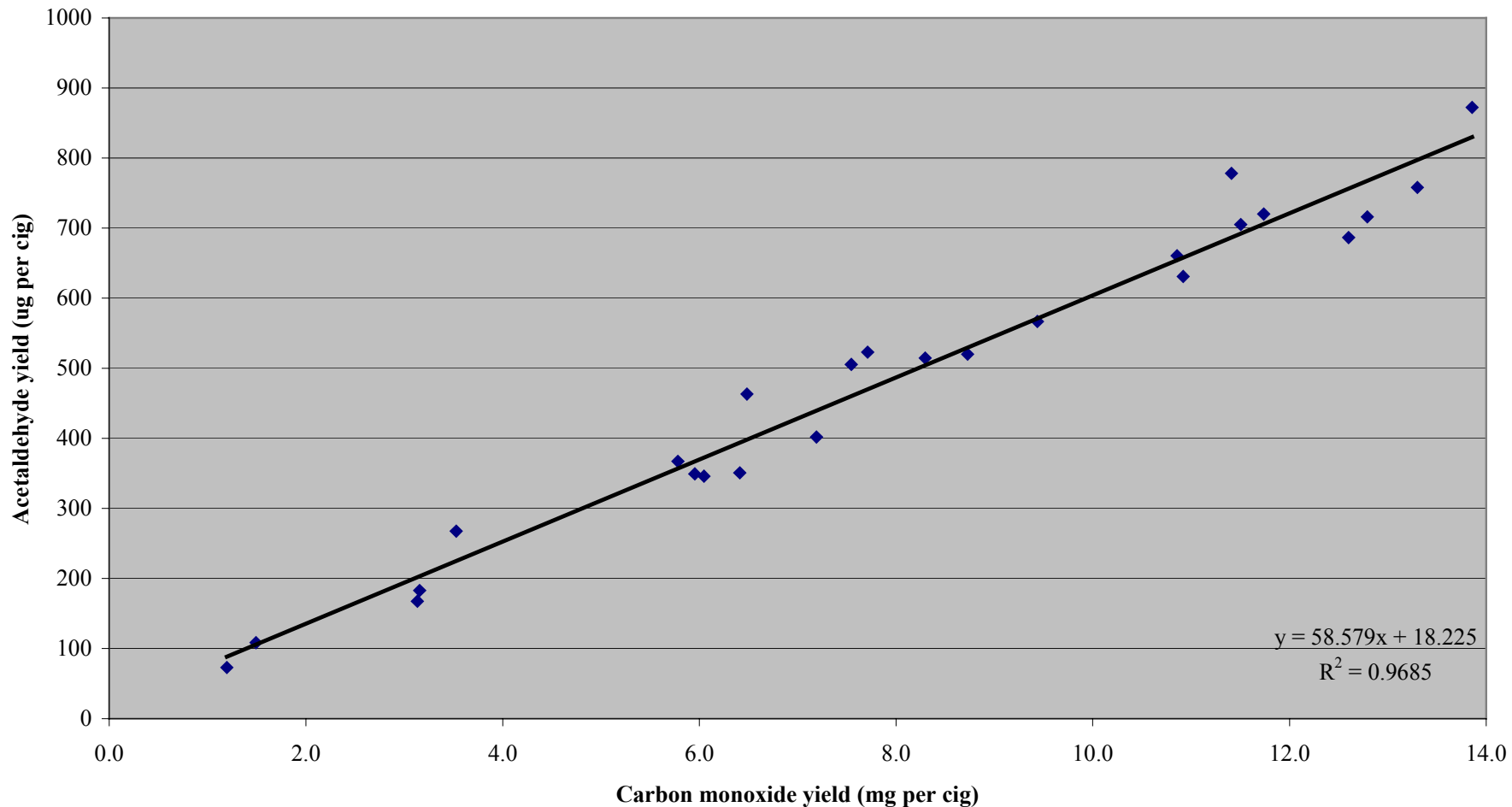
Figures 9 to 16 - regression analysis of each carbonyl versus carbon monoxide

Figure 9 - Regression analysis of formaldehyde versus carbon monoxide for 25 cigarette brands



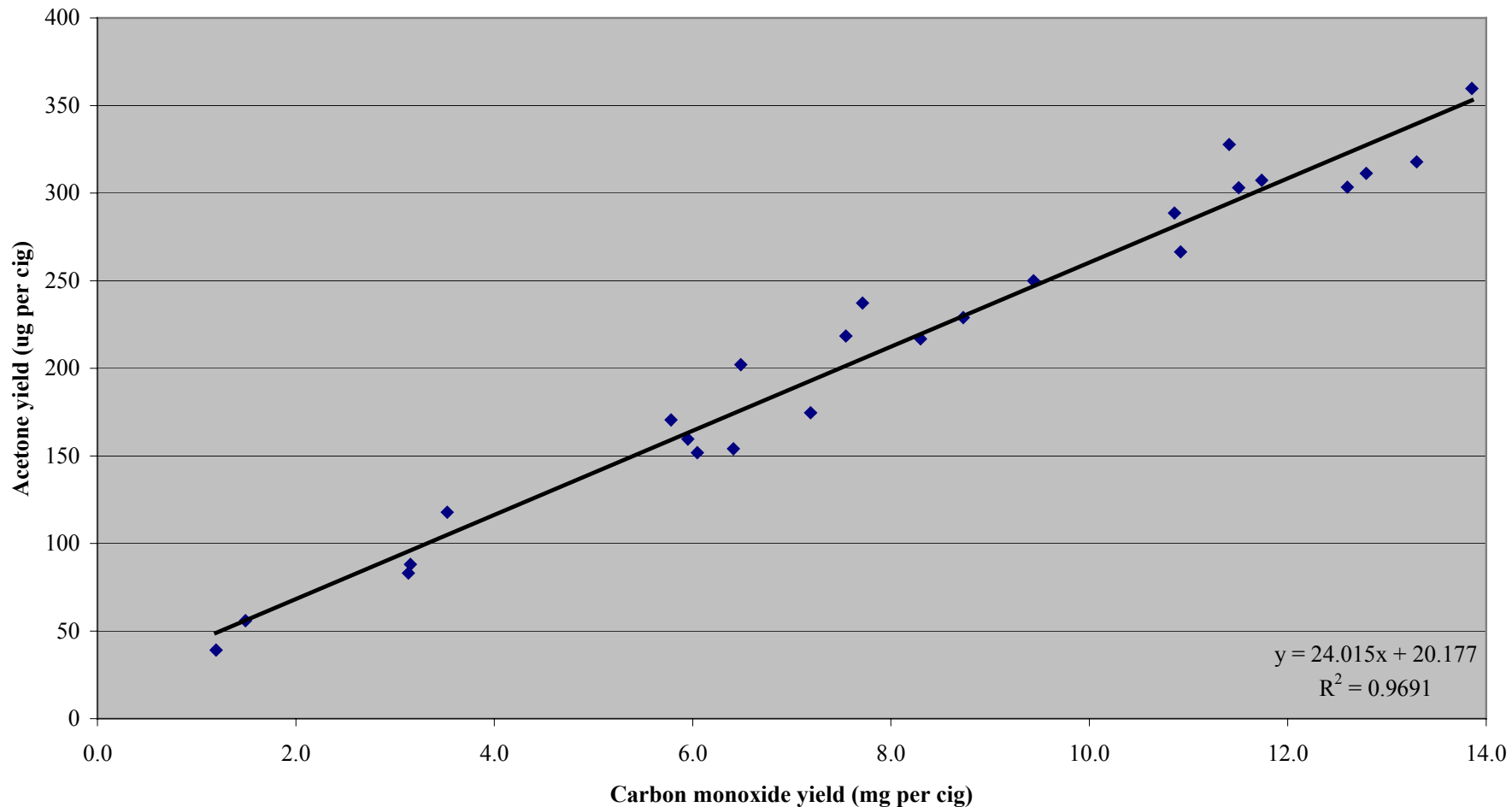
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 10 - Regression analysis of acetaldehyde versus carbon monoxide for 25 cigarette brands



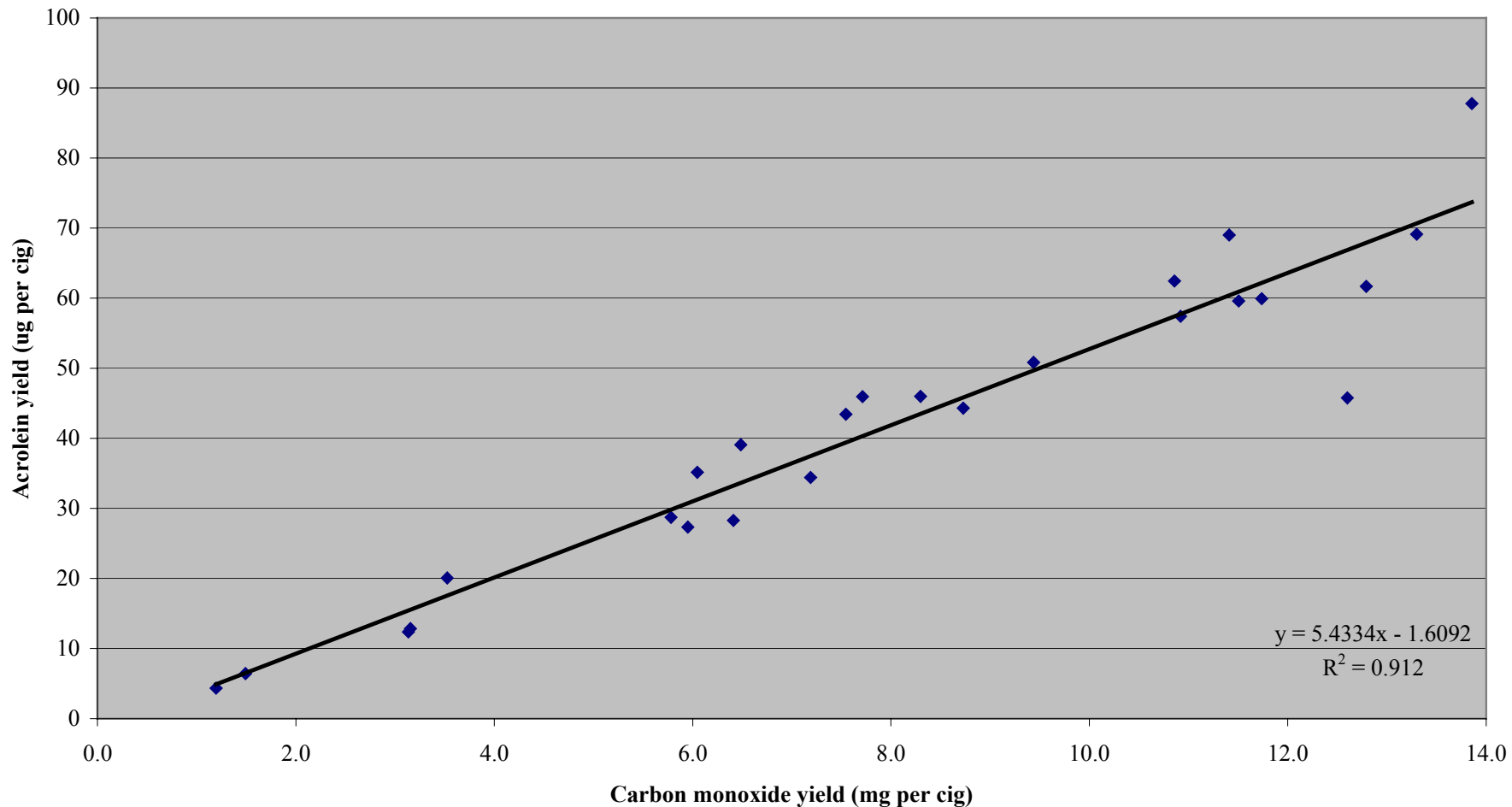
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 11 - Regression analysis of acetone versus carbon monoxide for 25 cigarette brands



