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THE EFFECT OF BANDING ON CIGARETTE PERFORMANCE

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The objective of this study was to determine the effects of banding on cigarette performance.

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The effects of banding on cigarette drafts, smoke deliveries, smoke pH and taste panel acceptance were evaluated. For this study, samples of WINSTON, WINSTON LIGHTS, DORAL II and Golden Lights were banded and compared to the unbanded product.

Small increases in cigarette drafts were observed for banded WINSTON and WINSTON LIGHTS as well as for Golden Lights (in which the mouthend dilution was reduced by banding). Since it is doubtful that the smoker can perceive these small differences, it is concluded that banding does not alter cigarette drafts to any important degree. No significant differences in smoke pH were observed between banded and unbanded cigarettes at either of two puff volumes (35 and 62 cc). The results of routine and puff-by-puff smoke analyses showed that with the exception of Golden Lights, only CO and CO₂ deliveries are affected by banding. Increases in FTC 'tar', nicotine, and H₂O deliveries were observed for banded Golden Lights in which the banding obstructed the mouthend dilution system. For all cigarettes except Golden Lights, no effects of banding on TPM deliveries were observed at a puff volume of 65 cc. Taste panel results showed no significant differences between banded and unbanded cigarettes.

It was concluded that as long as mouthend dilution is not altered, cigarette banding does not cause any changes which the smoker can detect.

STATUS:

The conclusions of this study have been communicated to Tobacco Development and Marketing Research. No additional work is planned.

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I. INTRODUCTION

Due to the increased use of cigarette banding in taste evaluations, it has become necessary to document any effects the presence of banding may have on cigarette performance. This report summarizes the results of a study which was designed jointly by Research and Development personnel.

The approach was to identify any changes in smoke deliveries, cigarette drafts, smoke pH, or taste panel acceptance which may occur as a result of cigarette banding. Three RJR brands (WINSTON, WINSTON LIGHTS, and DORAL II) were chosen for the study as configurationally representative of most cigarettes of interest. In addition, a cigarette constructed with inherently porous tipping (Golden Lights) was chosen for evaluation since it was suspected that banding of this cigarette would cause the largest changes.

II. RESULTS AND DISCUSSION

Samples of WINSTON, WINSTON LIGHTS, DORAL II and Golden Lights were purchased from the Winston-Salem market and were banded in two positions, one with maximum tobacco rod overlap and another with minimum tobacco rod overlap. Samples of Golden Lights were also banded with a new mechanically perforated banding (12-line). The position of the banding for each sample is shown in Figure 1. The width of the banding material was 15 mm except that used for one of the WINSTON LIGHTS samples (20 mm).

A. The Effect of Banding on Cigarette Drafts

Cigarette drafts were measured at the standard flow rate, 17.5 cc/sec, and at 45.0 cc/sec. Drafts were measured at the higher flow rate in order to obtain data at flow rates which bracket those corresponding to most human puffs. The results are presented in Table I.

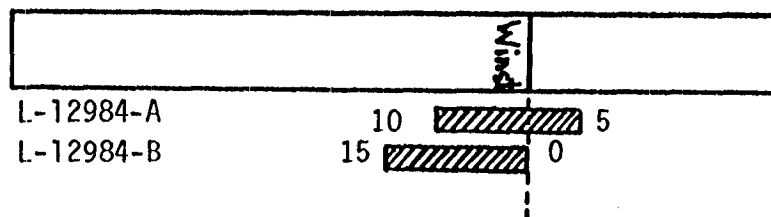
Inspection of the data in Table I shows that statistically significant (95% C.L.) increases were observed with banding for WINSTON LIGHTS at both flow rates and for WINSTON at the high flow rate. No differences were observed for DORAL II or Golden Lights with maximum tobacco rod overlap. The banding on Golden Lights with minimum tobacco rod overlap reduced the mouthend dilution flow and therefore increased the draft. That the drafts for samples L-12984-H and J were the same indicates that the use of perforated banding did not reduce the effect of the banding on Golden Lights' air dilution. Inspection of the perforated banding removed from cigarettes showed that most of the perforations were filled with glue.

While statistically significant increases in cigarette drafts were observed with banded cigarettes, the increases were small (~6%) even at the high flow rate. Since it is doubtful that the smoker could perceive this small difference, it is concluded that banding does not alter cigarette drafts to any important degree.

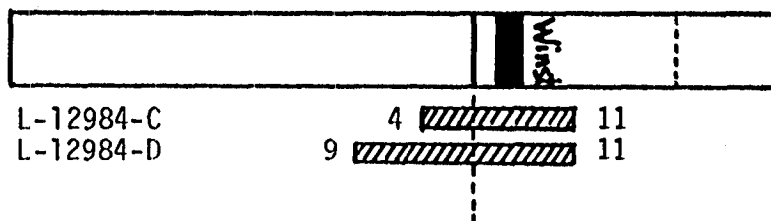
Figure 1. Banding Positions

Shaded bars indicate areas of cigarette covered by banding. Distance of tobacco rod and tipping covered (in mm) is indicated.

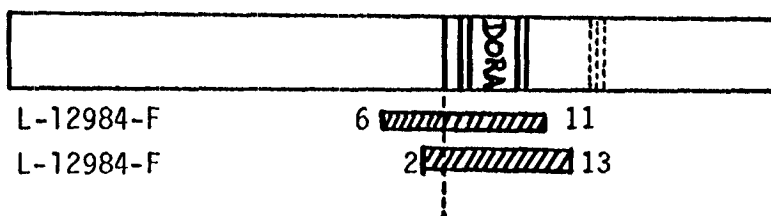
WINSTON



WINSTON LIGHTS



DORAL II



GOLDEN LIGHTS

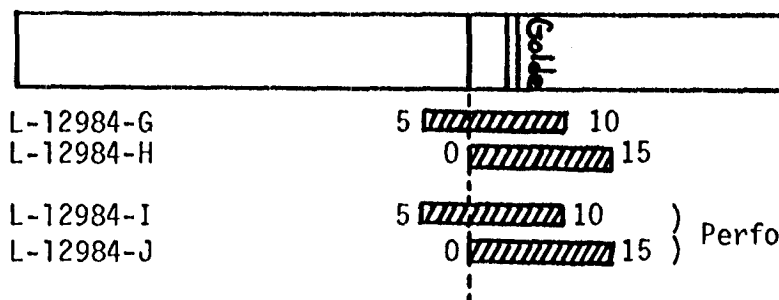


TABLE I
CIGARETTE DRAFTS MEASURED AT TWO FLOW RATES

| | Cigarette Drafts ¹ (mm H ₂ O) | |
|--|--|--------------|
| | 17.5 cc/sec | 45.0 cc/sec |
| WINSTON Controls | 110.9 (6.3) | 317.3 (16.4) |
| Banded WINSTON - Min Overlap L-12984-A | 114.4 (8.9) | -- |
| Banded WINSTON - Max Overlap L-12984-B | 111.9 (7.2) | 326.9 (16.9) |
| WINSTON LIGHTS Control | 112.2 (5.5) | 296.7 (11.8) |
| Banded WINSTON LIGHTS - Min Overlap L-12984-C | 120.6 (5.7) | 306.1 (10.5) |
| Banded WINSTON LIGHTS - Max Overlap L-12984-D | 122.5 (6.5) | 316.8 (11.2) |
| DORAL II Control | 86.6 (14.7) | 254.2 (27.1) |
| Banded DORAL II - Min Overlap L-12984-F | 82.8 (13.0) | -- |
| Banded DORAL II - Max Overlap L-12984-E | 86.6 (12.2) | 253.9 (24.5) |
| Golden Lights Control | 102.5 (4.7) | 251.7 (15.5) |
| Banded Golden Lights - Min Overlap L-12984-H | 107.7 (6.9) | -- |
| Banded Golden Lights - Max Overlap L-12984-G | 101.5 (7.0) | 247.0 (16.9) |
| Banded Golden Lights - Min Overlap Perforated Banding L-12984-J | 106.7 (5.1) | -- |
| Banded Golden Lights - Max Overlap Perforated Banding L-12984-I | 102.3 (5.1) | 246.7 (15.0) |

¹Standard deviations are included in parentheses. Each entry represents the average of 50 determinations.

B. The Effect of Banding on Smoke pH

Cigarettes were selected by draft (at 17.5 cc/sec flow rate) to fall within one standard deviation of the average cigarette draft (Table I) as well as the "holes closed" draft (Table II).

Smoke pH was measured for all cigarette samples at two puff volumes, 35.0 and 62.0 cc. The results are presented in Table III. Inspection of the data in Table III shows that while the smoke pH for any given cigarette decreased slightly at the higher puff volume, there were no significant differences between banded and unbanded cigarettes at either puff volume.

C. The Effect of Banding on Smoke Deliveries

1. Routine Smoke Analyses

The results of routine smoke analyses of draft-selected cigarettes (see above) are presented in Table IV. To enable comparison of banded and unbanded cigarettes, all samples of each brand were smoked to the same point on the tobacco rod. That point was chosen to be 3 mm in front of the banding on the cigarette with maximum rod overlap. Therefore, the same amount of tobacco was smoked for each sample within one brand.

Inspection of the data in Table IV shows that statistically significant (95% C.L.) increases were observed for the CO and CO₂ deliveries of banded WINSTON and WINSTON LIGHTS. 'Tar', nicotine, and H₂O deliveries were not affected. No significant differences were observed for DORAL II. For Golden Lights, statistically significant increases were observed for CO and CO₂ for all banded samples. 'Tar', nicotine, and H₂O deliveries increased for all banded Golden Light samples except L-12984-G (minimum rod overlap).

The increase in CO and CO₂ observed for WINSTON and WINSTON LIGHTS but not DORAL II may be rationalized as follows. Carbon monoxide and carbon dioxide efficiently diffuse from tobacco rods during smoking. The extent of diffusion is a function of, among other things, mouthend dilution. At high values of mouthend dilution, the linear smoke velocity inside the tobacco rod is reduced thus increasing the extent of diffusion of light molecular weight gases. At ~50% reduction (DORAL II) diffusion of CO and CO₂ can occur over a relatively short length of tobacco rod and the effect of covering ~10% of the cigarette wrapper at the filter is negligible. At low values of mouthend dilution, the banding is expected to interfere with diffusion to a greater extent.

In the case of Golden Lights, FTC 'tar', nicotine, H₂O, CO, and CO₂ deliveries increased due to banding. This is expected if the extent of mouthend dilution is reduced by covering the inherently porous tipping. One surprising observation was that smoke deliveries for L-12984-G and I were different while those for L-12984-H and J were the same. The latter observation would indicate that the perforated banding does not reduce the effect of banding on Golden Lights. However, that L-12984-G and I are

TABLE II
"HOLES CLOSED" DRAFT

| | "Holes Closed" Draft ¹ (mm H ₂ O) |
|--|---|
| WINSTON LIGHTS Control | 129.5 (7.1) |
| Banded WINSTON LIGHTS - Min Overlap L-12984-C | 134.2 (6.2) |
| Banded WINSTON LIGHTS - Max Overlap L-12984-D | 137.1 (6.7) |
| DORAL II Control | 139.1 (14.2) |
| Banded DORAL II - Min Overlap L-12984-F | 142.7 (11.1) |
| Banded DORAL II - Max Overlap L-12984-E | 144.5 (11.0) |
| Golden Lights Control | 131.5 (5.8) |
| Banded Golden Lights - Min Overlap L-12984-H | 135.8 (6.9) |
| Banded Golden Lights - Max Overlap L-12984-G | 131.4 (7.8) |
| Banded Golden Lights - Min Overlap Perforated Banding L-12984-J | 130.1 (5.3) |
| Banded Golden Lights - Max Overlap Perforated Banding L-12984-I | 132.7 (5.7) |

¹Drafts measured at 17.5 cc/sec flow rate. Standard deviations are included in parentheses. Each entry represents the average of 50 determinations.

TABLE III
SMOKE pH MEASURED AT TWO PUFF VOLUMES

| | pH ¹ | |
|--|----------------------|----------------------|
| | 35 cc Puff Volume | 62 cc Puff Volume |
| WINSTON Control | 6.15 ₀ | 6.06 ₆ |
| Banded WINSTON - Min Rod Overlap L-12984-A | 6.16 ₉ | 5.99 ₈ |
| Banded WINSTON - Max Rod Overlap L-12984-B | 6.16 ₅ | 6.04 ₂ |
| WINSTON LIGHTS Control | 6.52 ₀ | 6.44 ₄ |
| Banded WINSTON LIGHTS - Min Rod Overlap L-12984-C | 6.42 ₇ | 6.43 ₃ |
| Banded WINSTON LIGHTS - Max Rod Overlap L-12984-D | 6.54 ₇ | 6.37 ₃ |
| DORAL II Control | 6.85 ₄ | 6.72 ₂ |
| Banded DORAL II - Min Rod Overlap L-12984-F | 6.76 ₉ | 6.63 ₆ |
| Banded DORAL II - Max Rod Overlap L-12984-E | 6.82 ₃ | 6.65 ₅ |
| Golden Lights Control | 6.80 ₄ | 6.70 ₆ |
| Banded Golden Lights - Min Rod Overlap L-12984-H | 6.66 ₈ | 6.61 ₆ |
| Banded Golden Lights - Max Rod Overlap L-12984-G | 6.71 ₇ | 6.62 ₂ |
| Banded Golden Lights - Min Rod Overlap Perforated Banding L-12984-J | 6.76 ₁ | 6.65 ₃ |
| Banded Golden Lights - Max Rod Overlap Perforated Banding L-12984-I | 6.79 ₉ | 6.65 ₃ |

¹ Average of 2-6 determinations. Estimated S = 0.08.

TABLE IV
ROUTINE SMOKE ANALYSES¹

| | (mg/cig) | | | | | |
|--|--------------|------------|------------------|-------------|------------|-----------------|
| | FTC 'Tar' | TPM | H ₂ O | NICO | CO | CO ₂ |
| WINSTON Control | 11.5 (0.4) | 13.8 (0.5) | 1.4 (0.1) | 0.88 (0.05) | 10.4 (0.5) | 34.2 (1.7) |
| Banded WINSTON - Min Rod Overlap L-12984-A | 11.9 (0.5) | 14.3 (0.6) | 1.5 (0.1) | 0.89 (0.03) | 11.4 (0.5) | 37.4 (1.6) |
| Banded WINSTON - Max Rod Overlap L-12984-B | 11.9 (0.6) | 14.4 (0.7) | 1.5 (0.1) | 0.89 (0.04) | 11.6 (0.6) | 36.7 (1.2) |
| WINSTON LIGHTS Control | 10.2 (0.4) | 12.1 (0.4) | 1.2 (0.07) | 0.77 (0.03) | 9.4 (0.4) | 33.7 (0.6) |
| Banded WINSTON LIGHTS - Min Rod Overlap L-12984-C | 9.8 (0.4) | 11.7 (0.4) | 1.1 (0.09) | 0.74 (0.03) | 10.9 (0.7) | 33.6 (1.4) |
| Banded WINSTON LIGHTS - Max Rod Overlap L-12984-D | 9.5 (0.4) | 11.4 (0.4) | 1.2 (0.14) | 0.72 (0.04) | 11.3 (0.7) | 34.9 (1.4) |
| DORAL II Control | 4.2 (0.7) | 5.1 (0.8) | 0.5 (0.1) | 0.36 (0.06) | 3.1 (0.6) | 16.8 (1.9) |
| Banded DORAL II - Min Rod Overlap L-12984-F | 4.3 (0.2) | 5.1 (0.2) | 0.4 (0.06) | 0.36 (0.02) | 3.3 (0.2) | 17.5 (0.7) |
| Banded DORAL II - Max Rod Overlap L-12984-E | 4.2 (0.3) | 5.1 (0.4) | 0.4 (0.08) | 0.36 (0.03) | 3.3 (0.4) | 17.6 (1.3) |
| Golden Lights Control | 6.1 (0.4) | 7.5 (0.5) | 0.8 (0.09) | 0.54 (0.03) | 5.2 (0.4) | 21.8 (1.2) |
| Banded Golden Lights - Min Rod Overlap L-12984-A | 7.3 (0.4) | 8.9 (0.4) | 1.0 (0.09) | 0.61 (0.08) | 7.3 (0.5) | 26.3 (1.2) |
| Banded Golden Lights - Max Rod Overlap L-12984-G | 6.4 (0.4) | 7.9 (0.4) | 0.9 (0.09) | 0.56 (0.05) | 6.4 (0.6) | 24.6 (1.6) |
| Banded Golden Lights - Min Rod Overlap Perforated Banding L-12984-J | 7.4 (0.3) | 9.0 (0.4) | 0.9 (0.08) | 0.62 (0.02) | 7.3 (0.6) | 26.8 (1.2) |
| Banded Golden Lights - Max Rod Overlap Perforated Banding L-12984-I | 7.0 (0.3) | 8.4 (0.3) | 0.9 (0.08) | 0.59 (0.02) | 7.0 (0.7) | 25.8 (1.2) |

¹Each entry represents the average for 8 ports. Standard deviations are included in parentheses.

different and that deliveries for L-12984-G are not significantly different than those for the unbanded control is an unexplained observation at this point. Additional data below support the observation in Table IV.

2. Puff-by-Puff Smoke Analyses

Complete puff-by-puff smoke deliveries (FTC 'tar', nicotine, H₂O, CO, and CO₂) were obtained for draft-selected (see above) cigarette samples. Fifty cigarettes per sample were smoked by the Analytical Division. The complete data are presented in Appendix A while plots of FTC 'tar' and CO deliveries are presented in Figures 2 through 11. A comparison of the above smoke results with the puff-by-puff results showed excellent agreement between the two data sets.

Inspection of the plots of puff-by-puff FTC 'tar' deliveries shows no significant differences due to the banding except in the case of Golden Lights. The puff-by-puff results for Golden Lights agree with the results of routine smoke analyses in that the deliveries were highest for the cigarettes with minimum tobacco rod overlap (maximum filter overlap). The anomalous result with the two Golden Light samples (maximum tobacco rod overlap) is apparent from the puff-by-puff data.

Puff-by-puff nicotine deliveries follow the same behavior as FTC 'tar'.

Puff-by-puff carbon monoxide deliveries are presented in Figures 6-11. Higher CO deliveries were noted for WINSTON and WINSTON LIGHTS but not DORAL II. For Golden Lights, the CO deliveries essentially followed the FTC 'tar' delivery.

3. Delivery of TPM at High Puff Volumes

Delivery of TPM was determined for selected cigarette samples at a puff volume of 65.0 cc. The results are presented in Table V. Inspection of the data in Table V shows that even with a puff volume of 65.0 cc, which is closer to that of most human puffs, banding did not affect smoke deliveries except for Golden Lights. Again the discrepancy between Golden Light samples L-12984-G and I was observed.

The results of routine smoke analyses, puff-by-puff smoke analyses and measurements of TPM deliveries at a high puff volume are consistent and indicate that no statistically significant differences in FTC 'tar', nicotine or H₂O deliveries were caused by banding as long as the banding did not interfere with mouthend dilution. As a result of banding, differences were observed for the light gases, CO and CO₂. However, since both gases are odorless and tasteless the smoker would not discern a difference. Of course, the delivery of other light gases (e.g. NO) is expected to behave similarly.