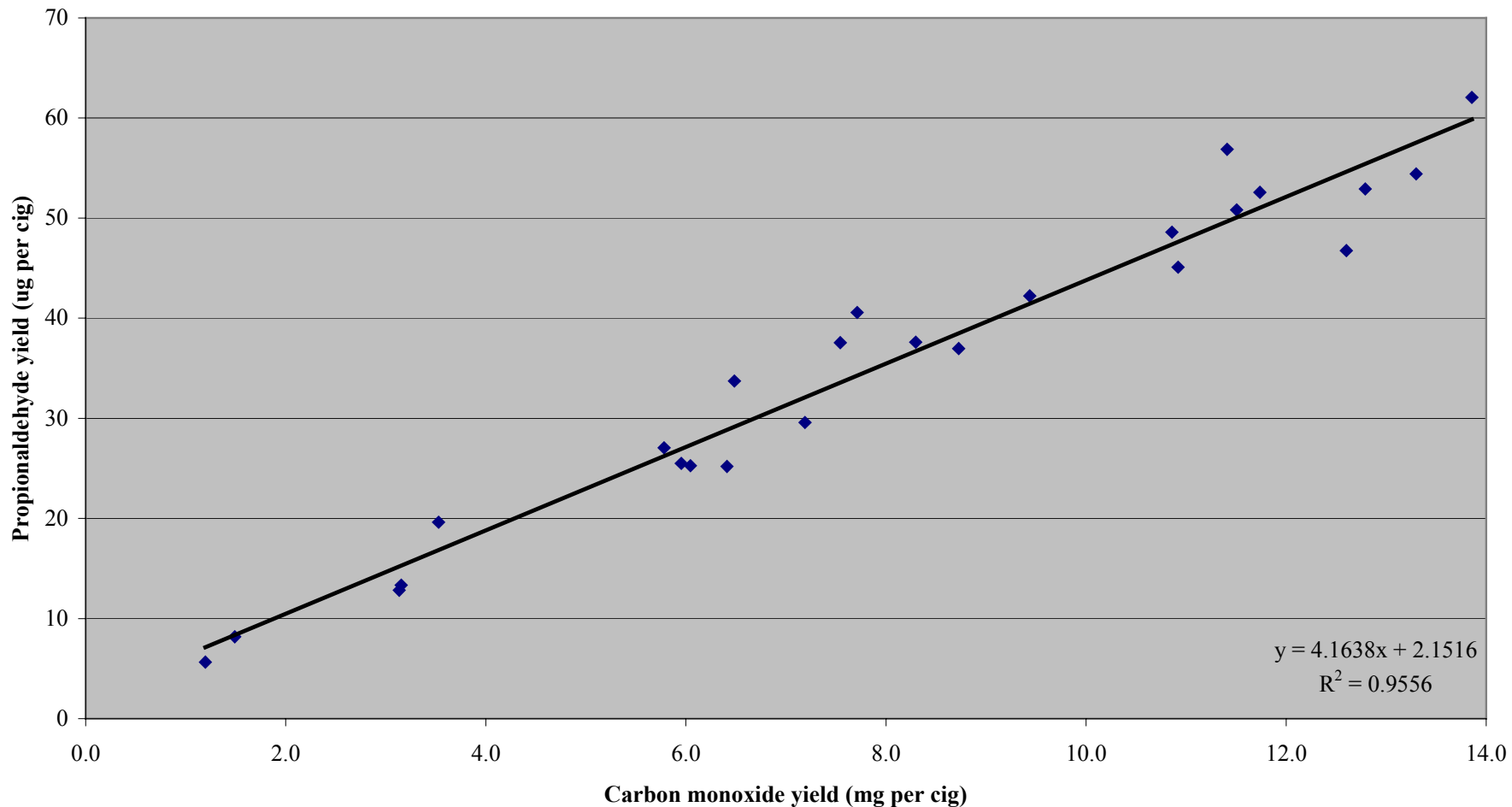
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 12 - Regression analysis of acrolein versus carbon monoxide for 25 cigarette brands



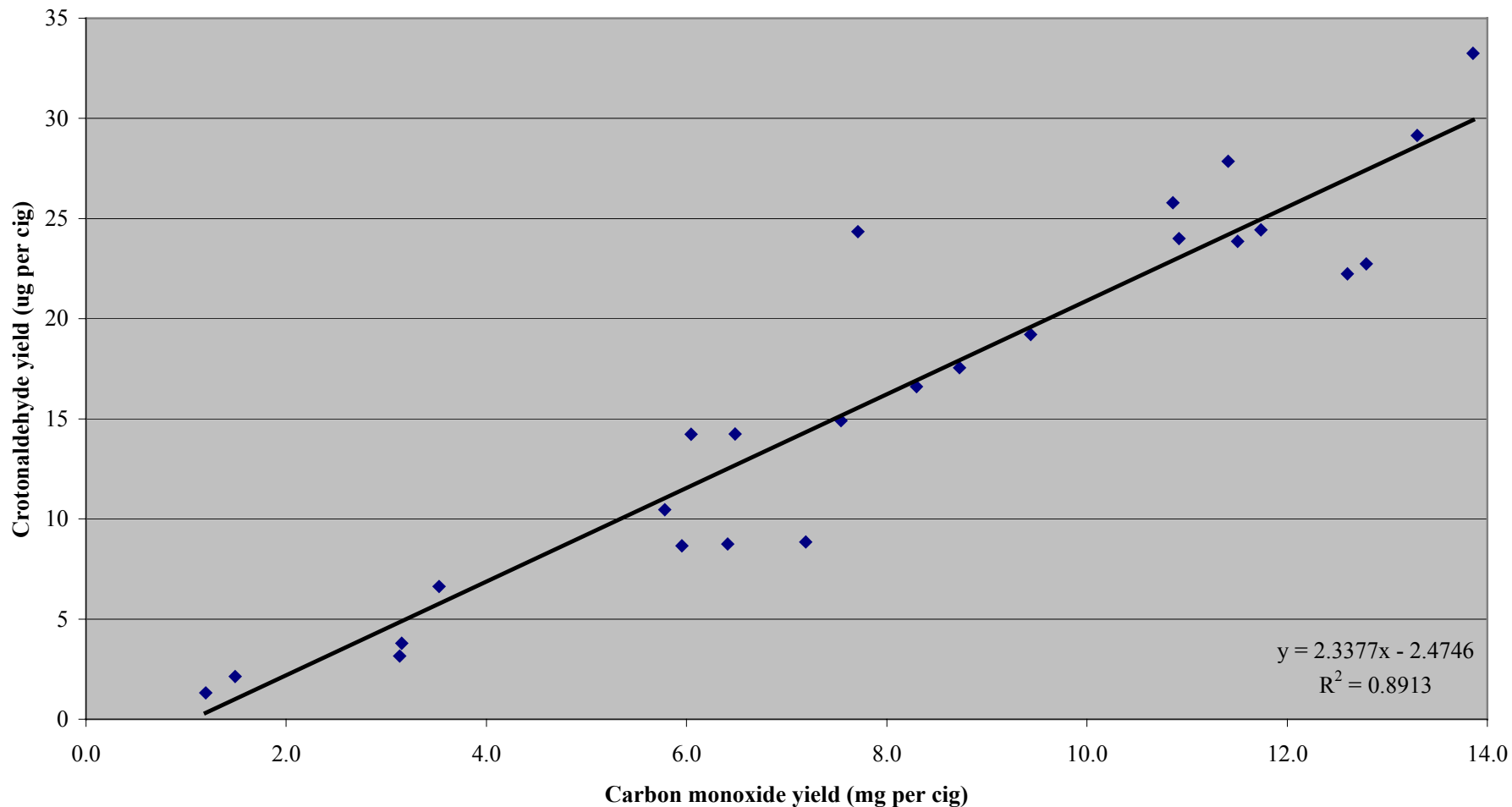
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Fig. 13 - Regression analysis of propionaldehyde versus carbon monoxide for 25 brands



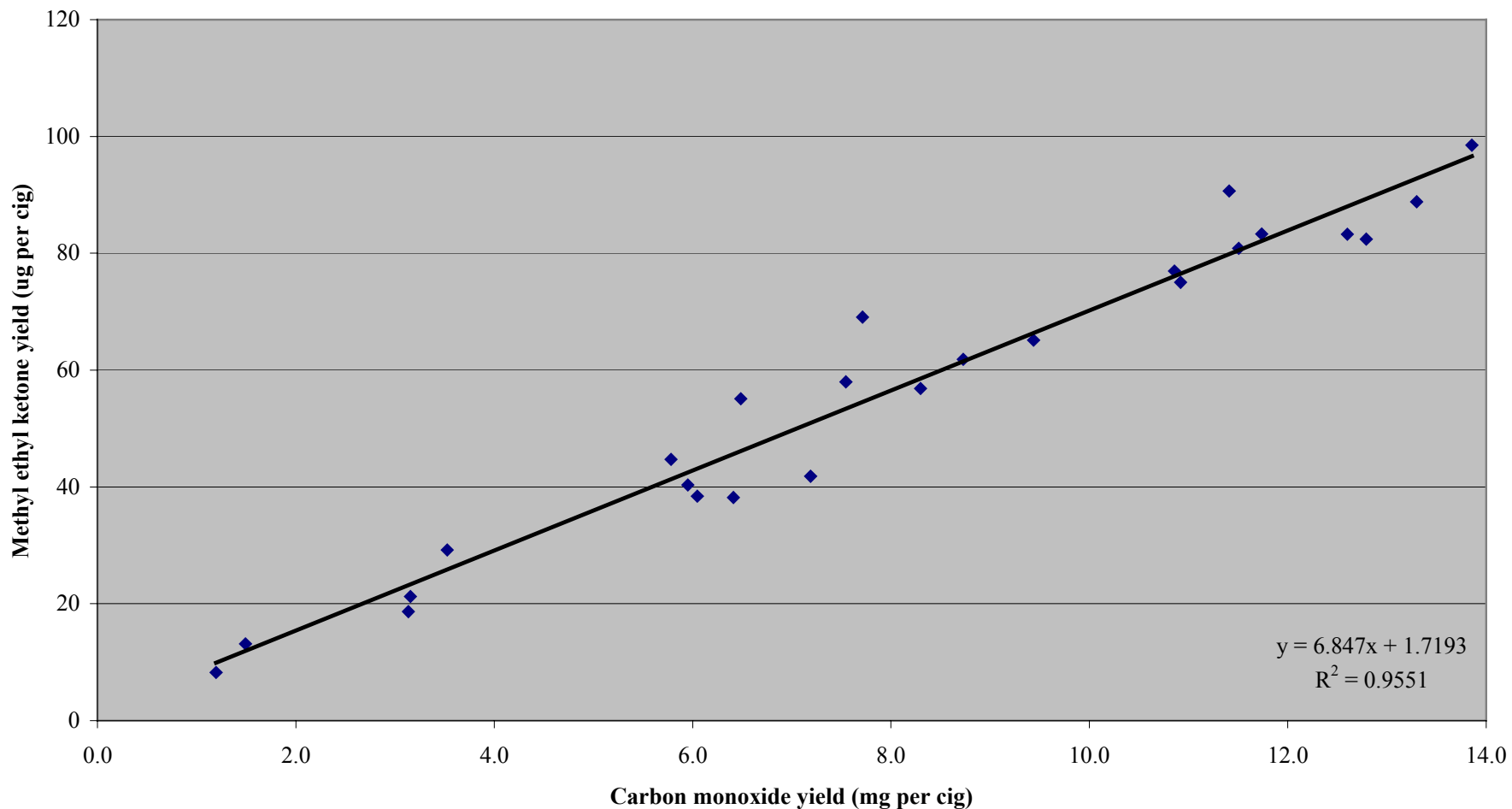
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Figure 14 - Regression analysis of crotonaldehyde versus carbon monoxide for 25 brands



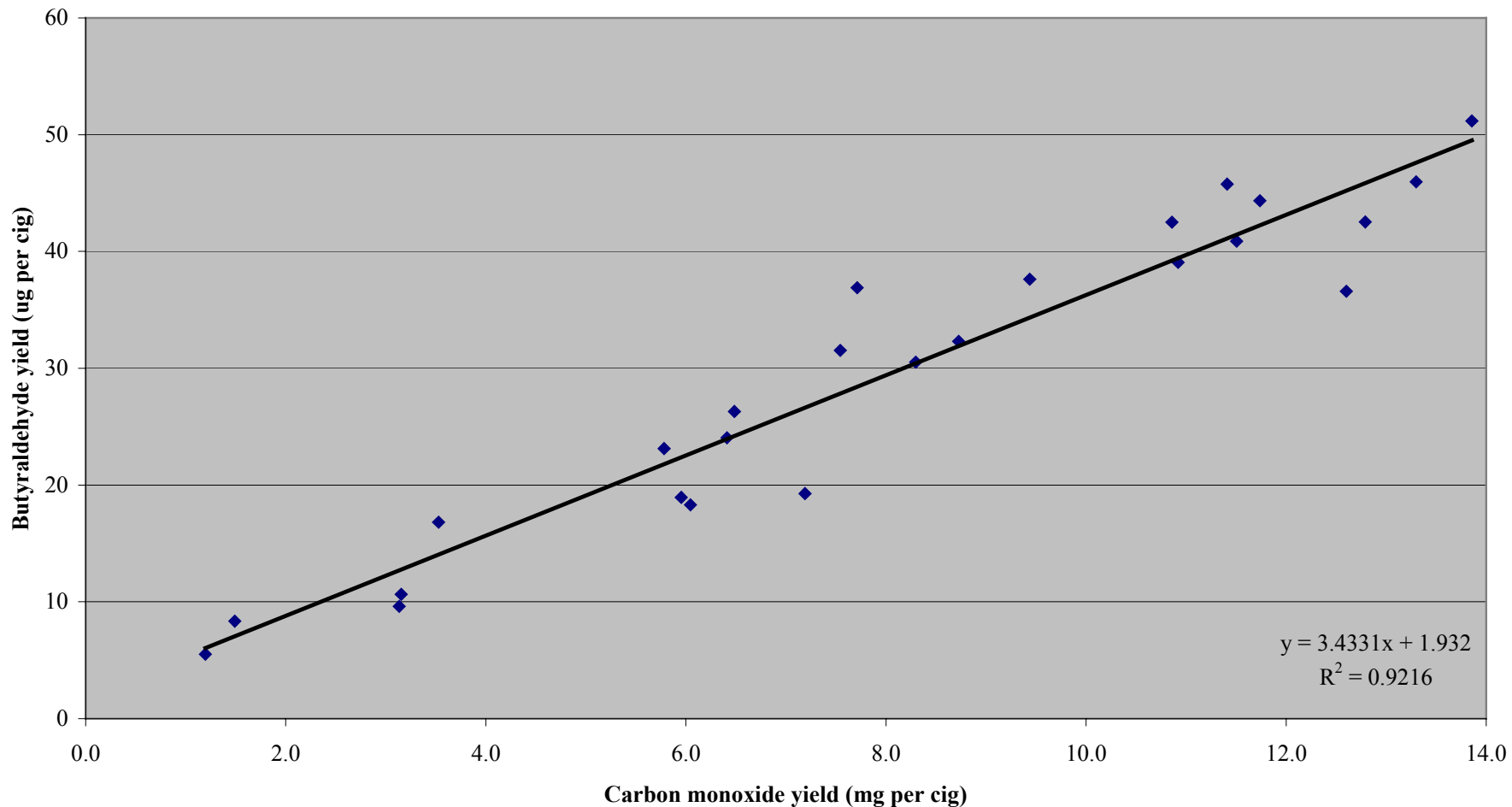
The regression analysis trend line has been calculated on the basis of a linear relationship ($y = mx + c$)

Fig. 15 - Regression analysis of methyl ethyl ketone versus carbon monoxide for 25 brands



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

Figure 16 - Regression analysis of butyraldehyde versus carbon monoxide for 25 brands



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

1R4F**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1810 | 18.9 | 722 | 300 | 56.7 | 54.1 | 18.1 | 76.2 | 40.7 |
| 2205 | 18.7 | 683 | 292 | 53.5 | 50.3 | 15.3 | 74.0 | 40.1 |
| 2502 | 14.7 | 653 | 280 | 51.8 | 48.3 | 14.9 | 71.4 | 36.7 |
| 2801 | 21.4 | 805 | 339 | 61.0 | 59.4 | 20.5 | 87.7 | 44.7 |
| 3005 | 17.6 | 684 | 287 | 52.1 | 51.8 | 15.0 | 73.4 | 39.5 |
| Mean (ug/cig) | 18.3 | 709 | 299 | 55.0 | 52.8 | 16.8 | 76.5 | 40.3 |
| Standard Deviation | 2.40 | 58.7 | 23.3 | 3.87 | 4.27 | 2.45 | 6.45 | 2.87 |
| CV (%) | 13.1 | 8.3 | 7.8 | 7.0 | 8.1 | 14.6 | 8.4 | 7.1 |

Outlier Test

Dixons outlier test was applied to the above data

| Data sorted | 14.744 | 652.978 | 279.772 | 51.754 | 48.298 | 14.876 | 71.432 | 36.704 |
|-------------|--------|---------|---------|--------|--------|--------|--------|--------|
| | 17.638 | 683.36 | 286.896 | 52.116 | 50.344 | 15.042 | 73.432 | 39.484 |
| | 18.692 | 683.872 | 291.552 | 53.462 | 51.8 | 15.302 | 73.984 | 40.096 |
| | 18.916 | 721.876 | 300.224 | 56.708 | 54.114 | 18.088 | 76.182 | 40.718 |
| | 21.356 | 804.966 | 338.906 | 60.992 | 59.426 | 20.452 | 87.684 | 44.668 |

Statistical test applied

| Dixons low end test | 0.438 | 0.200 | 0.120 | 0.039 | 0.184 | 0.030 | 0.123 | 0.349 |
|--------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.369 | 0.547 | 0.654 | 0.464 | 0.477 | 0.424 | 0.708 | 0.496 |
| 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) | 18.3 | 709 | 299 | 55.0 | 52.8 | 16.8 | 76.5 | 40.3 |
| Standard Deviation | 2.40 | 58.7 | 23.3 | 3.87 | 4.27 | 2.45 | 6.45 | 2.87 |
| CV (%) | 13.1 | 8.3 | 7.8 | 7.0 | 8.1 | 14.6 | 8.4 | 7.1 |

1R5F**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 2303 | 2.63 | 187 | 88.3 | 13.0 | 14.0 | 2.72 | 18.9 | 9.78 |
| 2603 | 3.27 | 190 | 88.3 | 13.1 | 13.7 | 2.84 | 18.7 | 9.16 |
| 2709 | 4.33 | 190 | 89.6 | 13.1 | 14.2 | 2.97 | 19.2 | 9.57 |
| 1702 | 2.89 | 189 | 90.2 | 12.9 | 14.4 | 3.03 | 18.6 | 9.40 |
| 3105 | 2.54 | 160 | 80.6 | 10.8 | 12.4 | 2.27 | 16.5 | 9.91 |
| Mean (ug/cig) | 3.13 | 183 | 87.4 | 12.6 | 13.7 | 2.77 | 18.4 | 9.57 |
| Standard Deviation | 0.73 | 12.7 | 3.9 | 1.02 | 0.81 | 0.30 | 1.07 | 0.30 |
| CV (%) | 23.2 | 7.0 | 4.5 | 8.1 | 5.9 | 10.9 | 5.8 | 3.1 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------|-------|---------|--------|--------|--------|-------|--------|-------|
| Data sorted | 2.542 | 160.436 | 80.58 | 10.773 | 12.363 | 2.271 | 16.502 | 9.16 |
| | 2.632 | 186.5 | 88.281 | 12.931 | 13.732 | 2.723 | 18.584 | 9.403 |
| | 2.887 | 188.803 | 88.292 | 13.046 | 13.952 | 2.837 | 18.726 | 9.572 |
| | 3.274 | 189.539 | 89.627 | 13.088 | 14.185 | 2.969 | 18.86 | 9.782 |
| | 4.333 | 190.148 | 90.249 | 13.111 | 14.421 | 3.026 | 19.206 | 9.912 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.050 | 0.877 | 0.796 | 0.923 | 0.665 | 0.599 | 0.770 | 0.323 |
| Outlier detected at 95% | | 95% | 95% | 95% | | | 95% | |
| Dixons high end test | 0.591 | 0.020 | 0.064 | 0.010 | 0.115 | 0.075 | 0.128 | 0.173 |
| 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) | 3.13 | 189 | 89.1 | 13.0 | 13.7 | 2.77 | 18.8 | 9.57 |
| Standard Deviation | 0.73 | 1.6 | 0.99 | 0.08 | 0.81 | 0.30 | 0.27 | 0.30 |
| CV (%) | 23.2 | 0.8 | 1.1 | 0.6 | 5.9 | 10.9 | 1.4 | 3.1 |

Benson & Hedges King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 2005 | 23.8 | 649 | 278 | 56.4 | 47.1 | 22.0 | 76.3 | 41.2 |
| 3201 | 24.0 | 711 | 306 | 56.6 | 52.6 | 22.7 | 82.3 | 42.3 |
| 2509 | 29.9 | 699 | 304 | 59.8 | 50.0 | 24.3 | 83.9 | 43.4 |
| 2807 | 32.7 | 808 | 342 | 68.6 | 61.0 | 28.2 | 92.0 | 50.9 |
| 1708 | 30.1 | 733 | 307 | 58.2 | 52.3 | 25.1 | 81.9 | 43.9 |
| Mean (ug/cig) | 28.1 | 720 | 307 | 59.9 | 52.6 | 24.4 | 83.3 | 44.3 |
| Standard Deviation | 3.96 | 58.1 | 22.7 | 5.05 | 5.18 | 2.44 | 5.64 | 3.79 |
| CV (%) | 14.1 | 8.1 | 7.4 | 8.4 | 9.9 | 10.0 | 6.8 | 8.5 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|------------|--------|--------|--------|------------|
| Data sorted | 23.784 | 649.17 | 278.416 | 56.426 | 47.098 | 21.956 | 76.328 | 41.196 |
| | 24.046 | 698.758 | 303.534 | 56.554 | 49.956 | 22.654 | 81.936 | 42.342 |
| | 29.868 | 711.186 | 306.276 | 58.192 | 52.27 | 24.27 | 82.294 | 43.408 |
| | 30.05 | 732.742 | 306.594 | 59.756 | 52.624 | 25.09 | 83.884 | 43.942 |
| | 32.658 | 808.238 | 342.032 | 68.616 | 60.97 | 28.182 | 91.98 | 50.858 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.030 | 0.312 | 0.395 | 0.011 | 0.206 | 0.112 | 0.358 | 0.119 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.294 | 0.475 | 0.557 | 0.727 | 0.602 | 0.497 | 0.517 | 0.716 |
| Outlier detected at 95% | | | | 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) | 28.1 | 720 | 307 | 57.7 | 52.6 | 24.4 | 83.3 | 42.7 |
| Standard Deviation | 3.96 | 58.1 | 22.7 | 1.57 | 5.18 | 2.44 | 5.64 | 1.22 |
| CV (%) | 14.1 | 8.1 | 7.4 | 2.7 | 9.9 | 10.0 | 6.8 | 2.8 |

Berkely Superkings**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1907 | 24.6 | 709 | 309 | 53.6 | 50.5 | 25.9 | 83.1 | 41.3 |
| 2204 | 27.7 | 758 | 325 | 62.7 | 53.7 | 24.2 | 86.7 | 45.5 |
| 2501 | 27.4 | 710 | 309 | 63.7 | 50.0 | 23.6 | 83.4 | 42.6 |
| 3207 | 28.5 | 634 | 272 | 55.4 | 46.6 | 21.8 | 71.6 | 31.7 |
| 3004 | 29.1 | 715 | 300 | 62.7 | 53.3 | 23.8 | 79.6 | 43.2 |
| Mean (ug/cig) | 27.4 | 705 | 303 | 59.6 | 50.8 | 23.9 | 80.9 | 40.9 |
| Standard Deviation | 1.73 | 44.6 | 19.4 | 4.73 | 2.85 | 1.46 | 5.77 | 5.37 |
| CV (%) | 6.3 | 6.3 | 6.4 | 7.9 | 5.6 | 6.1 | 7.1 | 13.1 |

Outlier Test

Dixons outlier test was applied to the above data

| Data sorted | 24.568 | 634.092 | 272.398 | 53.606 | 46.63 | 21.836 | 71.56 | 31.67 |
|-------------|--------|---------|---------|--------|--------|--------|--------|--------|
| | 27.428 | 709.264 | 299.65 | 55.37 | 50.036 | 23.552 | 79.59 | 41.302 |
| | 27.704 | 709.586 | 308.5 | 62.654 | 50.454 | 23.82 | 83.08 | 42.634 |
| | 28.452 | 715.132 | 309.498 | 62.684 | 53.272 | 24.164 | 83.386 | 43.242 |
| | 29.066 | 757.654 | 325.172 | 63.708 | 53.688 | 25.914 | 86.666 | 45.538 |