Figure 2. Puff-by-Puff FTC 'Tar' Delivery

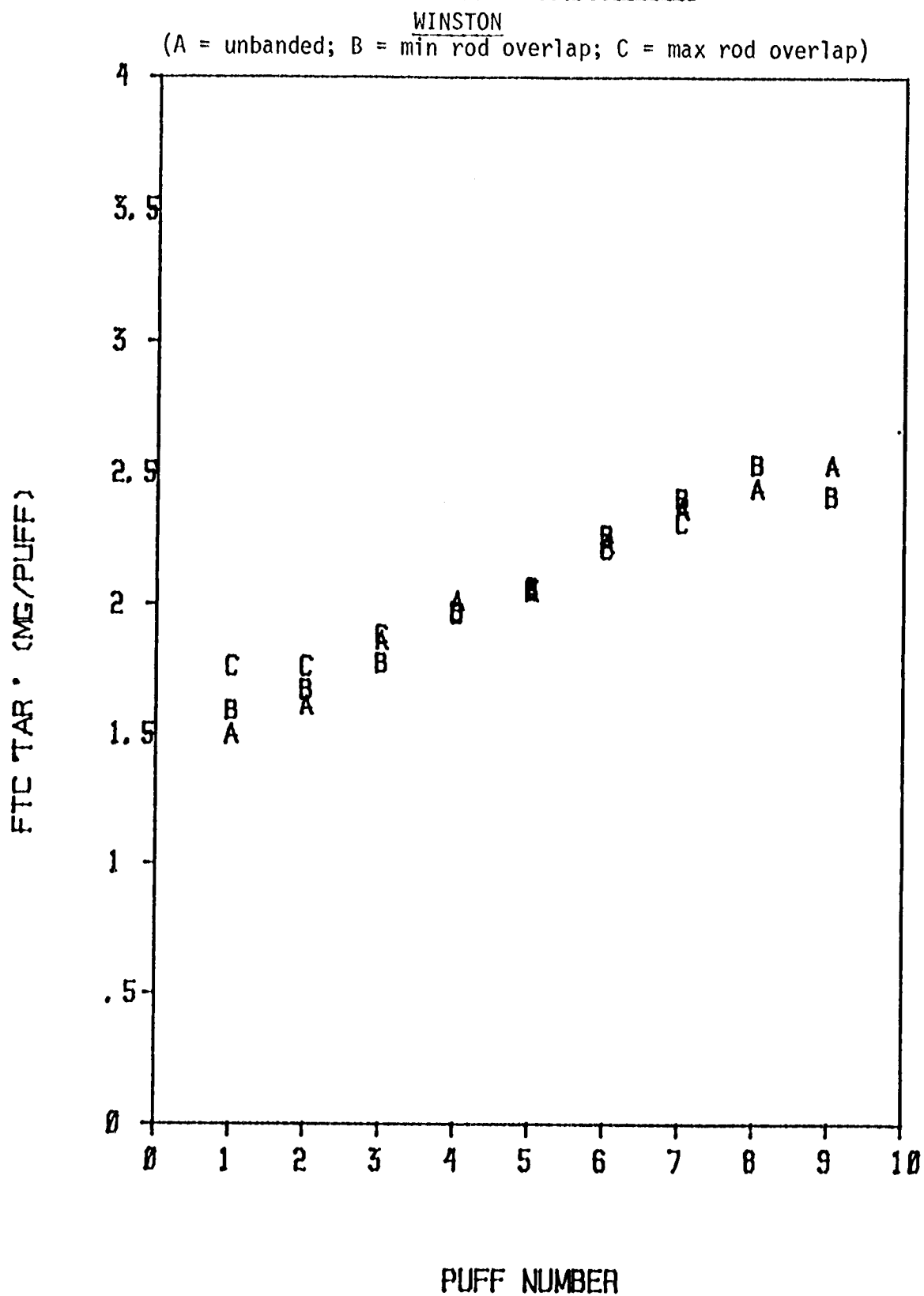


Figure 3. Puff-by-Puff FTC 'Tar' Delivery

WINSTON LIGHTS

(A = unbanded; B = min rod overlap; C = max rod overlap)

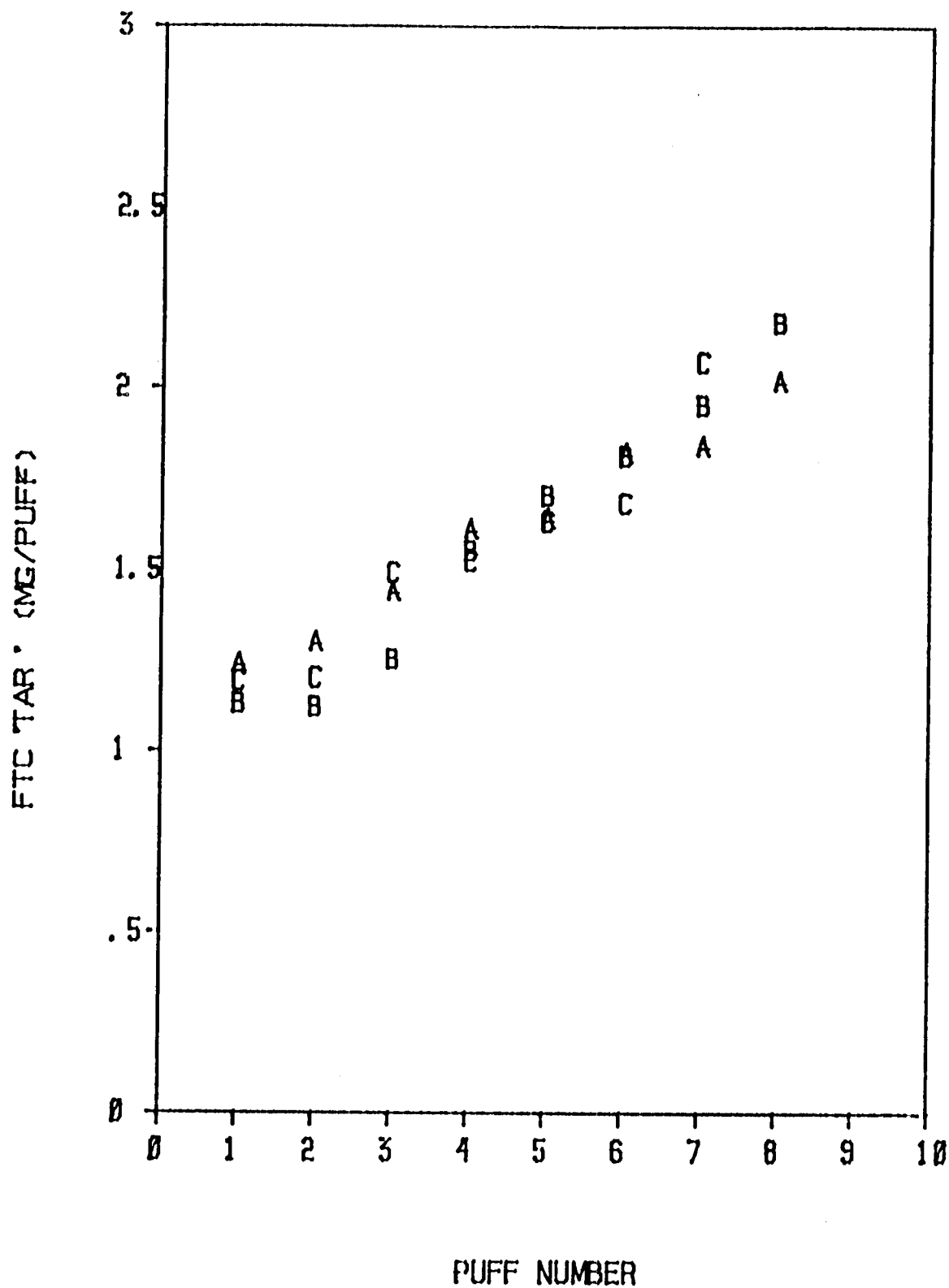


Figure 4. Puff-by-Puff FTC 'Tar' Delivery

DORAL II

(A = unbanded; B = min rod overlap; C = max rod overlap)

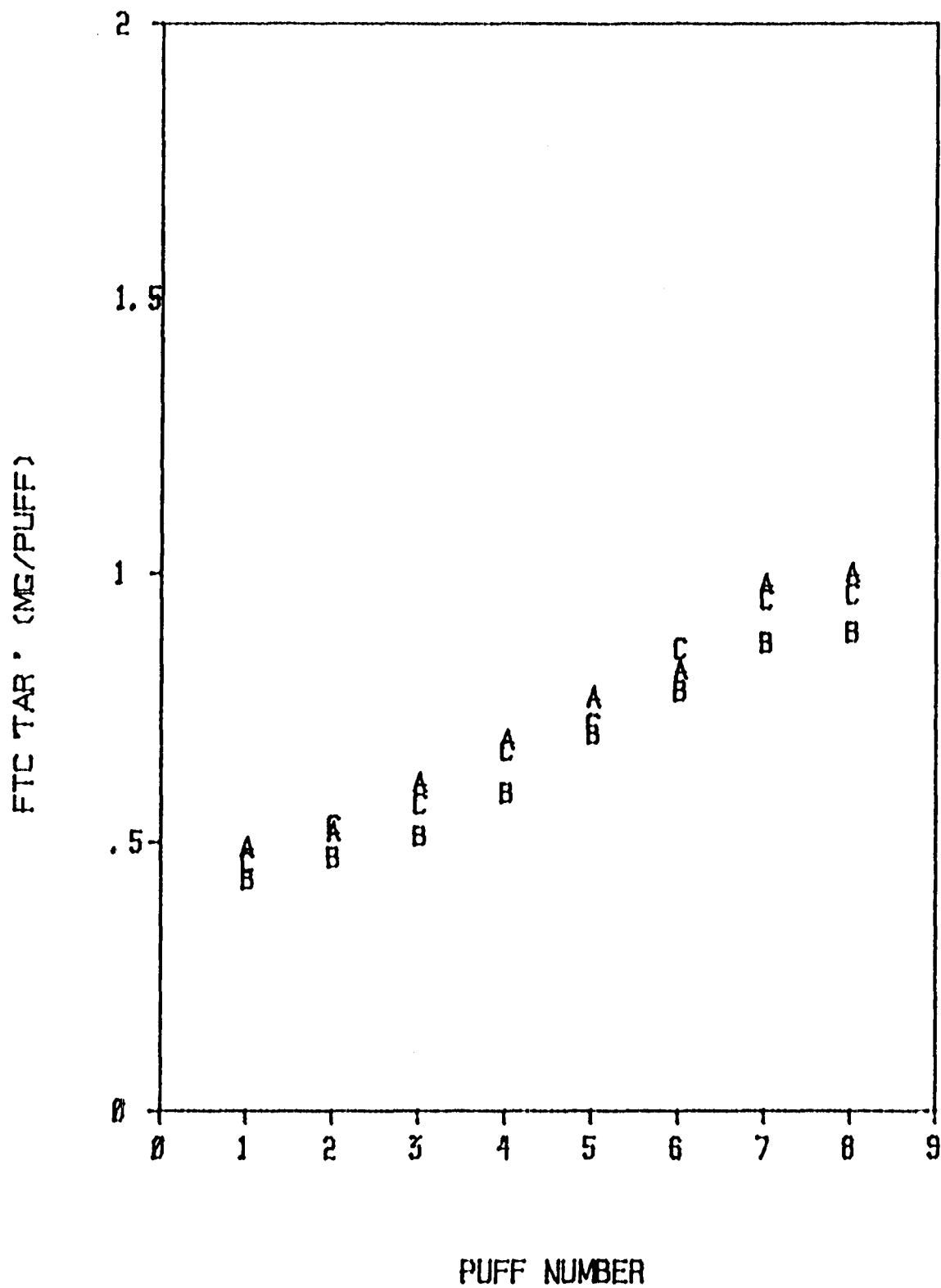


Figure 5. Puff-by-Puff FTC 'Tar' Delivery

GOLDEN LIGHTS

(A = unbanded; B = min rod overlap; C = max rod overlap)