Statistical test applied

Dixons low end test 0.636 0.608 0.516 0.175 0.483 0.421 0.532 0.695

Outlier detected at 95%

Dixons high end test 0.137 0.344 0.297 0.101 0.059 0.429 0.217 0.166

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) | 27.4 | 705 | 303 | 60 | 50.8 | 23.9 | 80.9 | 40.9 |
| Standard Deviation | 1.73 | 44.6 | 19.4 | 4.73 | 2.85 | 1.46 | 5.77 | 5.37 |
| CV (%) | 6.3 | 6.3 | 6.4 | 7.9 | 5.6 | 6.1 | 7.1 | 13.1 |

r = Analysis repeated - original result discarded as carbon monoxide yield outside range

Camel Ultra Lights**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1906 | 3.09 | 162 | 78.7 | 10.8 | 12.3 | 3.53 | 17.8 | 9.07 |
| 2203 | 3.09 | 143 | 72.4 | 10.4 | 11.4 | 2.55 | 16.2 | 8.61 |
| 2410 | 4.19 | 167 | 81.7 | 12.9 | 11.9 | 3.02 | 18.3 | 9.50 |
| 2707 | 5.54 | 200 | 102 | 15.5 | 15.6 | 4.02 | 23.0 | 11.55 |
| 3003 | 3.96 | 164 | 81.0 | 12.3 | 13.0 | 2.66 | 18.0 | 9.31 |
| Mean (ug/cig) | 3.97 | 167 | 83.1 | 12.4 | 12.8 | 3.15 | 18.7 | 9.6 |
| Standard Deviation | 1.01 | 20.3 | 11.0 | 2.04 | 1.65 | 0.62 | 2.57 | 1.14 |
| CV (%) | 25.4 | 12.1 | 13.3 | 16.5 | 12.9 | 19.5 | 13.8 | 11.8 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|-------|---------|---------|--------|--------|-------|--------|--------|
| Data sorted | 3.088 | 143.467 | 72.434 | 10.421 | 11.393 | 2.549 | 16.244 | 8.605 |
| | 3.089 | 162.111 | 78.739 | 10.751 | 11.873 | 2.659 | 17.772 | 9.069 |
| | 3.962 | 164.441 | 80.961 | 12.339 | 12.266 | 3.019 | 17.971 | 9.306 |
| | 4.187 | 167.22 | 81.662 | 12.864 | 12.973 | 3.526 | 18.297 | 9.498 |
| | 5.544 | 199.682 | 101.748 | 15.536 | 15.582 | 4.018 | 23.032 | 11.548 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.000 | 0.332 | 0.215 | 0.065 | 0.115 | 0.075 | 0.225 | 0.158 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.553 | 0.577 | 0.685 | 0.522 | 0.623 | 0.335 | 0.698 | 0.697 |
| 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) | 4.0 | 167 | 83 | 12 | 12.8 | 3.2 | 18.7 | 9.6 |
| Standard Deviation | 1.01 | 20.3 | 11.0 | 2.04 | 1.65 | 0.62 | 2.57 | 1.14 |
| CV (%) | 25.4 | 12.1 | 13.3 | 16.5 | 12.9 | 19.5 | 13.8 | 11.8 |

Consulate Menthol**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1902 | 23.8 | 500 | 210 | 39.9 | 35.5 | 17.6 | 56.5 | 30.8 |
| 2109 | 25.3 | 518 | 216 | 47.9 | 37.5 | 15.4 | 55.4 | 25.0 |
| 2406 | 19.0 | 439 | 188 | 38.7 | 32.0 | 13.5 | 48.9 | 25.4 |
| 2703 | 29.8 | 564 | 234 | 51.9 | 40.5 | 18.9 | 61.3 | 35.9 |
| 2910 | 29.6 | 552 | 236 | 51.7 | 42.5 | 17.6 | 62.1 | 35.5 |
| Mean (ug/cig) | 25.5 | 514 | 217 | 46.0 | 37.6 | 16.6 | 56.8 | 30.5 |
| Standard Deviation | 4.49 | 49.4 | 19.7 | 6.33 | 4.10 | 2.16 | 5.33 | 5.26 |
| CV (%) | 17.6 | 9.6 | 9.1 | 13.8 | 10.9 | 13.0 | 9.4 | 17.2 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|-------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 18.974 | 438.73 | 187.954 | 38.682 | 32.036 | 13.464 | 48.869 | 25.023 |
| | 23.837 | 500.101 | 210.108 | 39.916 | 35.547 | 15.447 | 55.358 | 25.384 |
| | 25.26 | 518.037 | 215.895 | 47.896 | 37.482 | 17.595 | 56.506 | 30.826 |
| | 29.62 | 551.699 | 234.218 | 51.662 | 40.538 | 17.617 | 61.302 | 35.525 |
| | 29.756 | 563.738 | 236.076 | 51.855 | 42.45 | 18.927 | 62.128 | 35.895 |

Statistical test applied

Dixons low end test 0.451 0.491 0.460 0.094 0.337 0.363 0.489 0.033

Outlier detected at 95%

Dixons high end test 0.013 0.096 0.039 0.015 0.184 0.240 0.062 0.034

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) | 25.49 | 514 | 217 | 46.0 | 37.6 | 16.6 | 56.8 | 30.5 |
| Standard Deviation | 4.49 | 49.4 | 19.7 | 6.33 | 4.10 | 2.16 | 5.33 | 5.26 |
| CV (%) | 17.6 | 9.6 | 9.1 | 13.8 | 10.9 | 13.0 | 9.4 | 17.2 |

Yields were higher than expected and exceeded the calibration range in some cases

Therefore a check was performed by testing additional samples and diluting the solution by half before analysis

| | | | | | | | | |
|--------------------|------|------|------|------|------|------|------|------|
| 3101 | 22.9 | 488 | 208 | 45.0 | 36.4 | 14.2 | 51.9 | 28.9 |
| 3103 | 29.3 | 542 | 226 | 50.9 | 40.4 | 17.1 | 57.3 | 34.0 |
| 3106 | 14.3 | 464 | 200 | 14.0 | 34.1 | 15.4 | 50.8 | 26.1 |
| 3108 | 22.7 | 479 | 207 | 43.6 | 36.1 | 15.5 | 53.4 | 28.0 |
| Mean (ug/cig) | 22.3 | 493 | 210 | 38.4 | 36.7 | 15.5 | 53.3 | 29.2 |
| Standard Deviation | 6.12 | 34.3 | 10.9 | 16.5 | 2.64 | 1.16 | 2.86 | 3.37 |
| CV (%) | 27.5 | 7.0 | 5.2 | 43.1 | 7.2 | 7.5 | 5.4 | 11.5 |

Gitanes Caporal Filter**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1909 | 14.1 | 599 | 257 | 38.0 | 44.0 | 21.1 | 70.8 | 29.4 |
| 2207 | 14.9 | 705 | 318 | 45.6 | 32.4 | 22.6 | 88.9 | 32.5 |
| 2504 | 15.3 | 664 | 297 | 46.7 | 49.0 | 21.0 | 82.5 | 38.4 |
| 2802 | 18.2 | 721 | 311 | 48.9 | 53.0 | 22.6 | 84.7 | 40.7 |
| 1703 | 14.8 | 745 | 333 | 49.8 | 55.4 | 24.0 | 89.3 | 41.9 |
| Mean (ug/cig) | 15.4 | 687 | 303 | 45.8 | 46.7 | 22.2 | 83.2 | 36.6 |
| Standard Deviation | 1.59 | 57.2 | 28.9 | 4.66 | 9.12 | 1.23 | 7.51 | 5.40 |
| CV (%) | 10.3 | 8.3 | 9.5 | 10.2 | 19.5 | 5.5 | 9.0 | 14.7 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 14.094 | 598.776 | 257.112 | 38.004 | 32.358 | 21.004 | 70.82 | 29.412 |
| | 14.756 | 663.806 | 297.356 | 45.566 | 44.034 | 21.066 | 82.474 | 32.548 |
| | 14.906 | 704.874 | 311.498 | 46.728 | 48.984 | 22.582 | 84.712 | 38.386 |
| | 15.25 | 720.772 | 317.762 | 48.864 | 52.99 | 22.584 | 88.902 | 40.716 |
| | 18.18 | 744.554 | 333.41 | 49.756 | 55.372 | 23.952 | 89.278 | 41.914 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.162 | 0.446 | 0.527 | 0.643 | 0.507 | 0.021 | 0.631 | 0.251 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.717 | 0.163 | 0.205 | 0.076 | 0.104 | 0.464 | 0.020 | 0.096 |
| 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) | 14.8 | 687 | 303 | 45.8 | 46.7 | 22.2 | 83.2 | 36.6 |
| Standard Deviation | 0.48 | 57.2 | 28.9 | 4.66 | 9.12 | 1.23 | 7.51 | 5.40 |
| CV (%) | 3.3 | 8.3 | 9.5 | 10.2 | 19.5 | 5.5 | 9.0 | 14.7 |

Lambert & Butler King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1802 | 46.4 | 711 | 306 | 61.8 | 51.4 | 27.8 | 86.7 | 43.5 |
| 1910 | 50.4 | 717 | 298 | 61.0 | 50.9 | 29.6 | 82.2 | 43.6 |
| 2314 | 54.8 | 815 | 349 | 74.3 | 58.7 | 29.9 | 99.9 | 49.7 |
| 2604 | 54.9 | 730 | 295 | 71.6 | 52.6 | 27.3 | 79.2 | 41.8 |
| 2901 | 55.0 | 816 | 341 | 76.9 | 58.4 | 31.1 | 96.2 | 51.2 |
| Mean (ug/cig) | 52.3 | 758 | 318 | 69.1 | 54.4 | 29.14 | 88.8 | 46.0 |
| Standard Deviation | 3.82 | 53.0 | 25.5 | 7.27 | 3.84 | 1.57 | 8.92 | 4.22 |
| CV (%) | 7.3 | 7.0 | 8.0 | 10.5 | 7.1 | 5.4 | 10.0 | 9.2 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|-------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 46.414 | 710.906 | 295.098 | 61.02 | 50.946 | 27.328 | 79.152 | 41.772 |
| | 50.384 | 717.41 | 297.64 | 61.824 | 51.428 | 27.774 | 82.176 | 43.464 |
| | 54.754 | 730.49 | 305.524 | 71.602 | 52.558 | 29.582 | 86.734 | 43.618 |
| | 54.924 | 815.3 | 341.49 | 74.25 | 58.426 | 29.942 | 96.232 | 49.69 |
| | 54.966 | 815.892 | 348.96 | 76.89 | 58.704 | 31.092 | 99.852 | 51.244 |

Statistical test applied

Dixons low end test 0.464 0.062 0.047 0.051 0.062 0.118 0.146 0.179

Outlier detected at 95%

Dixons high end test 0.005 0.006 0.139 0.166 0.036 0.306 0.175 0.164

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) | 52.3 | 758 | 318 | 69 | 54.4 | 29.1 | 88.8 | 46.0 |
| Standard Deviation | 3.82 | 53.0 | 25.5 | 7.27 | 3.84 | 1.57 | 8.92 | 4.22 |
| CV (%) | 7.3 | 7.0 | 8.0 | 10.5 | 7.1 | 5.4 | 10.0 | 9.2 |

Lambert & Butler Lights King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1805 | 20.3 | 461 | 201 | 39.6 | 33.5 | 15.7 | 56.5 | 25.9 |
| 3203 | 18.3 | 480 | 216 | 38.2 | 36.1 | 15.0 | 59.7 | 23.8 |
| 2317 | 20.6 | 450 | 193 | 39.0 | 32.1 | 13.4 | 51.5 | 27.6 |
| 2607 | 16.7 | 447 | 196 | 37.4 | 32.2 | 13.2 | 52.6 | 25.0 |
| 2904 | 20.6 | 477 | 204 | 41.3 | 34.7 | 14.0 | 55.3 | 29.2 |
| Mean (ug/cig) | 19.3 | 463 | 202 | 39.1 | 33.7 | 14.25 | 55.1 | 26.3 |
| Standard Deviation | 1.75 | 15.3 | 8.9 | 1.48 | 1.70 | 1.09 | 3.27 | 2.11 |
| CV (%) | 9.1 | 3.3 | 4.4 | 3.8 | 5.0 | 7.7 | 5.9 | 8.0 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 16.696 | 447.08 | 192.955 | 37.352 | 32.122 | 13.164 | 51.454 | 23.833 |
| | 18.324 | 449.653 | 196.057 | 38.217 | 32.194 | 13.369 | 52.597 | 24.996 |
| | 20.313 | 460.528 | 201.212 | 39.018 | 33.49 | 13.954 | 55.33 | 25.928 |
| | 20.629 | 477.309 | 204.249 | 39.575 | 34.739 | 15.036 | 56.49 | 27.562 |
| | 20.64 | 480.298 | 215.831 | 41.269 | 36.082 | 15.709 | 59.705 | 29.171 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.413 | 0.077 | 0.136 | 0.221 | 0.018 | 0.081 | 0.139 | 0.218 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.003 | 0.090 | 0.506 | 0.432 | 0.339 | 0.264 | 0.390 | 0.301 |
| 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) | 19.3 | 463 | 202 | 39 | 33.7 | 14.2 | 55.1 | 26.3 |
| Standard Deviation | 1.75 | 15.3 | 8.9 | 1.48 | 1.70 | 1.09 | 3.27 | 2.11 |
| CV (%) | 9.1 | 3.3 | 4.4 | 3.8 | 5.0 | 7.7 | 5.9 | 8.0 |

r = Analysis repeated - original result discarded as carbon monoxide yield outside range

Lambert & Butler Ultra Lights**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 2008 | 1.11 | 82.2 | 43.4 | 4.62 | 6.38 | 1.64 | 10.6 | 6.99 |
| 2312 | 1.36 | 104 | 53.7 | 5.93 | 7.87 | 2.25 | 13.0 | 8.45 |
| 2602 | 2.60 | 120.3 | 59.9 | 7.65 | 8.80 | 2.27 | 13.7 | 7.83 |
| 2810 | 2.43 | 126.5 | 64.4 | 7.74 | 9.49 | 2.32 | 15.2 | 9.76 |
| 1701 | 1.55 | 109.0 | 58.1 | 6.17 | 8.35 | 2.16 | 13.2 | 8.70 |
| Mean (ug/cig) | 1.8 | 108 | 56 | 6.4 | 8.2 | 2.13 | 13.1 | 8.3 |
| Standard Deviation | 0.66 | 17.1 | 8.0 | 1.31 | 1.17 | 0.28 | 1.67 | 1.03 |
| CV (%) | 36.7 | 15.8 | 14.3 | 20.3 | 14.3 | 13.2 | 12.7 | 12.3 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|-------|---------|--------|-------|-------|------------|--------|-------|
| Data sorted | 1.107 | 82.21 | 43.391 | 4.616 | 6.384 | 1.635 | 10.603 | 6.986 |
| | 1.362 | 104.403 | 53.743 | 5.925 | 7.866 | 2.16 | 12.958 | 7.833 |
| | 1.549 | 108.954 | 58.144 | 6.174 | 8.348 | 2.254 | 13.213 | 8.452 |
| | 2.429 | 120.286 | 59.949 | 7.653 | 8.803 | 2.268 | 13.728 | 8.704 |
| | 2.596 | 126.459 | 64.363 | 7.741 | 9.493 | 2.321 | 15.214 | 9.756 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.171 | 0.502 | 0.494 | 0.419 | 0.477 | 0.765 | 0.511 | 0.306 |
| Outlier detected at 95% | | | | | | 95% | | |
| Dixons high end test | 0.112 | 0.140 | 0.210 | 0.028 | 0.222 | 0.077 | 0.322 | 0.380 |
| 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) | 1.8 | 108 | 55.9 | 6.42 | 8.18 | 2.3 | 13.1 | 8.35 |
| Standard Deviation | 0.66 | 17.1 | 7.97 | 1.31 | 1.17 | 0.07 | 1.67 | 1.03 |
| CV (%) | 36.7 | 15.8 | 14.3 | 20.3 | 14.3 | 3.0 | 12.7 | 12.3 |

Marlboro King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1809 | 30.6 | 758 | 329 | 64.6 | 55.9 | 25.7 | 87.1 | 45.9 |
| 2107 | 31.2 | 691 | 304 | 62.5 | 51.4 | 21.5 | 79.1 | 36.4 |
| 2404 | 28.6 | 726 | 315 | 60.4 | 53.1 | 22.5 | 83.8 | 43.5 |
| 2701 | 27.8 | 686 | 299 | 60.1 | 50.8 | 21.3 | 79.4 | 41.9 |
| 2908 | 30.5 | 719 | 310 | 60.7 | 53.3 | 22.6 | 82.8 | 44.9 |
| Mean (ug/cig) | 29.7 | 716 | 311 | 61.7 | 52.9 | 22.7 | 82.4 | 42.5 |
| Standard Deviation | 1.46 | 28.9 | 11.6 | 1.86 | 2.01 | 1.77 | 3.31 | 3.72 |
| CV (%) | 4.9 | 4.0 | 3.7 | 3.0 | 3.8 | 7.8 | 4.0 | 8.8 |

Outlier Test

Dixons outlier test was applied to the above data

| Data sorted | 27.82 | 686.112 | 298.944 | 60.14 | 50.818 | 21.334 | 79.106 | 36.438 |
|-------------|--------|---------|---------|--------|--------|--------|--------|--------|
| | 28.556 | 691.168 | 303.574 | 60.44 | 51.362 | 21.476 | 79.38 | 41.868 |
| | 30.504 | 718.776 | 309.75 | 60.734 | 53.122 | 22.526 | 82.782 | 43.506 |
| | 30.562 | 725.732 | 314.69 | 62.486 | 53.336 | 22.63 | 83.802 | 44.926 |
| | 31.198 | 757.662 | 329.044 | 64.564 | 55.93 | 25.726 | 87.05 | 45.868 |

Statistical test applied

Dixons low end test 0.218 0.071 0.154 0.068 0.106 0.032 0.034 0.576

Outlier detected at 95%

Dixons high end test 0.188 0.446 0.477 0.470 0.507 0.705 0.409 0.100

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) | 29.7 | 716 | 311 | 62 | 53 | 22.7 | 82.4 | 42.5 |
| Standard Deviation | 1.46 | 28.9 | 11.6 | 1.86 | 2.01 | 1.77 | 3.31 | 3.72 |
| CV (%) | 4.9 | 4.0 | 3.7 | 3.0 | 3.8 | 7.8 | 4.0 | 8.8 |

Marlboro Lights King Size

Carbonyl yields in cigarette smoke per cigarette

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1808 | 13.9 | 402 | 176 | 34.6 | 30.3 | 10.2 | 43.2 | 19.5 |
| 2106 | 10.6 | 383 | 168 | 33.5 | 27.9 | 8.2 | 40.6 | 18.3 |
| 2403 | 12.0 | 410 | 176 | 34.5 | 29.7 | 8.8 | 42.7 | 19.8 |
| 3206 | 10.6 | 401 | 176 | 32.3 | 29.8 | 8.2 | 40.9 | 19.0 |
| 2907 | 15.5 | 413 | 176 | 37.1 | 30.1 | 8.7 | 41.8 | 19.7 |
| Mean (ug/cig) | 12.5 | 402 | 175 | 34.4 | 29.6 | 8.8 | 41.8 | 19.3 |
| Standard Deviation | 2.15 | 11.6 | 3.6 | 1.75 | 0.96 | 0.84 | 1.12 | 0.62 |
| CV (%) | 17.2 | 2.9 | 2.1 | 5.1 | 3.2 | 9.4 | 2.7 | 3.2 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|-------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 10.607 | 383.185 | 168.186 | 32.333 | 27.94 | 8.197 | 40.601 | 18.328 |
| | 10.629 | 401.136 | 176.109 | 33.535 | 29.747 | 8.21 | 40.909 | 19.004 |
| | 11.953 | 401.986 | 176.215 | 34.533 | 29.829 | 8.735 | 41.787 | 19.462 |
| | 13.926 | 410.298 | 176.31 | 34.555 | 30.121 | 8.845 | 42.659 | 19.733 |
| | 15.52 | 412.676 | 176.343 | 37.069 | 30.34 | 10.244 | 43.231 | 19.845 |

Statistical test applied

| | | | | | | | | |
|--------------------------------|-------|-------|------------|-------|------------|-------|-------|-------|
| Dixons low end test | 0.004 | 0.609 | 0.971 | 0.254 | 0.753 | 0.006 | 0.117 | 0.446 |
| Outlier detected at 95% | | | 95% | | 95% | | | |
| Dixons high end test | 0.324 | 0.081 | 0.004 | 0.531 | 0.091 | 0.683 | 0.217 | 0.074 |
| 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) | 12.5 | 402 | 176 | 34 | 30.0 | 8.8 | 41.8 | 19.3 |
| Standard Deviation | 2.15 | 11.6 | 0.1 | 1.75 | 0.3 | 0.84 | 1.12 | 0.62 |
| CV (%) | 17.2 | 2.9 | 0.1 | 5.1 | 0.9 | 9.4 | 2.7 | 3.2 |

Mayfair Lights King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 2004 | 19.9 | 561 | 245 | 49.2 | 39.9 | 18.7 | 66.0 | 31.8 |
| 2308 | 17.4 | 482 | 210 | 40.6 | 33.8 | 15.3 | 56.6 | 29.8 |
| 2508 | 21.5 | 530 | 238 | 48.1 | 38.0 | 19.0 | 65.2 | 34.7 |
| 2806 | 18.6 | 466 | 201 | 40.2 | 33.1 | 15.4 | 53.4 | 29.7 |
| 1707 | 18.7 | 561 | 249 | 43.6 | 40.0 | 19.4 | 68.1 | 35.5 |
| Mean (ug/cig) | 19.2 | 520 | 229 | 44.3 | 37.0 | 17.6 | 61.9 | 32.3 |
| Standard Deviation | 1.55 | 44.2 | 21.5 | 4.16 | 3.32 | 2.04 | 6.47 | 2.69 |
| CV (%) | 8.1 | 8.5 | 9.4 | 9.4 | 9.0 | 11.6 | 10.5 | 8.3 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 17.437 | 466.067 | 201.49 | 40.17 | 33.109 | 15.25 | 53.374 | 29.724 |
| | 18.626 | 481.595 | 210.348 | 40.609 | 33.802 | 15.44 | 56.586 | 29.772 |
| | 18.655 | 530.431 | 238.4 | 43.568 | 38.02 | 18.652 | 65.222 | 31.796 |
| | 19.929 | 560.624 | 245.102 | 48.096 | 39.912 | 19.014 | 65.979 | 34.706 |
| | 21.514 | 560.944 | 249.059 | 49.164 | 40.034 | 19.424 | 68.125 | 35.45 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.292 | 0.164 | 0.186 | 0.049 | 0.100 | 0.046 | 0.218 | 0.008 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.389 | 0.003 | 0.083 | 0.119 | 0.018 | 0.098 | 0.145 | 0.130 |
| 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) | 19.2 | 520 | 229 | 44.3 | 37.0 | 17.6 | 61.9 | 32.3 |
| Standard Deviation | 1.55 | 44.2 | 21.5 | 4.16 | 3.32 | 2.04 | 6.47 | 2.69 |
| CV (%) | 8.1 | 8.5 | 9.4 | 9.4 | 9.0 | 11.6 | 10.5 | 8.3 |

Yields were higher than expected and exceeded the calibration range in some cases

Therefore a check was performed by testing additional samples and diluting the solution by half before analysis

| | | | | | | | | |
|--------------------|------|------|------|------|------|------|------|------|
| 3102 | 18.5 | 510 | 228 | 44.2 | 37.3 | 15.9 | 60.1 | 32.3 |
| 3104 | 19.2 | 488 | 213 | 44.5 | 37.5 | 15.3 | 55.9 | 31.0 |
| 3107 | 17.5 | 469 | 206 | 40.4 | 33.8 | 14.8 | 53.8 | 30.9 |
| 3109 | 22.6 | 602 | 258 | 56.1 | 46.7 | 18.9 | 67.8 | 38.6 |
| Mean (ug/cig) | 19.5 | 517 | 226 | 46.3 | 38.8 | 16.2 | 59.4 | 33.2 |
| Standard Deviation | 2.20 | 58.9 | 23.0 | 6.80 | 5.51 | 1.84 | 6.21 | 3.64 |
| CV (%) | 11.3 | 11.4 | 10.2 | 14.7 | 14.2 | 11.4 | 10.5 | 11.0 |