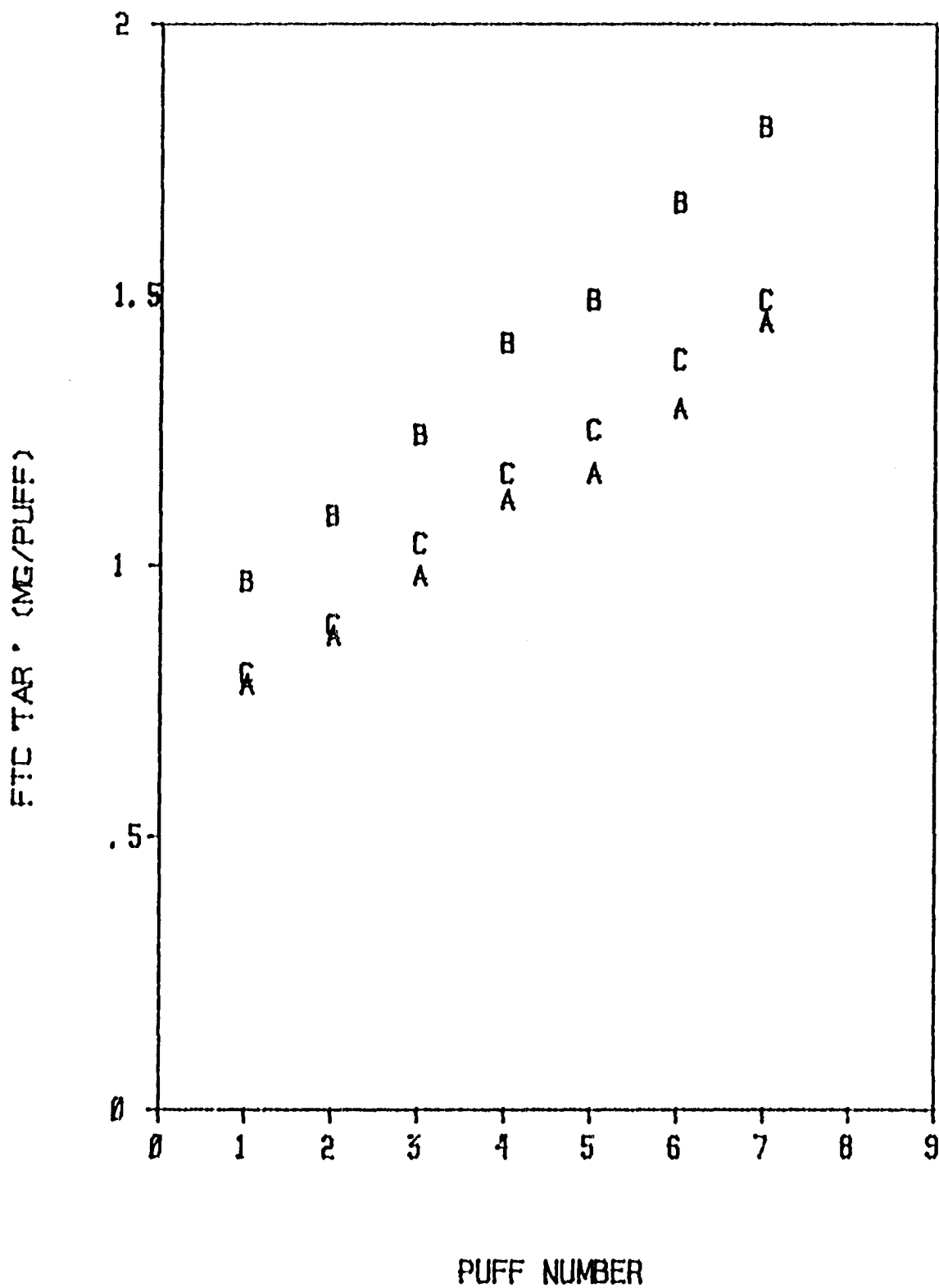


Figure 6. Puff-by-Puff FTC 'Tar' Delivery

GOLDEN LIGHTS - PERFORATED BANDING

(A = unbanded; B = min rod overlap; C = max rod overlap)

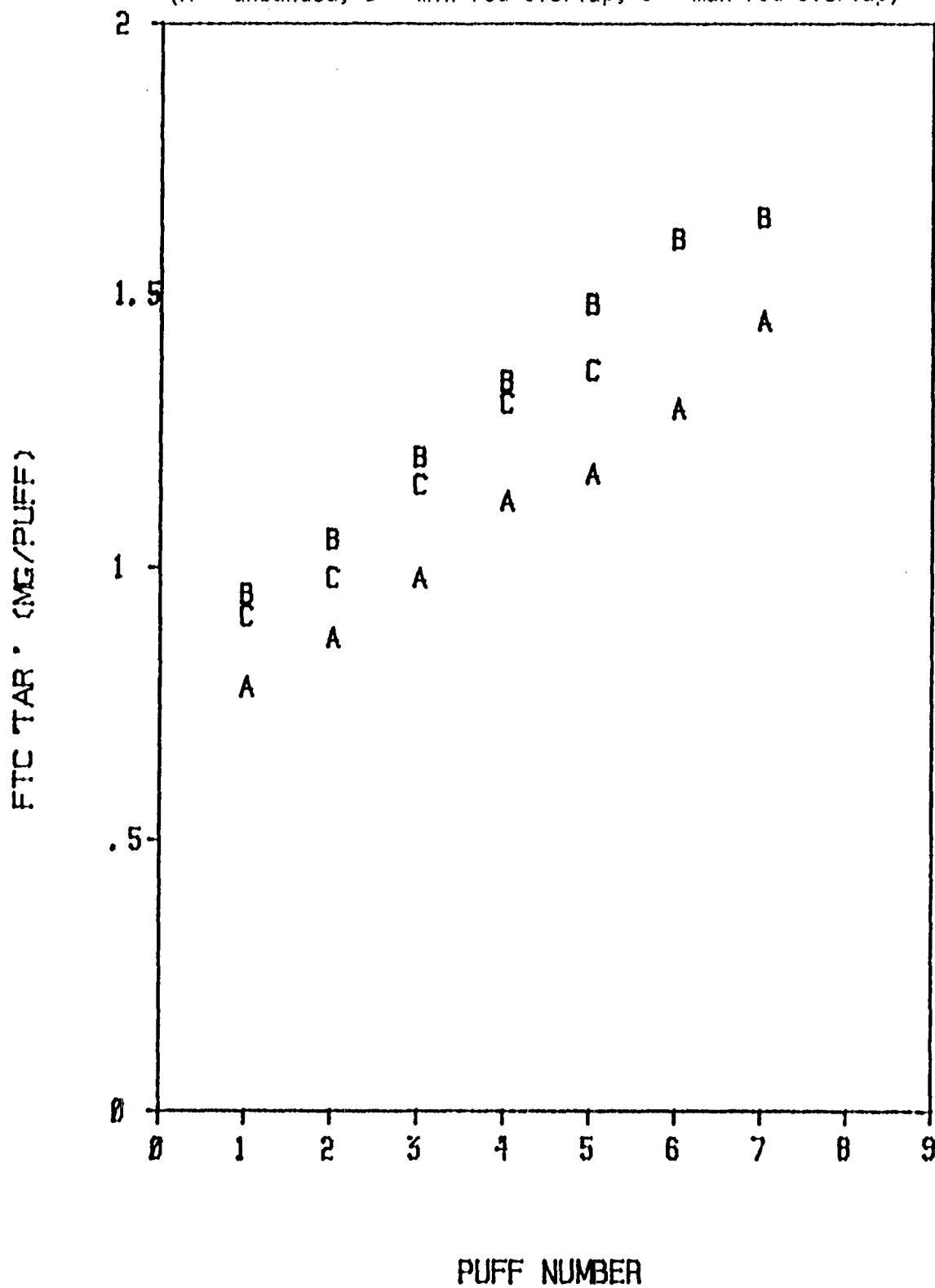


Figure 7. Puff-by-Puff CO Delivery

WINSTON

(A = unbanded; B = min rod overlap; C = max rod overlap)