Mayfair Menthol King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 2006 | 9.58 | 345 | 158 | 28.3 | 25.4 | 8.53 | 40.8 | 17.6 |
| 3202 | 9.07 | 365 | 164 | 26.8 | 26.9 | 8.59 | 39.5 | 19.2 |
| 2510 | 12.0 | 368 | 173 | 30.3 | 26.8 | 9.53 | 44.8 | 21.6 |
| 2808 | 10.4 | 332 | 151 | 25.9 | 24.0 | 8.04 | 38.3 | 19.2 |
| 1709 | 10.2 | 335 | 152 | 25.3 | 24.3 | 8.60 | 38.3 | 17.2 |
| Mean (ug/cig) | 10.3 | 349 | 160 | 27.3 | 25.5 | 8.7 | 40.3 | 19.0 |
| Standard Deviation | 1.12 | 16.9 | 9.15 | 2.02 | 1.36 | 0.54 | 2.70 | 1.74 |
| CV (%) | 10.9 | 4.8 | 5.7 | 7.4 | 5.3 | 6.2 | 6.7 | 9.2 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|--------|--------|-------|--------|--------|
| Data sorted | 9.066 | 331.716 | 151.101 | 25.307 | 24.026 | 8.038 | 38.3 | 17.213 |
| | 9.584 | 335.476 | 151.513 | 25.926 | 24.305 | 8.532 | 38.339 | 17.58 |
| | 10.243 | 344.735 | 158.407 | 26.776 | 25.427 | 8.59 | 39.464 | 19.163 |
| | 10.435 | 365.139 | 163.582 | 28.318 | 26.838 | 8.6 | 40.833 | 19.191 |
| | 12.019 | 368.466 | 173.029 | 30.332 | 26.926 | 9.531 | 44.807 | 21.606 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.175 | 0.102 | 0.019 | 0.123 | 0.096 | 0.331 | 0.006 | 0.084 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.536 | 0.091 | 0.431 | 0.401 | 0.030 | 0.624 | 0.611 | 0.550 |
| 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) | 10.3 | 349 | 160 | 27.3 | 25.5 | 8.7 | 40.3 | 19.0 |
| Standard Deviation | 1.12 | 16.9 | 9.2 | 2.02 | 1.36 | 0.54 | 2.70 | 1.74 |
| CV (%) | 10.9 | 4.8 | 5.7 | 7.4 | 5.3 | 6.2 | 6.7 | 9.2 |

Red Band Lights King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 2007 | 9.73 | 315 | 148 | 24.7 | 23.0 | 7.60 | 37.4 | 21.0 |
| 2311 | 11.26 | 337 | 139 | 27.0 | 23.7 | 7.68 | 33.6 | 22.5 |
| 2601 | 12.14 | 352 | 151 | 28.7 | 25.3 | 8.48 | 37.0 | 24.1 |
| 2809 | 13.43 | 360 | 156 | 29.2 | 25.8 | 9.26 | 38.9 | 24.9 |
| 1710 | 14.08 | 390 | 176 | 31.8 | 28.1 | 10.7 | 43.9 | 27.7 |
| Mean (ug/cig) | 12.1 | 351 | 154 | 28.3 | 25.2 | 8.75 | 38.2 | 24.0 |
| Standard Deviation | 1.73 | 27.6 | 13.7 | 2.62 | 1.99 | 1.30 | 3.75 | 2.54 |
| CV (%) | 14.3 | 7.9 | 8.9 | 9.3 | 7.9 | 14.8 | 9.8 | 10.6 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 9.734 | 315.055 | 147.693 | 24.721 | 22.998 | 7.603 | 33.643 | 20.976 |
| | 11.258 | 337.495 | 139.329 | 27.028 | 23.741 | 7.683 | 37.017 | 22.526 |
| | 12.141 | 351.902 | 150.887 | 28.686 | 25.258 | 8.475 | 37.408 | 24.107 |
| | 13.428 | 359.729 | 156.231 | 29.193 | 25.838 | 9.255 | 38.937 | 24.879 |
| | 14.075 | 389.596 | 175.865 | 31.777 | 28.095 | 10.734 | 43.933 | 27.715 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.351 | 0.301 | -0.297 | 0.327 | 0.146 | 0.026 | 0.328 | 0.230 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.149 | 0.401 | 0.697 | 0.366 | 0.443 | 0.472 | 0.486 | 0.421 |
| 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) | 12.1 | 351 | 154 | 28.3 | 25.2 | 8.8 | 38.2 | 24.0 |
| Standard Deviation | 1.73 | 27.6 | 13.7 | 2.62 | 1.99 | 1.30 | 3.75 | 2.54 |
| CV (%) | 14.3 | 7.9 | 8.9 | 9.3 | 7.9 | 14.8 | 9.8 | 10.6 |

Regal Filter

Carbonyl yields in cigarette smoke per cigarette

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1801 | 38.6 | 638 | 271 | 54.9 | 45.7 | 25.4 | 75.7 | 38.7 |
| 2009 | 39.3 | 598 | 255 | 54.4 | 42.9 | 22.7 | 71.8 | 38.4 |
| 2206 | 33.5 | 642 | 283 | 50.0 | 46.5 | 23.6 | 82.6 | 41.4 |
| 2503 | 49.3 | 673 | 274 | 72.7 | 47.6 | 26.1 | 76.4 | 39.5 |
| 2710 | 35.1 | 603 | 249 | 55.1 | 42.7 | 22.2 | 68.6 | 37.3 |
| Mean (ug/cig) | 39.2 | 631 | 266 | 57.4 | 45.1 | 24.01 | 75.0 | 39.1 |
| Standard Deviation | 6.13 | 31.0 | 14.2 | 8.79 | 2.20 | 1.69 | 5.28 | 1.54 |
| CV (%) | 15.6 | 4.9 | 5.3 | 15.3 | 4.9 | 7.0 | 7.0 | 3.9 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|------------|--------|--------|--------|--------|
| Data sorted | 33.546 | 597.758 | 248.91 | 49.956 | 42.67 | 22.228 | 68.618 | 37.328 |
| | 35.136 | 603.236 | 255.01 | 54.396 | 42.924 | 22.718 | 71.796 | 38.4 |
| | 38.568 | 637.746 | 271.076 | 54.926 | 45.746 | 23.572 | 75.664 | 38.678 |
| | 39.304 | 642.236 | 273.96 | 55.098 | 46.466 | 25.414 | 76.362 | 39.502 |
| | 49.264 | 673.376 | 283.346 | 72.674 | 47.634 | 26.098 | 82.638 | 41.444 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.101 | 0.072 | 0.177 | 0.195 | 0.051 | 0.127 | 0.227 | 0.260 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.634 | 0.412 | 0.273 | 0.774 | 0.235 | 0.177 | 0.448 | 0.472 |
| 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) | 39.2 | 631 | 266 | 53.6 | 45.1 | 24.0 | 75.0 | 39.1 |
| Standard Deviation | 6.13 | 31.0 | 14.2 | 2.44 | 2.20 | 1.69 | 5.28 | 1.54 |
| CV (%) | 15.6 | 4.9 | 5.3 | 4.6 | 4.9 | 7.0 | 7.0 | 3.9 |

Regal King Size

Carbonyl yields in cigarette smoke per cigarette

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1803 | 60.7 | 1006 | 406 | 100 | 72.1 | 39.3 | 112 | 58.3 |
| 2101 | 52.8 | 822 | 345 | 84.4 | 58.6 | 30.3 | 93.0 | 47.7 |
| 2315 | 60.6 | 882 | 362 | 91.0 | 62.2 | 33.8 | 98.6 | 51.2 |
| 2605 | 58.3 | 865 | 351 | 88.9 | 61.7 | 34.1 | 96.2 | 50.3 |
| 2902 | 49.2 | 786 | 334 | 74.7 | 55.8 | 28.8 | 93.2 | 48.3 |
| Mean (ug/cig) | 56.3 | 872 | 360 | 87.8 | 62.1 | 33.25 | 98.5 | 51.2 |
| Standard Deviation | 5.12 | 83.6 | 28.0 | 9.21 | 6.15 | 4.06 | 7.67 | 4.23 |
| CV (%) | 9.1 | 9.6 | 7.8 | 10.5 | 9.9 | 12.2 | 7.8 | 8.3 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 49.16 | 785.692 | 333.558 | 74.702 | 55.82 | 28.806 | 92.988 | 47.718 |
| | 52.814 | 822.33 | 344.772 | 84.388 | 58.554 | 30.25 | 93.162 | 48.332 |
| | 58.324 | 864.748 | 351.322 | 88.87 | 61.65 | 33.808 | 96.16 | 50.272 |
| | 60.57 | 881.87 | 362.398 | 91.028 | 62.238 | 34.128 | 98.568 | 51.228 |
| | 60.692 | 1005.84 | 406.128 | 99.808 | 72.054 | 39.264 | 111.58 | 58.286 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.317 | 0.166 | 0.155 | 0.386 | 0.168 | 0.138 | 0.009 | 0.058 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.011 | 0.563 | 0.603 | 0.350 | 0.605 | 0.491 | 0.700 | 0.668 |
| 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) | 56.3 | 872 | 360 | 88 | 62.1 | 33.3 | 98.5 | 51.2 |
| Standard Deviation | 5.12 | 83.6 | 28.0 | 9.21 | 6.15 | 4.06 | 7.67 | 4.23 |
| CV (%) | 9.1 | 9.6 | 7.8 | 10.5 | 9.9 | 12.2 | 7.8 | 8.3 |

Rothman Royals 120s**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1905 | 21.7 | 539 | 236 | 46.3 | 39.9 | 20.7 | 63.1 | 34.2 |
| 2202 | 24.5 | 556 | 237 | 53.4 | 41.5 | 18.0 | 60.7 | 36.4 |
| 2409 | 22.9 | 598 | 261 | 53.4 | 44.6 | 20.5 | 68.9 | 41.7 |
| 2706 | 22.0 | 559 | 255 | 50.7 | 41.5 | 19.0 | 65.7 | 37.6 |
| 3002 | 21.2 | 582 | 260 | 50.4 | 43.7 | 17.8 | 67.2 | 38.2 |
| Mean (ug/cig) | 22.5 | 567 | 250 | 50.8 | 42.2 | 19.2 | 65.1 | 37.6 |
| Standard Deviation | 1.30 | 23.3 | 12.3 | 2.91 | 1.88 | 1.34 | 3.25 | 2.76 |
| CV (%) | 5.8 | 4.1 | 4.9 | 5.7 | 4.5 | 7.0 | 5.0 | 7.3 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|-------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 21.166 | 538.85 | 236.156 | 46.304 | 39.942 | 17.838 | 60.724 | 34.214 |
| | 21.712 | 555.746 | 237.274 | 50.396 | 41.45 | 18.014 | 63.078 | 36.406 |
| | 22.044 | 558.656 | 254.976 | 50.716 | 41.46 | 19 | 65.668 | 37.554 |
| | 22.878 | 582.238 | 259.894 | 53.376 | 43.692 | 20.522 | 67.158 | 38.206 |
| | 24.514 | 597.696 | 261.42 | 53.408 | 44.594 | 20.674 | 68.902 | 41.748 |

Statistical test applied

Dixons low end test 0.163 0.287 0.044 0.576 0.324 0.062 0.288 0.291

Outlier detected at 95%

Dixons high end test 0.489 0.263 0.060 0.005 0.194 0.054 0.213 0.470

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) | 22.5 | 567 | 250 | 51 | 42.2 | 19.2 | 65.1 | 37.6 |
| Standard Deviation | 1.30 | 23.3 | 12.3 | 2.91 | 1.88 | 1.34 | 3.25 | 2.76 |
| CV (%) | 5.8 | 4.1 | 4.9 | 5.7 | 4.5 | 7.0 | 5.0 | 7.3 |

Rothman Royals King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1904 | 24.0 | 639 | 282 | 50.4 | 47.4 | 26.0 | 76.7 | 39.5 |
| 2010 | 38.3 | 670 | 295 | 64.9 | 49.8 | 25.9 | 78.6 | 44.1 |
| 2201 | 40.3 | 675 | 296 | 65.5 | 49.7 | 25.2 | 78.3 | 43.8 |
| 2408 | 44.7 | 681 | 293 | 67.8 | 49.6 | 27.3 | 77.5 | 43.8 |
| 2705 | 35.7 | 638 | 277 | 63.5 | 46.4 | 24.5 | 73.7 | 41.3 |
| Mean (ug/cig) | 36.6 | 661 | 289 | 62.4 | 48.6 | 25.8 | 76.9 | 42.5 |
| Standard Deviation | 7.77 | 20.8 | 8.6 | 6.92 | 1.58 | 1.04 | 1.97 | 2.03 |
| CV (%) | 21.2 | 3.1 | 3.0 | 11.1 | 3.2 | 4.0 | 2.6 | 4.8 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|------------|--------|--------|--------|--------|
| Data sorted | 24.032 | 637.562 | 276.956 | 50.38 | 46.402 | 24.52 | 73.68 | 39.516 |
| | 35.684 | 638.868 | 282.018 | 63.492 | 47.418 | 25.242 | 76.66 | 41.264 |
| | 38.312 | 669.718 | 292.814 | 64.92 | 49.636 | 25.884 | 77.522 | 43.764 |
| | 40.318 | 675.248 | 295.44 | 65.504 | 49.658 | 26.002 | 78.25 | 43.848 |
| | 44.734 | 681.244 | 295.654 | 67.844 | 49.842 | 27.326 | 78.622 | 44.11 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.563 | 0.030 | 0.271 | 0.751 | 0.295 | 0.257 | 0.603 | 0.380 |
| Outlier detected at 95% | | | | 95% | | | | |
| Dixons high end test | 0.213 | 0.137 | 0.011 | 0.134 | 0.053 | 0.472 | 0.075 | 0.057 |
| 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) | 36.6 | 661 | 289 | 65.4 | 48.6 | 25.8 | 76.9 | 42.5 |
| Standard Deviation | 7.77 | 20.8 | 8.6 | 1.81 | 1.58 | 1.04 | 1.97 | 2.03 |
| CV (%) | 21.2 | 3.1 | 3.0 | 2.8 | 3.2 | 4.0 | 2.6 | 4.8 |

Senior Service**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 2002 | 27.5 | 488 | 221 | 43.6 | 37.1 | 22.0 | 63.8 | 34.1 |
| 2209 | 32.8 | 559 | 254 | 50.3 | 43.6 | 25.6 | 73.6 | 40.1 |
| 2506 | 26.9 | 490 | 226 | 42.9 | 38.6 | 23.8 | 67.8 | 35.3 |
| 2804 | 28.2 | 549 | 249 | 47.8 | 42.6 | 24.8 | 72.4 | 38.1 |
| 1705 | 27.4 | 530 | 236 | 45.1 | 41.0 | 25.4 | 67.7 | 36.9 |
| Mean (ug/cig) | 28.6 | 523 | 237 | 46.0 | 40.6 | 24.3 | 69.1 | 36.9 |
| Standard Deviation | 2.42 | 33.0 | 14.4 | 3.09 | 2.71 | 1.49 | 3.97 | 2.34 |
| CV (%) | 8.5 | 6.3 | 6.1 | 6.7 | 6.7 | 6.1 | 5.7 | 6.3 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 26.86 | 487.912 | 221.174 | 42.92 | 37.076 | 22.016 | 63.824 | 34.072 |
| | 27.408 | 489.7 | 225.73 | 43.576 | 38.598 | 23.81 | 67.69 | 35.328 |
| | 27.494 | 529.644 | 235.568 | 45.112 | 41.028 | 24.836 | 67.834 | 36.892 |
| | 28.214 | 549.384 | 249.06 | 47.838 | 42.584 | 25.432 | 72.432 | 38.078 |
| | 32.802 | 558.666 | 254.484 | 50.322 | 43.566 | 25.648 | 73.612 | 40.068 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.092 | 0.025 | 0.137 | 0.089 | 0.235 | 0.494 | 0.395 | 0.209 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.772 | 0.131 | 0.163 | 0.336 | 0.151 | 0.059 | 0.121 | 0.332 |
| 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) | 27.5 | 523 | 237 | 46.0 | 40.6 | 24.3 | 69.1 | 36.9 |
| Standard Deviation | 0.56 | 33.0 | 14 | 3.09 | 2.71 | 1.49 | 3.97 | 2.34 |
| CV (%) | 2.0 | 6.3 | 6.1 | 6.7 | 6.7 | 6.1 | 5.7 | 6.3 |

Silk Cut Extra Mild**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1901 | 2.86 | 164 | 79.8 | 9.93 | 11.6 | 3.56 | 19.6 | 8.53 |
| 2108 | 4.19 | 174 | 83.4 | 11.97 | 12.4 | 3.39 | 20.3 | 9.71 |
| 2405 | 4.77 | 205 | 99.1 | 14.76 | 15.0 | 4.41 | 24.4 | 11.56 |
| 2702 | 3.87 | 162 | 78.6 | 11.64 | 12.0 | 3.12 | 18.0 | 10.26 |
| 2909 | 6.86 | 211 | 99.1 | 15.85 | 15.7 | 4.52 | 23.8 | 13.10 |
| Mean (ug/cig) | 4.5 | 183 | 88 | 12.8 | 13.3 | 3.8 | 21.2 | 10.6 |
| Standard Deviation | 1.49 | 23.4 | 10.3 | 2.42 | 1.86 | 0.63 | 2.75 | 1.76 |
| CV (%) | 33.0 | 12.8 | 11.7 | 18.8 | 13.9 | 16.6 | 12.9 | 16.5 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|-------|---------|--------|--------|--------|-------|--------|--------|
| Data sorted | 2.86 | 161.525 | 78.606 | 9.934 | 11.64 | 3.115 | 18.046 | 8.533 |
| | 3.866 | 163.702 | 79.792 | 11.639 | 11.988 | 3.386 | 19.625 | 9.712 |
| | 4.189 | 173.653 | 83.353 | 11.972 | 12.412 | 3.562 | 20.273 | 10.256 |
| | 4.771 | 205.081 | 99.092 | 14.756 | 15.005 | 4.41 | 23.811 | 11.558 |
| | 6.861 | 210.813 | 99.095 | 15.849 | 15.679 | 4.519 | 24.38 | 13.098 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.251 | 0.044 | 0.058 | 0.288 | 0.086 | 0.193 | 0.249 | 0.258 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.522 | 0.116 | 0.000 | 0.185 | 0.167 | 0.078 | 0.090 | 0.337 |
| 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) | 4.51 | 183 | 88.0 | 12.8 | 13.3 | 3.8 | 21.2 | 10.6 |
| Standard Deviation | 1.49 | 23.4 | 10.3 | 2.42 | 1.86 | 0.63 | 2.75 | 1.76 |
| CV (%) | 33.0 | 12.8 | 11.7 | 18.8 | 13.9 | 16.6 | 12.9 | 16.5 |

Silk Cut King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 2003 | 9.5 | 346 | 157 | 28.3 | 25.0 | 8.94 | 39.6 | 17.8 |
| 2210 | 9.5 | 358 | 165 | 27.2 | 26.8 | 9.58 | 43.1 | 22.7 |
| 2507 | 9.7 | 362 | 168 | 29.2 | 26.3 | 10.7 | 45.1 | 25.2 |
| 2805 | 10.9 | 407 | 194 | 30.9 | 30.8 | 12.7 | 52.6 | 28.2 |
| 1706 | 10.8 | 362 | 168 | 28.0 | 26.4 | 10.4 | 43.1 | 21.7 |
| Mean (ug/cig) | 10.1 | 367 | 171 | 28.7 | 27.1 | 10.5 | 44.7 | 23.1 |
| Standard Deviation | 0.73 | 23.5 | 13.8 | 1.45 | 2.21 | 1.41 | 4.83 | 3.88 |
| CV (%) | 7.2 | 6.4 | 8.1 | 5.0 | 8.1 | 13.5 | 10.8 | 16.8 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 9.453 | 345.768 | 157.39 | 27.155 | 24.961 | 8.943 | 39.641 | 17.799 |
| | 9.46 | 358.099 | 164.827 | 27.981 | 26.336 | 9.579 | 43.06 | 21.738 |
| | 9.698 | 361.687 | 168.284 | 28.284 | 26.387 | 10.448 | 43.112 | 22.68 |
| | 10.763 | 362.263 | 168.309 | 29.243 | 26.842 | 10.676 | 45.066 | 25.222 |
| | 10.931 | 407.308 | 193.942 | 30.939 | 30.805 | 12.665 | 52.594 | 28.162 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.005 | 0.200 | 0.203 | 0.218 | 0.235 | 0.171 | 0.264 | 0.380 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.114 | 0.732 | 0.701 | 0.448 | 0.678 | 0.534 | 0.581 | 0.284 |
| 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) | 10.1 | 357 | 171 | 28.7 | 27.1 | 10.5 | 44.7 | 23.1 |
| Standard Deviation | 0.73 | 7.7 | 13.8 | 1.45 | 2.21 | 1.41 | 4.83 | 3.88 |
| CV (%) | 7.2 | 2.2 | 8.1 | 5.0 | 8.1 | 13.5 | 10.8 | 16.8 |

Silk Cut Ultra King Size**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 2001 | 1.13 | 75.1 | 39.3 | 4.62 | 5.83 | 1.39 | 8.53 | 5.07 |
| 2208 | 1.04 | 70.1 | 37.5 | 3.85 | 5.62 | 1.27 | 8.11 | 6.60 |
| 2505 | 1.17 | 68.0 | 36.4 | 4.12 | 5.12 | 1.17 | 7.37 | 5.75 |
| 2803 | 1.77 | 76.4 | 41.5 | 4.73 | 5.90 | 1.38 | 8.87 | 5.04 |
| 1704 | 1.21 | 75.3 | 40.7 | 4.40 | 5.79 | 1.36 | 8.37 | 5.19 |
| Mean (ug/cig) | 1.26 | 73.0 | 39.1 | 4.34 | 5.65 | 1.31 | 8.25 | 5.53 |
| Standard Deviation | 0.29 | 3.69 | 2.12 | 0.36 | 0.31 | 0.09 | 0.56 | 0.66 |
| CV (%) | 22.8 | 5.1 | 5.4 | 8.4 | 5.5 | 7.1 | 6.8 | 12.0 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|-------|--------|--------|-------|-------|-------|-------|-------|
| Data sorted | 1.037 | 67.993 | 36.429 | 3.848 | 5.123 | 1.171 | 7.372 | 5.038 |
| | 1.131 | 70.132 | 37.487 | 4.12 | 5.623 | 1.265 | 8.109 | 5.065 |
| | 1.172 | 75.088 | 39.343 | 4.398 | 5.788 | 1.357 | 8.372 | 5.191 |
| | 1.208 | 75.286 | 40.702 | 4.619 | 5.829 | 1.38 | 8.526 | 5.746 |
| | 1.765 | 76.42 | 41.455 | 4.734 | 5.9 | 1.389 | 8.868 | 6.601 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.129 | 0.254 | 0.211 | 0.307 | 0.644 | 0.431 | 0.493 | 0.017 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.765 | 0.135 | 0.150 | 0.130 | 0.091 | 0.041 | 0.229 | 0.547 |
| 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) | 1.1 | 73.0 | 39.1 | 4.3 | 5.7 | 1.3 | 8.2 | 5.5 |
| Standard Deviation | 0.07 | 3.69 | 2.12 | 0.36 | 0.31 | 0.09 | 0.56 | 0.66 |
| CV (%) | 6.5 | 5.1 | 5.4 | 8.4 | 5.5 | 7.1 | 6.8 | 12.0 |

Superkings

Carbonyl yields in cigarette smoke per cigarette

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butryaldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1806 | 50.1 | 780 | 331 | 69.6 | 56.7 | 30.2 | 93.1 | 46.1 |
| 3208 | 42.8 | 822 | 354 | 69.3 | 61.9 | 29.2 | 96.9 | 44.5 |
| 2401 | 40.4 | 754 | 309 | 68.4 | 54.2 | 24.8 | 83.7 | 45.6 |
| 2608 | 46.5 | 759 | 314 | 68.5 | 54.9 | 27.3 | 86.3 | 44.9 |
| 2905 | 51.3 | 776 | 331 | 69.3 | 56.6 | 27.8 | 93.3 | 47.7 |
| Mean (ug/cig) | 46.2 | 778 | 328 | 69.0 | 56.9 | 27.86 | 90.7 | 45.8 |
| Standard Deviation | 4.65 | 26.5 | 17.6 | 0.54 | 3.02 | 2.06 | 5.45 | 1.26 |
| CV (%) | 10.1 | 3.4 | 5.4 | 0.8 | 5.3 | 7.4 | 6.0 | 2.7 |