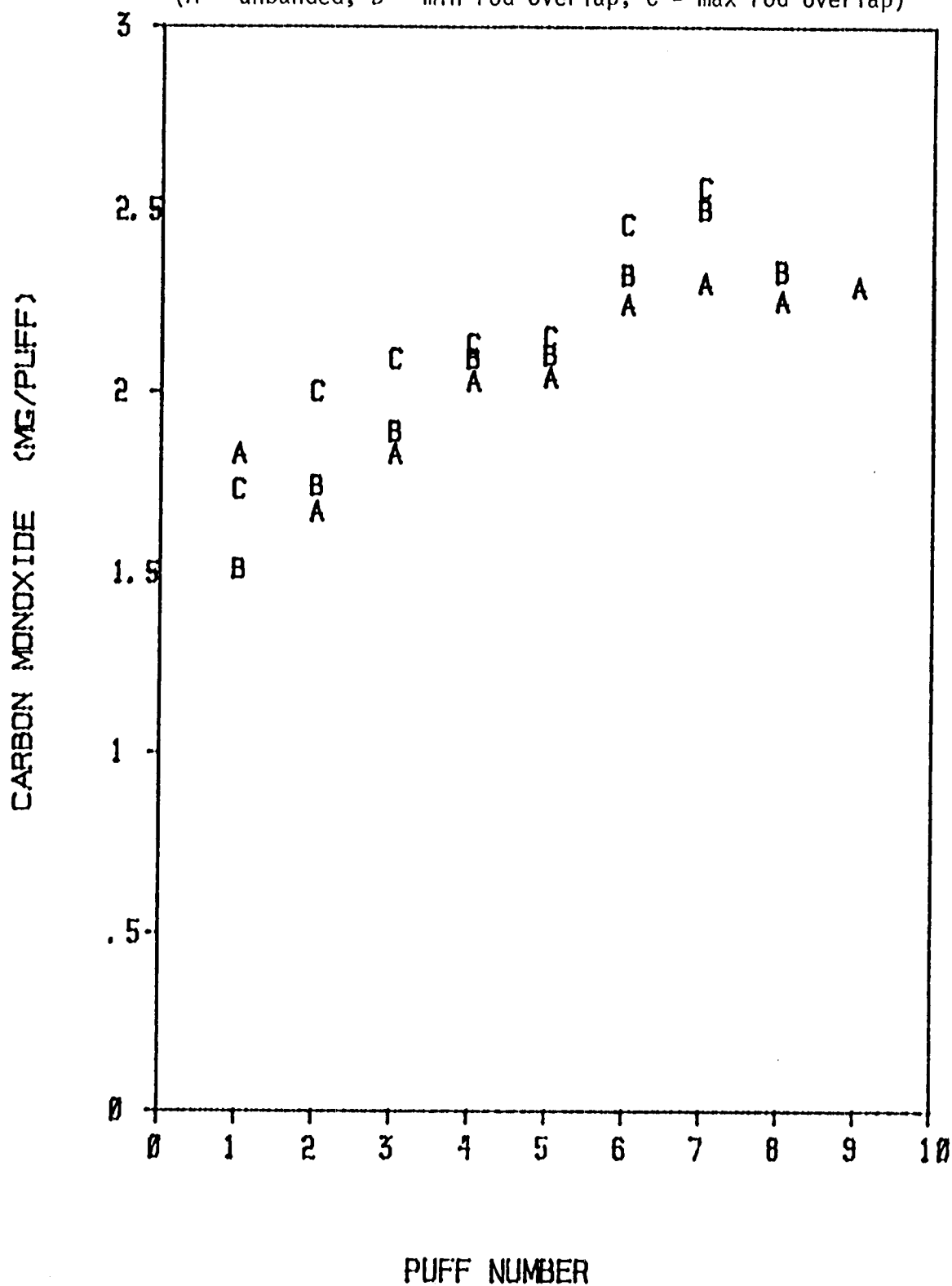


Figure 8. Puff-by-Puff CO Delivery

WINSTON LIGHTS

(A = unbanded; B = min rod overlap; C = max rod overlap)

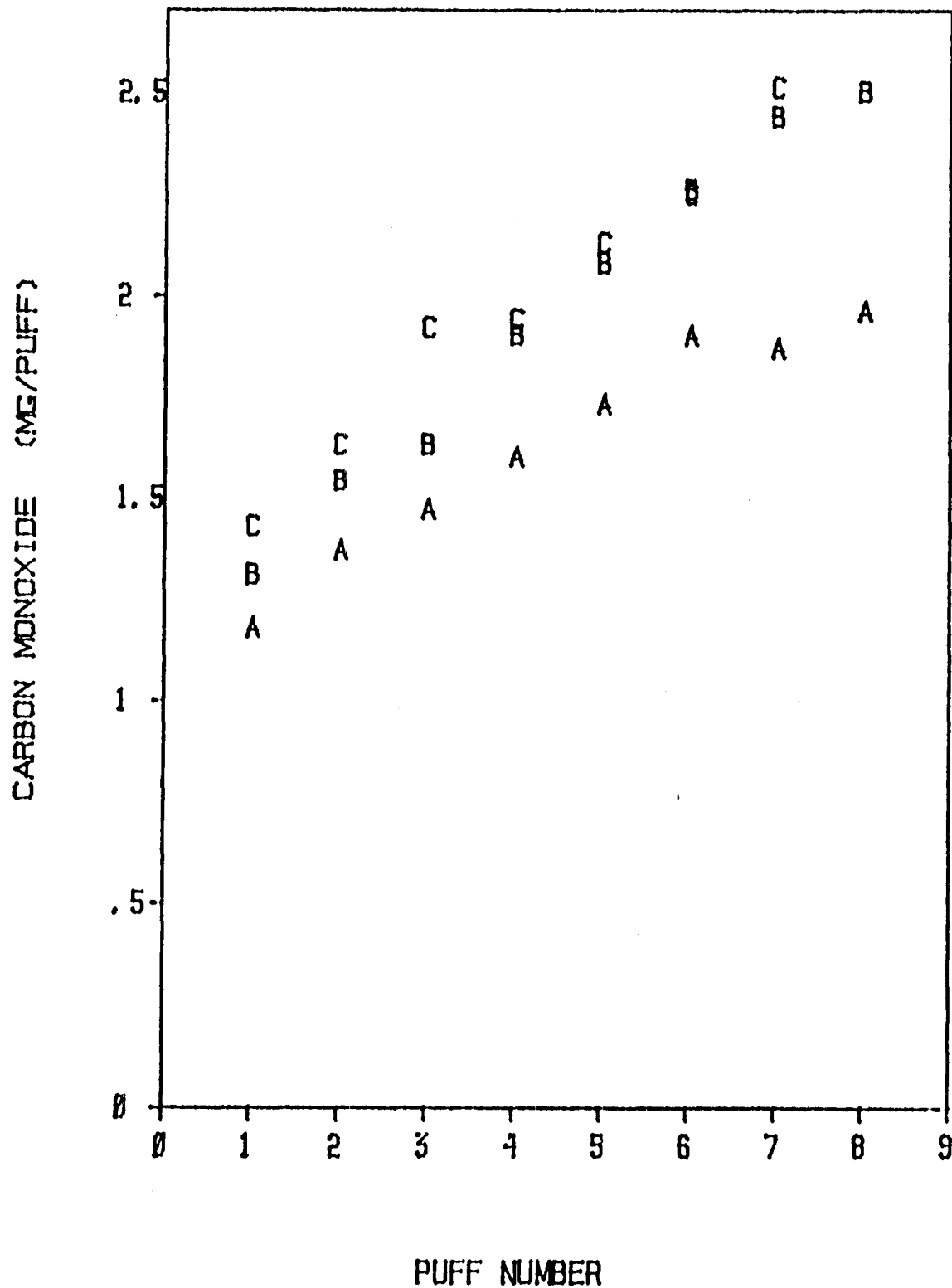


Figure 9. Puff-by-Puff CO Delivery

DORAL II

(A = unbanded; B = min rod overlap; C = max rod overlap)

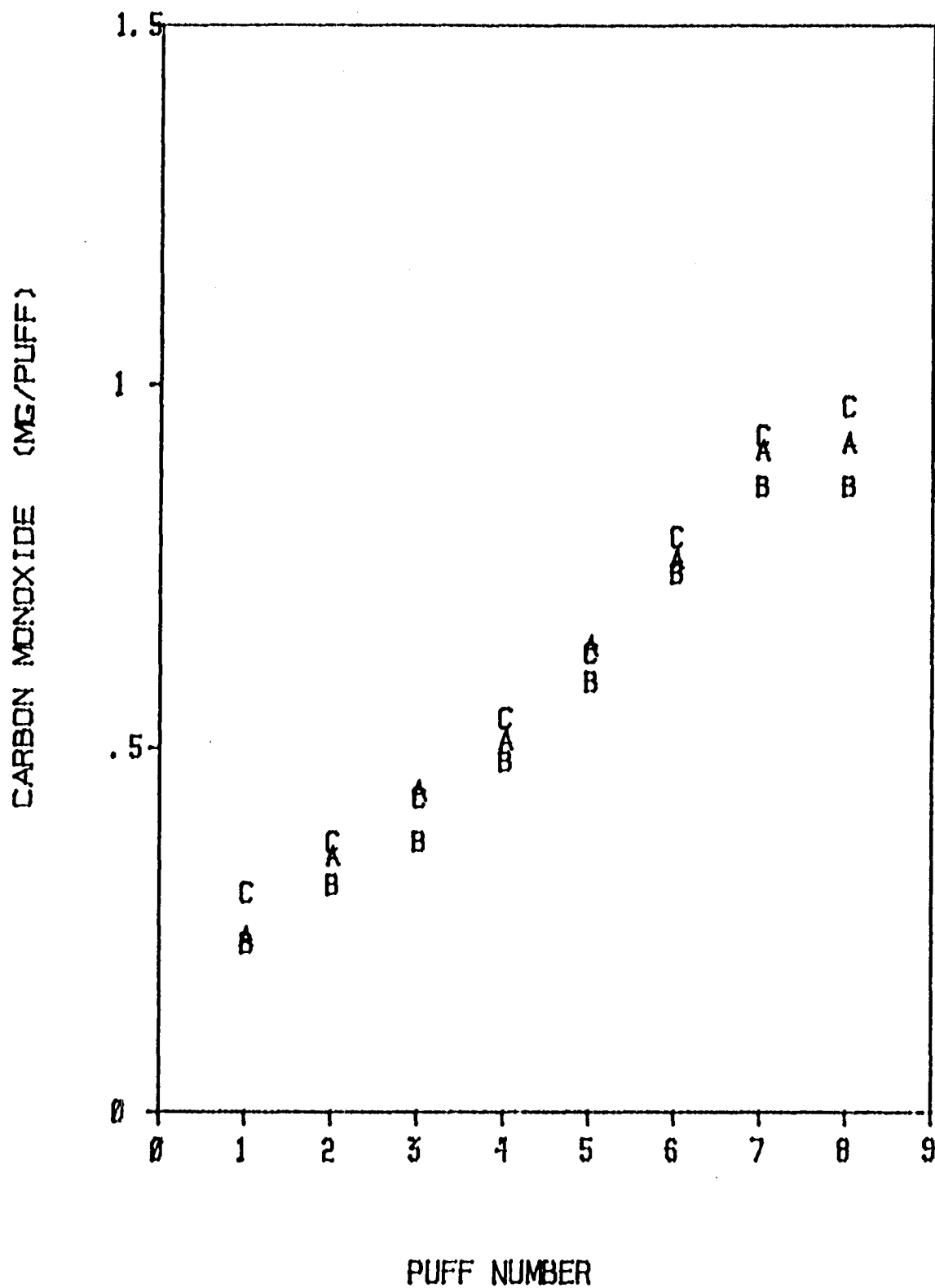


Figure 10. Puff-by-Puff CO Delivery

GOLDEN LIGHTS

(A = unbanded; B = min rod overlap; C = max rod overlap)