Outlier Test

Dixons outlier test was applied to the above data

| Data sorted | 40.386 | 754.448 | 309.398 | 68.406 | 54.21 | 24.806 | 83.694 | 44.544 |
|-------------|--------|---------|---------|--------|--------|--------|--------|--------|
| | 42.768 | 759.288 | 313.772 | 68.466 | 54.912 | 27.322 | 86.332 | 44.882 |
| | 46.498 | 775.732 | 330.81 | 69.26 | 56.616 | 27.752 | 93.07 | 45.604 |
| | 50.114 | 780.248 | 331.044 | 69.278 | 56.748 | 29.226 | 93.314 | 46.088 |
| | 51.264 | 821.55 | 353.886 | 69.604 | 61.914 | 30.194 | 96.87 | 47.746 |

Statistical test applied

Dixons low end test 0.219 0.072 0.098 0.050 0.091 0.467 0.200 0.106

Outlier detected at 95%

Dixons high end test 0.106 0.616 0.513 0.272 0.671 0.180 0.270 0.518

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) | 46.2 | 778 | 328 | 69 | 56.9 | 27.9 | 90.7 | 45.8 |
| Standard Deviation | 4.65 | 26.5 | 17.6 | 0.54 | 3.02 | 2.06 | 5.45 | 1.26 |
| CV (%) | 10.1 | 3.4 | 5.4 | 0.8 | 5.3 | 7.4 | 6.0 | 2.7 |

Superkings Lights**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde | |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|---|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | |
| 3204 | 24.3 | 530 | 229 | 46.7 | 40.5 | 16.6 | 60.2 | 30.3 | r |
| 2105 | 17.1 | 467 | 203 | 39.1 | 34.4 | 12.8 | 55.5 | 29.5 | |
| 2402 | 23.1 | 501 | 216 | 42.6 | 36.7 | 14.7 | 57.5 | 33.3 | |
| 3205 | 20.0 | 496 | 216 | 40.2 | 37.0 | 14.1 | 55.8 | 32.0 | r |
| 2906 | 26.9 | 533 | 228 | 48.4 | 39.2 | 16.2 | 60.8 | 32.5 | |
| Mean (ug/cig) | 22.3 | 505 | 218 | 43.4 | 37.6 | 14.9 | 58.0 | 31.5 | |
| Standard Deviation | 3.82 | 27.4 | 10.9 | 4.02 | 2.38 | 1.55 | 2.43 | 1.56 | |
| CV (%) | 17.1 | 5.4 | 5.0 | 9.3 | 6.3 | 10.4 | 4.2 | 5.0 | |

Outlier Test

Dixons outlier test was applied to the above data

| Data sorted | 17.088 | 466.624 | 202.682 | 39.118 | 34.36 | 12.834 | 55.506 | 29.534 |
|-------------|--------|---------|---------|--------|--------|--------|--------|--------|
| | 19.976 | 495.684 | 215.788 | 40.248 | 36.722 | 14.126 | 55.842 | 30.294 |
| | 23.132 | 501.452 | 216.006 | 42.628 | 36.978 | 14.732 | 57.534 | 31.966 |
| | 24.322 | 530.298 | 228.156 | 46.658 | 39.208 | 16.22 | 60.212 | 32.546 |
| | 26.88 | 533.128 | 229.438 | 48.432 | 40.518 | 16.614 | 60.762 | 33.276 |

Statistical test applied

Dixons low end test 0.295 0.437 0.490 0.121 0.384 0.342 0.064 0.203

Outlier detected at 95%

Dixons high end test 0.261 0.043 0.048 0.190 0.213 0.104 0.105 0.195

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) | 22.3 | 505 | 218 | 43 | 37.6 | 14.9 | 58.0 | 31.5 |
| Standard Deviation | 3.82 | 27.4 | 10.9 | 4.02 | 2.38 | 1.55 | 2.43 | 1.56 |
| CV (%) | 17.1 | 5.4 | 5.0 | 9.3 | 6.3 | 10.4 | 4.2 | 5.0 |

r = Analysis repeated - original results discarded as carbon monoxide yield outside range

Superkings Ultra Lights**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1804 | 6.75 | 266 | 119 | 18.8 | 19.4 | 7.12 | 30.2 | 14.4 |
| 2102 | 4.93 | 269 | 116 | 18.3 | 19.4 | 6.33 | 28.4 | 15.5 |
| 2316 | 5.72 | 249 | 108 | 20.0 | 18.2 | 5.94 | 26.8 | 17.1 |
| 2606 | 5.38 | 274 | 125 | 19.8 | 20.4 | 6.87 | 31.2 | 18.7 |
| 2903 | 7.87 | 280 | 120 | 23.5 | 20.8 | 6.89 | 29.6 | 18.3 |
| Mean (ug/cig) | 6.13 | 268 | 118 | 20.1 | 19.6 | 6.63 | 29.2 | 16.8 |
| Standard Deviation | 1.18 | 11.9 | 6.2 | 2.04 | 1.01 | 0.48 | 1.69 | 1.85 |
| CV (%) | 19.3 | 4.5 | 5.3 | 10.2 | 5.2 | 7.3 | 5.8 | 11.0 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|-------|---------|---------|--------|--------|-------|--------|--------|
| Data sorted | 4.925 | 248.697 | 108.179 | 18.288 | 18.178 | 5.937 | 26.792 | 14.4 |
| | 5.38 | 265.575 | 116.446 | 18.787 | 19.367 | 6.334 | 28.401 | 15.51 |
| | 5.722 | 268.721 | 118.886 | 19.791 | 19.42 | 6.872 | 29.575 | 17.119 |
| | 6.752 | 274.342 | 120.093 | 19.986 | 20.377 | 6.889 | 30.17 | 18.348 |
| | 7.87 | 280.287 | 125.137 | 23.506 | 20.788 | 7.124 | 31.178 | 18.732 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.154 | 0.534 | 0.487 | 0.096 | 0.456 | 0.334 | 0.367 | 0.256 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.380 | 0.188 | 0.297 | 0.675 | 0.157 | 0.198 | 0.230 | 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 (ug/cig) | 6.1 | 268 | 118 | 20 | 19.6 | 6.6 | 29.2 | 16.8 |
| Standard Deviation | 1.18 | 11.9 | 6.2 | 2.04 | 1.01 | 0.48 | 1.69 | 1.85 |
| CV (%) | 19.3 | 4.5 | 5.3 | 10.2 | 5.2 | 7.3 | 5.8 | 11.0 |

Vogue Superslims**Carbonyl yields in cigarette smoke per cigarette**

| Sample Number | Formaldehyde | Acetaldehyde | Acetone | Acrolein | Propionaldehyde | Crotonaldehyde | Methyl ethyl ketone | Butyraldehyde |
|---------------------------|--------------|--------------|---------|----------|-----------------|----------------|---------------------|---------------|
| | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig | ug/cig |
| 1903 | 20.3 | 313 | 140 | 29.8 | 22.9 | 13.5 | 36.9 | 16.0 |
| 2110 | 24.7 | 310 | 136 | 32.7 | 22.7 | 12.7 | 34.1 | 16.0 |
| 2407 | 29.6 | 395 | 175 | 39.8 | 28.5 | 16.4 | 44.0 | 19.9 |
| 2704 | 27.6 | 350 | 153 | 36.8 | 25.3 | 14.5 | 37.8 | 18.3 |
| 3001 | 25.1 | 361 | 155 | 36.6 | 27.0 | 14.2 | 39.3 | 21.3 |
| Mean (ug/cig) | 25.5 | 346 | 152 | 35.1 | 25.3 | 14.2 | 38.4 | 18.3 |
| Standard Deviation | 3.50 | 35.6 | 15.1 | 3.93 | 2.54 | 1.39 | 3.68 | 2.36 |
| CV (%) | 13.7 | 10.3 | 9.9 | 11.2 | 10.0 | 9.8 | 9.6 | 12.9 |

Outlier Test

Dixons outlier test was applied to the above data

| | | | | | | | | |
|--------------------------------|--------|---------|---------|--------|--------|--------|--------|--------|
| Data sorted | 20.301 | 310.233 | 136.183 | 29.783 | 22.654 | 12.664 | 34.055 | 15.968 |
| | 24.677 | 312.793 | 140.483 | 32.658 | 22.885 | 13.482 | 36.87 | 16.006 |
| | 25.138 | 349.604 | 152.73 | 36.611 | 25.267 | 14.173 | 37.84 | 18.308 |
| | 27.556 | 361.483 | 154.73 | 36.843 | 27.015 | 14.476 | 39.26 | 19.942 |
| | 29.604 | 395.378 | 174.766 | 39.799 | 28.455 | 16.385 | 44.038 | 21.279 |
| Statistical test applied | | | | | | | | |
| Dixons low end test | 0.470 | 0.030 | 0.111 | 0.287 | 0.040 | 0.220 | 0.282 | 0.007 |
| Outlier detected at 95% | | | | | | | | |
| Dixons high end test | 0.220 | 0.398 | 0.519 | 0.295 | 0.248 | 0.513 | 0.479 | 0.252 |
| 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 | 346 | 152 | 35.1 | 25.3 | 14.2 | 38.4 | 18.3 |
| Standard Deviation | 3.50 | 35.6 | 15.1 | 3.93 | 2.54 | 1.39 | 3.68 | 2.36 |
| CV (%) | 13.7 | 10.3 | 9.9 | 11.2 | 10.0 | 9.8 | 9.6 | 12.9 |

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 trapping system should be capable of trapping 100% of the analyte(s) under investigation. It should not significantly affect the way that the cigarette smokes – i.e. cigarette should be smoked to ISO conditions. In practice, a compromise had to be reached between using a trap with 100% efficiency and a trap that does not interfere with the puff profile. For the purposes of the study a single bubbler with a Grade 0 sinter was found to be an acceptable compromise.

The sinter bubbler used to trap the carbonyls has a "dead volume" and therefore a significant proportion of the smoke sample will have resided in the 'delivery tube' for 58 seconds before passing through the trapping solution. During this time various reactions will have occurred between smoke constituents which may affect the carbonyl(s) yields.

Interference

A method should be checked to show that it is not susceptible to interference from the sample matrix. In practice there are many thousand of chemicals present in cigarette smoke and it is not feasible to check the method for every potential interference. Therefore, an assumption has been made that the HPLC - diode array detection system is measuring only the analyte of interest.

Blank correction

Due to the laboratory environment, acetone was present at low level concentrations in the blank DNPH solution. The concentration of acetone measured was generally much lower than that found in the cigarette smoke solutions. Therefore, the results have not been blank corrected. The levels of acetone measured in the blank solutions ranged from approximately $0.25 \mu\text{g mL}^{-1}$ to $0.5 \mu\text{g mL}^{-1}$ (equivalent to $5 \mu\text{g cig}^{-1}$ to $10 \mu\text{g cig}^{-1}$ - 40 mL undiluted sample solution).

Measurement uncertainty

All measurements have an uncertainty associated with them. There are three components in the uncertainty of each result (a) sample (smoking of the cigarette), (b) trapping the smoke and (c) the analytical method. From the results of the study, it would appear that the largest uncertainty is associated with the measurement of formaldehyde. In addition, samples containing low concentrations of carbonyls gave larger uncertainties than "high yield" brands.

Outlier test

It was agreed as part of the study protocol that the Dixon's outlier test would be performed on each set of results and a judgement made as to whether to use the original results or recalculate the mean excluding the outlier. Dixon's test does not take into account the standard deviation of the set of results. Therefore in making a judgement as to which set of results to use, we compared the CV values for each analyte across the 25 brands. In our opinion, all the original results should be used as comparison of the CV values did not confirm that there are true outliers present in the original data.

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-nitrosanonicotine (nnn) |
| | n-nitrosoanatabine (nat) |
| | n-nitrosanabasine (nab) |
| | n-nitrosanormicotine ketone (nnk) |
| Phenols | phenol |
| | catchechol |
| | 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 |
| DNPH | Dinitrophenylhydrazine |
| CV(%) | Coefficient of Variation |

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 |