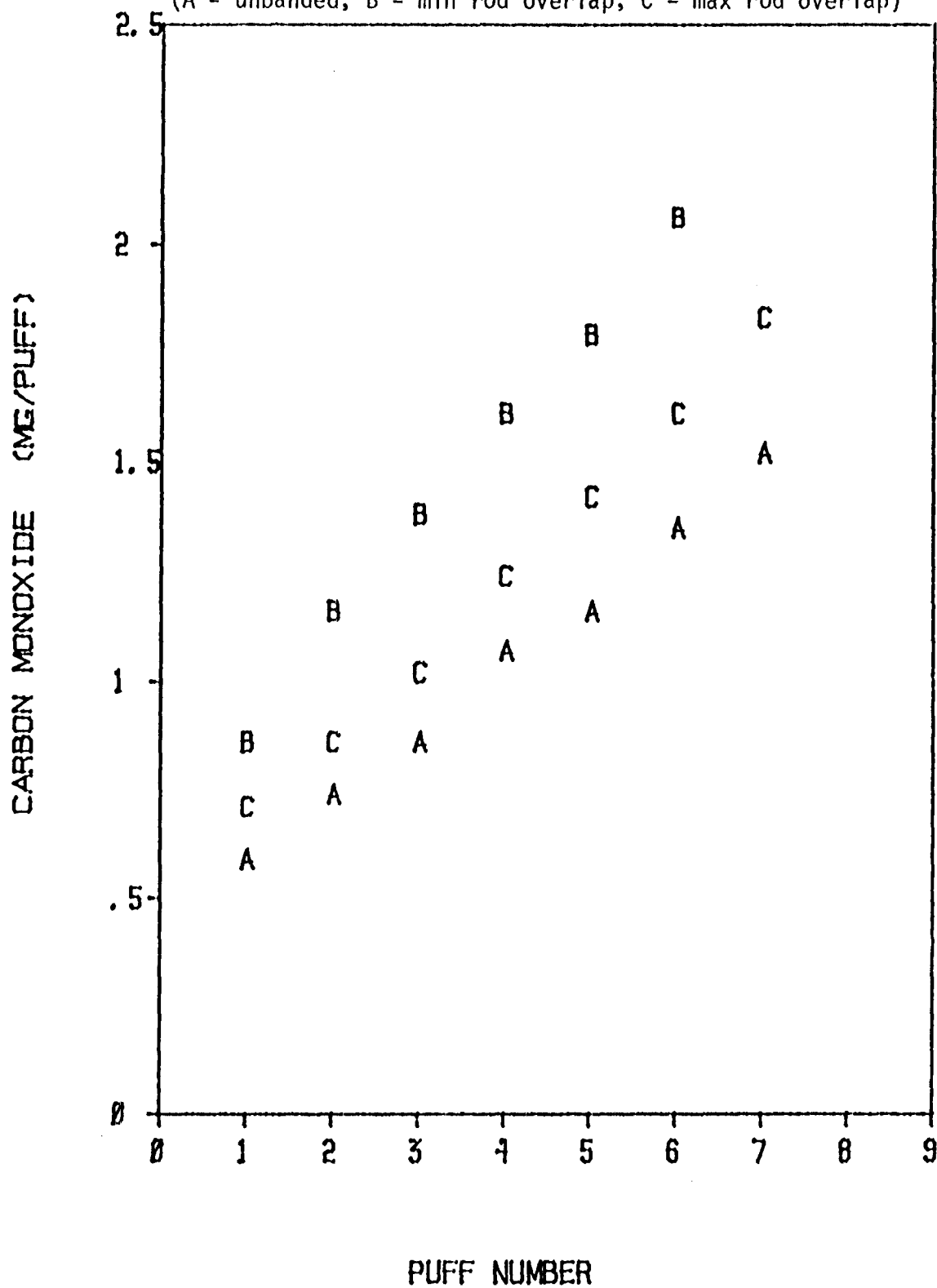


Figure 11. Puff-by-Puff CO Delivery

GOLDEN LIGHTS - PERFORATED BANDING

(A = unbanded; B = min rod overlap; C = max rod overlap)

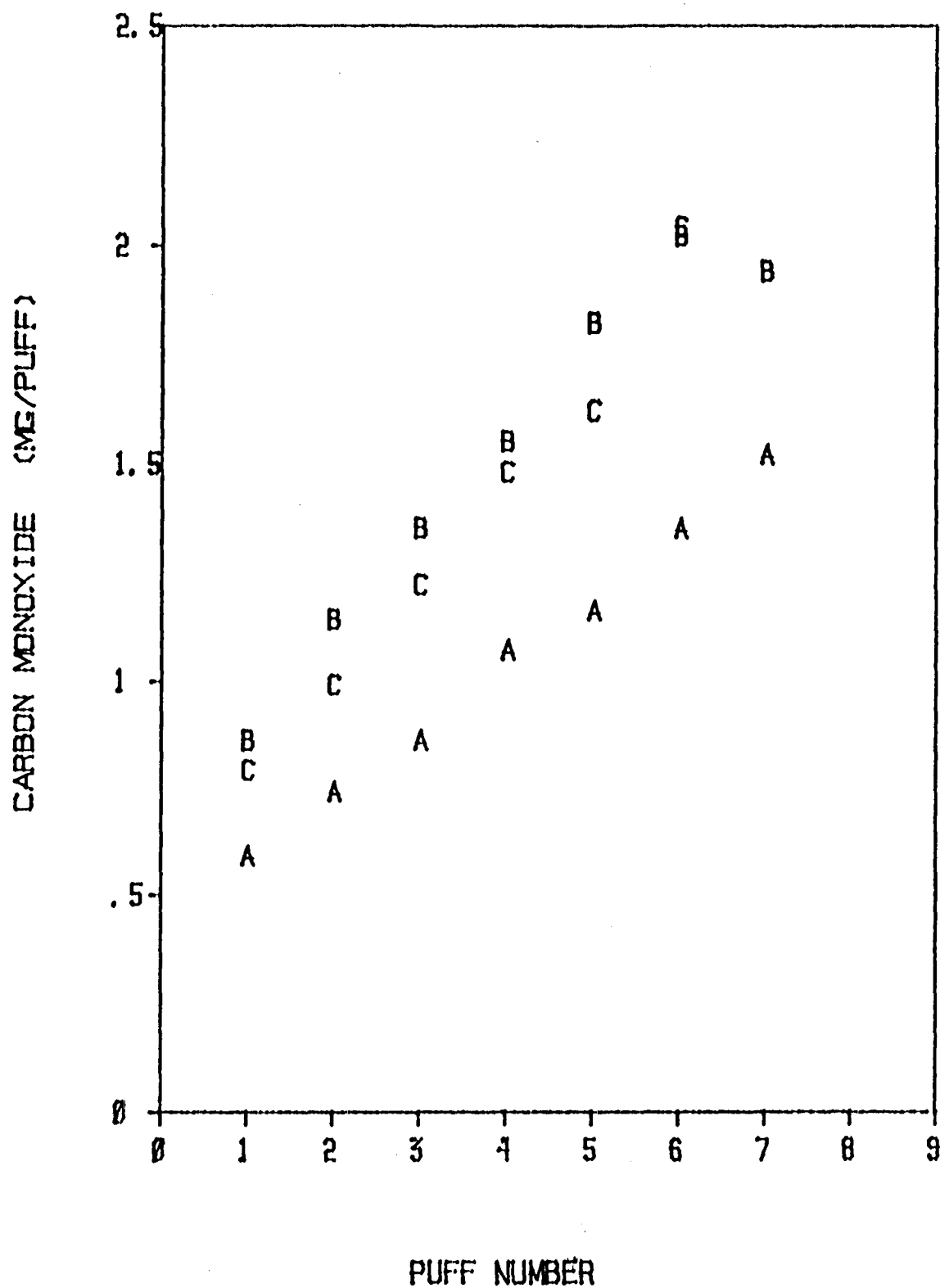


TABLE V
TPM DELIVERY AT HIGH PUFF VOLUME

| | TPM ¹ (mg/cig) | S | |
|---|------------------------------|-----|----------|
| WINSTON Control | 24.3 | 1.5 | |
| Banded WINSTON - Max Rod Overlap L-12984-B | 24.7 | 1.8 | NSD |
| WINSTON LIGHTS Control | 19.7 | 1.3 | |
| Banded WINSTON LIGHTS - Max Rod Overlap L-12984-D | 20.6 | 1.2 | NSD |
| DORAL II Control | 10.7 | 0.5 | |
| Banded DORAL II - Max Rod Overlap L-12984-E | 11.1 | 1.3 | NSD |
| Golden Lights Control | 13.4 | 0.8 | |
| Banded Golden Lights - Max Rod Overlap L-12984-G | 13.7 | 1.1 | NSD |
| Banded Golden Lights - Max Rod Overlap L-12984-I | 15.4 | 1.2 | SD |
| | | | (99% CL) |

¹Puff Volume = 65.0 cc

D. Taste Panel Acceptance

Replicated taste tests on both the Research Booth Panel and the Development Expert Panel were completed. The results of comparisons between banded and unbanded cigarettes are presented in Appendix B. In all of the comparisons, no significant differences were noted between banded and unbanded cigarettes.

An experiment was performed to identify any psychological effect on preference caused by the presence of banding. Two cigarettes were compared on both taste panels. The cigarettes were essentially WINSTONS and were identical in all respects (drafts, deliveries, etc.) except that one (L-12985-B) had cork tipping covering the same extent of the tobacco rod as that covered by banding on the other cigarette (L-12985-A). Taste panel results (Appendix B) showed no significant difference in preference between the two cigarettes.

III. CONCLUSION

From the above results, it is concluded that if mouthend dilution is not altered, banding does not cause any changes that the smoker can detect. Since the cigarette configurations and banding positions are representative of those typically used in consumer tests, it is expected that any cigarette may be similarly banded without affecting cigarette performance. Exceptions to this are those in which banding interferes with mouthend dilution (e.g., Golden Lights, Newport Lights).

Because of the nature of the banding operation, the position of the banding on the cigarette may sometimes shift enough to cover air dilution vents. Therefore, it is strongly advised that banded cigarettes be visually inspected before packing to insure that the air dilution vents are not obstructed.

All cigarettes used in this study were carefully selected by visual appearance as well as draft. It is possible that cigarettes banded less neatly or banded with alternate materials (e.g., tape) may receive poorer acceptance by the smoker.

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David E. Townsend 5/22/79
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V. APPENDICES

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APPENDIX A: PUFF-BY-PUFF SMOKE DELIVERIES

| Sample | Puff No. | (mg/puff) | | | | | |
|----------------|----------|-----------|-------|------------------|------|------|-----------------|
| | | TPM | NICO | H ₂ O | FTCT | CO | CO ₂ |
| WINSTON | 1 | 1.81 | 0.102 | 0.21 | 1.50 | 1.83 | 5.9 |
| | 2 | 1.96 | 0.129 | 0.22 | 1.61 | 1.67 | 5.4 |
| | 3 | 2.23 | 0.147 | 0.22 | 1.86 | 1.83 | 5.9 |
| | 4 | 2.39 | 0.154 | 0.23 | 2.01 | 2.03 | 6.2 |
| | 5 | 2.46 | 0.162 | 0.25 | 2.05 | 2.04 | 6.3 |
| | 6 | 2.68 | 0.172 | 0.27 | 2.23 | 2.24 | 6.7 |
| | 7 | 2.87 | 0.181 | 0.33 | 2.36 | 2.30 | 6.9 |
| | 8 | 3.16 | 0.187 | 0.54 | 2.44 | 2.25 | 7.0 |
| | 9 | 4.27 | 0.196 | 0.55 | 2.53 | 2.29 | 7.3 |
| L-12984-A | 1 | 1.90 | 0.113 | 0.19 | 1.59 | 1.51 | 6.3 |
| | 2 | 2.01 | 0.141 | 0.21 | 1.67 | 1.74 | 5.7 |
| | 3 | 2.14 | 0.151 | 0.22 | 1.77 | 1.89 | 6.1 |
| | 4 | 2.39 | 0.162 | 0.26 | 1.97 | 2.09 | 6.5 |
| | 5 | 2.48 | 0.164 | 0.27 | 2.05 | 2.10 | 6.6 |
| | 6 | 2.72 | 0.182 | 0.28 | 2.26 | 2.32 | 7.1 |
| | 7 | 3.00 | 0.194 | 0.40 | 2.40 | 2.50 | 7.5 |
| | 8 | 3.56 | 0.195 | 0.83 | 2.53 | 2.33 | 7.5 |
| L-12984-B | 1 | 2.09 | 0.118 | 0.21 | 1.76 | 1.73 | 7.3 |
| | 2 | 2.14 | 0.134 | 0.25 | 1.76 | 2.00 | 6.2 |
| | 3 | 2.31 | 0.140 | 0.29 | 1.88 | 2.09 | 6.6 |
| | 4 | 2.40 | 0.151 | 0.29 | 1.96 | 2.13 | 6.7 |
| | 5 | 2.54 | 0.160 | 0.32 | 2.06 | 2.15 | 6.8 |
| | 6 | 2.74 | 0.164 | 0.37 | 2.21 | 2.46 | 7.6 |
| | 7 | 2.95 | 0.159 | 0.48 | 2.31 | 2.56 | 8.1 |
| WINSTON LIGHTS | 1 | 1.46 | 0.083 | 0.14 | 1.24 | 1.18 | 5.0 |
| | 2 | 1.57 | 0.109 | 0.16 | 1.30 | 1.37 | 4.8 |
| | 3 | 1.73 | 0.115 | 0.17 | 1.44 | 1.47 | 5.1 |
| | 4 | 1.90 | 0.125 | 0.16 | 1.61 | 1.60 | 5.4 |
| | 5 | 1.96 | 0.130 | 0.19 | 1.64 | 1.73 | 5.7 |
| | 6 | 2.15 | 0.140 | 0.19 | 1.82 | 1.90 | 6.1 |
| | 7 | 2.20 | 0.143 | 0.21 | 1.84 | 1.87 | 6.2 |
| | 8 | 2.52 | 0.152 | 0.35 | 2.02 | 1.96 | 6.6 |

| Sample | Puff No. | (mg/puff) | | | | | |
|-----------|----------|-----------|-------|------------------|------|------|-----------------|
| | | TPM | NIPO | H ₂ O | FTCT | CO | CO ₂ |
| L-12984-C | 1 | 1.43 | 0.080 | 0.23 | 1.13 | 1.31 | 5.3 |
| | 2 | 1.37 | 0.102 | 0.14 | 1.12 | 1.54 | 4.9 |
| | 3 | 1.47 | 0.100 | 0.12 | 1.25 | 1.63 | 5.2 |
| | 4 | 1.84 | 0.127 | 0.16 | 1.55 | 1.90 | 5.6 |
| | 5 | 2.02 | 0.142 | 0.18 | 1.70 | 2.08 | 6.1 |
| | 6 | 2.18 | 0.146 | 0.22 | 1.81 | 2.26 | 6.5 |
| | 7 | 2.33 | 0.153 | 0.23 | 1.95 | 2.44 | 7.0 |
| | 8 | 2.82 | 0.164 | 0.48 | 2.18 | 2.50 | 7.5 |
| L-12984-D | 1 | 1.43 | 0.078 | 0.16 | 1.19 | 1.43 | 5.4 |
| | 2 | 1.46 | 0.094 | 0.16 | 1.20 | 1.63 | 5.1 |
| | 3 | 1.80 | 0.113 | 0.19 | 1.49 | 1.92 | 5.7 |
| | 4 | 1.87 | 0.117 | 0.23 | 1.52 | 1.94 | 5.9 |
| | 5 | 1.97 | 0.122 | 0.22 | 1.63 | 2.13 | 6.2 |
| | 6 | 2.03 | 0.123 | 0.22 | 1.68 | 2.25 | 6.6 |
| | 7 | 2.28 | 0.134 | -- | -- | 2.51 | 7.1 |
| DORAL II | 1 | 0.57 | 0.033 | 0.04 | 0.49 | 0.24 | 2.1 |
| | 2 | 0.63 | 0.044 | 0.06 | 0.52 | 0.35 | 2.0 |
| | 3 | 0.71 | 0.052 | 0.05 | 0.61 | 0.44 | 2.3 |
| | 4 | 0.80 | 0.059 | 0.05 | 0.69 | 0.51 | 2.6 |
| | 5 | 0.91 | 0.069 | 0.07 | 0.77 | 0.64 | 3.0 |
| | 6 | 0.98 | 0.074 | 0.08 | 0.82 | 0.76 | 3.4 |
| | 7 | 1.17 | 0.089 | 0.10 | 0.98 | 0.91 | 3.9 |
| | 8 | 1.21 | 0.089 | 0.12 | 1.00 | 0.92 | 4.2 |
| L-12984-E | 1 | 0.52 | 0.030 | 0.04 | 0.46 | 0.30 | 2.1 |
| | 2 | 0.60 | 0.041 | 0.03 | 0.53 | 0.37 | 2.1 |
| | 3 | 0.67 | 0.048 | 0.05 | 0.57 | 0.43 | 2.3 |
| | 4 | 0.78 | 0.058 | 0.06 | 0.67 | 0.54 | 2.7 |
| | 5 | 0.86 | 0.065 | 0.08 | 0.72 | 0.63 | 3.0 |
| | 6 | 0.99 | 0.074 | 0.06 | 0.86 | 0.79 | 3.4 |
| | 7 | 1.09 | 0.080 | 0.06 | 0.95 | 0.93 | 3.9 |
| | 8 | 1.10 | 0.073 | 0.07 | 0.96 | 0.97 | 4.6 |

| Sample | Puff No. | (mg/puff) | | | | | |
|---------------|----------|-----------|-------|------------------|------|------|-----------------|
| | | TPM | NICO | H ₂ O | FTCT | CO | CO ₂ |
| L-12984-F | 1 | 0.51 | 0.030 | 0.05 | 0.43 | 0.23 | 1.9 |
| | 2 | 0.56 | 0.040 | 0.05 | 0.47 | 0.31 | 1.9 |
| | 3 | 0.61 | 0.047 | 0.05 | 0.51 | 0.37 | 2.2 |
| | 4 | 0.71 | 0.055 | 0.06 | 0.59 | 0.48 | 2.5 |
| | 5 | 0.83 | 0.064 | 0.07 | 0.70 | 0.59 | 2.9 |
| | 6 | 0.93 | 0.073 | 0.08 | 0.78 | 0.74 | 3.4 |
| | 7 | 1.04 | 0.080 | 0.09 | 0.87 | 0.86 | 3.8 |
| | 8 | 1.07 | 0.083 | 0.09 | 0.89 | 0.86 | 4.1 |
| Golden Lights | 1 | 0.94 | 0.060 | 0.10 | 0.78 | 0.59 | 3.1 |
| | 2 | 1.04 | 0.077 | 0.10 | 0.87 | 0.74 | 3.2 |
| | 3 | 1.17 | 0.090 | 0.98 | 0.98 | 0.86 | 3.6 |
| | 4 | 1.36 | 0.105 | 0.13 | 1.12 | 1.17 | 4.2 |
| | 5 | 1.41 | 0.109 | 0.13 | 1.17 | 1.16 | 4.5 |
| | 6 | 1.58 | 0.124 | 0.17 | 1.29 | 1.35 | 5.0 |
| | 7 | 1.76 | 0.136 | 0.18 | 1.45 | 1.52 | 5.6 |
| L-12984-I | 1 | 1.08 | 0.065 | 0.11 | 0.91 | 0.79 | 3.6 |
| | 2 | 1.19 | 0.085 | 0.13 | 0.98 | 0.99 | 3.8 |
| | 3 | 1.39 | 0.101 | 0.14 | 1.15 | 1.22 | 4.3 |
| | 4 | 1.58 | 0.112 | 0.16 | 1.30 | 1.48 | 4.9 |
| | 5 | 1.66 | 0.119 | 0.18 | 1.36 | 1.62 | 5.2 |
| | 6 | -- | 0.133 | 0.22 | -- | 2.04 | 6.4 |
| L-12984-J | 1 | 1.13 | 0.071 | 0.11 | 0.95 | 0.86 | 4.1 |
| | 2 | 1.26 | 0.095 | 0.12 | 1.05 | 1.14 | 4.1 |
| | 3 | 1.45 | 0.108 | 0.15 | 1.20 | 1.35 | 4.7 |
| | 4 | 1.61 | 0.122 | 0.15 | 1.34 | 1.55 | 5.2 |
| | 5 | 1.80 | 0.137 | 0.19 | 1.48 | 1.82 | 5.7 |
| | 6 | 1.97 | 0.147 | 0.22 | 1.60 | 2.02 | 6.2 |
| | 7 | 2.10 | 0.149 | 0.31 | 1.64 | 1.94 | 6.5 |
| L-12984-G | 1 | 0.96 | 0.054 | 0.10 | 0.80 | 0.71 | 3.4 |
| | 2 | 1.07 | 0.074 | 0.10 | 0.89 | 0.86 | 3.5 |
| | 3 | 1.26 | 0.091 | 0.12 | 1.04 | 1.02 | 4.0 |
| | 4 | 1.41 | 0.098 | 0.14 | 1.17 | 1.24 | 4.4 |
| | 5 | 1.52 | 0.105 | 0.16 | 1.25 | 1.42 | 4.9 |
| | 6 | 1.65 | 0.114 | 0.16 | 1.38 | 1.61 | 5.4 |
| | 7 | 1.81 | 0.121 | 0.20 | 1.49 | 1.83 | 6.0 |
| L-12984-H | 1 | 1.15 | 0.070 | 0.11 | 0.97 | 0.86 | 4.1 |
| | 2 | 1.32 | 0.095 | 0.14 | 1.09 | 1.16 | 4.1 |
| | 3 | 1.53 | 0.111 | 0.18 | 1.24 | 1.38 | 4.6 |
| | 4 | 1.72 | 0.125 | 0.18 | 1.41 | 1.61 | 5.2 |
| | 5 | 1.80 | 0.121 | 0.19 | 1.49 | 1.79 | 5.6 |
| | 6 | 2.06 | 0.137 | 0.25 | 1.67 | 2.06 | 6.2 |
| | 7 | 2.33 | 0.140 | 0.38 | 1.81 | 1.82 | 5.6 |

APPENDIX B: TASTE PANEL RESULTS

1. RESEARCH BOOTH PANEL EVALUATION OF BANDED WINSTON

| | WINSTON Control | Banded (Max Overlap) L-12984-B | ND | Analysis |
|----------------------------|-----------------|--------------------------------------|----|-----------------|
| TEST NO. 2084 | | | | |
| Preference | 17 | 16 | 7 | NSD (0.13 C.L.) |
| Milder | 15 | 17 | 8 | NSD (0.25 C.L.) |
| Better Overall Flavor | 16 | 16 | 8 | NSD (0.00 C.L.) |
| TEST NO. 2109 | | | | |
| Preference | 19 | 14 | 7 | NSD (0.57 C.L.) |
| Which cigarette is milder? | 20 | 13 | 7 | NSD (0.73 C.L.) |
| Better Overall Flavor | 18 | 14 | 8 | NDS (0.47 C.L.) |

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2. DEVELOPMENT EXPERT PANEL EVALUATION OF BANDED WINSTON (L-12984-B) vs. UNBANDED WINSTON

| Item | Unbanded Control | Run 1 | | | | Run 2 | | | |
|------------------|------------------|-------|-----|---------|-----------------------|-------|-----|---------|-----------------------|
| | | Mean | S | # Resp. | Analysis ¹ | Mean | S | # Resp. | Analysis ¹ |
| Blend | 49 | 48.9 | 4.6 | 8 | NSD | 50.6 | 4.1 | 22 | DD |
| Aroma Quality | 49 | 48.0 | 5.5 | 8 | NSD | 51.0 | 4.9 | 22 | DD |
| Mildness | 50 | 51.1 | 5.8 | 8 | NSD | 50.0 | 7.5 | 22 | NSD |
| Overall Opinion | 49 | 49.1 | 5.6 | 8 | NSD | 49.4 | 5.0 | 22 | NSD |
| Stemmy Taste | 51 | 51.4 | 6.2 | 8 | NSD | 49.0 | 6.4 | 22 | NSD |
| Nasal Sting | 51 | 51.4 | 3.0 | 8 | NSD | 48.3 | 2.8 | 22 | SD |
| Throat Harshness | 51 | 50.9 | 3.2 | 8 | NSD | 48.3 | 4.9 | 22 | SD |
| Nicotine Effect | 50 | 49.4 | 3.4 | 8 | NSD | 49.4 | 3.7 | 22 | NSD |
| Burley Taste | 50 | 50.6 | 4.5 | 8 | NSD | 48.8 | 3.8 | 22 | DD |
| Flue-Cured Taste | 50 | 50.6 | 3.8 | 8 | NSD | 50.2 | 4.8 | 22 | NSD |
| Turkish Taste | 50 | 50.9 | 2.7 | 8 | NSD | 49.8 | 2.7 | 22 | NSD |

¹95% C.L. for Significant Difference (SD); 85% C.L. for Directional Difference (DD); No Significant Difference = NSD

3. RESEARCH BOOTH PANEL EVALUATION OF BANDED WINSTON LIGHTS

| | WINSTON LIGHTS Control | Banded (Max Overlap) L-12984-D | ND | Analysis |
|-----------------------|---------------------------|--------------------------------------|----|-----------------|
| TEST NO. 2107 | | | | |
| Preference | 18 | 10 | 12 | NSD (0.79 C.L.) |
| Milder | 17 | 11 | 12 | NSD (0.66 C.L.) |
| Better Overall Flavor | 19 | 10 | 11 | NSD (0.84 C.L.) |

4. DEVELOPMENT EXPERT PANEL EVALUATION OF BANDED WINSTON LIGHTS (L-12984-D)
vs. UNBANDED WINSTON LIGHTS

| Item | Unbanded Control | Mean | S | # Resp. | Analysis ¹ |
|------------------|------------------|------|-----|---------|-----------------------|
| Blend | 49 | 50.2 | 4.3 | 11 | NSD |
| Aroma Quality | 49 | 50.4 | 3.8 | 11 | NSD |
| Mildness | 50 | 49.8 | 4.7 | 11 | NSD |
| Overall Opinion | 49 | 49.8 | 5.0 | 11 | NSD |
| Stemmy Taste | 51 | 49.8 | 3.9 | 11 | NSD |
| Nasal Sting | 51 | 49.6 | 4.0 | 11 | NSD |
| Throat Harshness | 51 | 49.6 | 3.9 | 11 | NSD |
| Nicotine Effect | 50 | 48.8 | 1.9 | 11 | DD |
| Burley Taste | 50 | 48.8 | 4.0 | 11 | NSD |
| Flue-Cured Taste | 50 | 48.3 | 4.2 | 11 | NSD |
| Turkish Taste | 50 | 49.0 | 4.5 | 11 | NSD |

¹95% C.L. for Significant Difference (SD); 85% C.L. for Directional Difference (DD);
No Significant Difference = NSD

5. RESEARCH BOOTH PANEL EVALUATION OF BANDED DORAL II

| | DORAL II CONTROL | Banded (Max Overlap) L-12984-E | ND | Analysis |
|-----------------------|------------------|-----------------------------------|----|----------------|
| TEST NO. 2086 | | | | |
| Preference | 19 | 19 | 2 | NSD (0.00 C.L. |
| Milder | 17 | 20 | 2 | NSD (0.36 C.L. |
| Better Overall Flavor | 17 | 20 | 2 | NSD (0.36 C.L. |

6. DEVELOPMENT EXPERT PANEL EVALUATION OF BANDED DORAL II (L-12984-E) vs UNBANDED DORAL II

| Item | Unbanded Control | Run 1 | | | | Run 2 | | | |
|------------------|------------------|-------|-----|---------|-----------------------|-------|-----|---------|-----------------------|
| | | Mean | S | # Resp. | Analysis ¹ | Mean | S | # Resp. | Analysis ¹ |
| Blend | 49 | 49.5 | 3.7 | 10 | NSD | 50.9 | 4.0 | 8 | NSD |
| Aroma Quality | 49 | 49.3 | 5.2 | 10 | NSD | 50.6 | 4.9 | 8 | NSD |
| Mildness | 50 | 48.4 | 5.1 | 10 | NSD | 50.6 | 4.8 | 8 | NSD |
| Overall Opinion | 49 | 49.1 | 4.1 | 10 | NSD | 50.6 | 5.1 | 8 | NSD |
| Stemmy Taste | 51 | 49.8 | 3.6 | 10 | NSD | 49.4 | 4.2 | 8 | NSD |
| Nasal Sting | 51 | 48.9 | 3.5 | 10 | DD | 49.1 | 3.7 | 8 | NSD |
| Throat Harshness | 51 | 47.7 | 3.9 | 10 | SD | 50.3 | 4.5 | 8 | NSD |
| Nicotine Effect | 50 | 48.4 | 3.6 | 10 | NSD | 50.6 | 2.7 | 8 | NSD |
| Burley Taste | 50 | 49.5 | 5.0 | 10 | NSD | 51.4 | 3.9 | 8 | NSD |
| Flue-Cured Taste | 50 | 49.3 | 4.4 | 10 | NSD | 50.3 | 4.3 | 8 | NSD |
| Turkish Taste | 50 | 48.6 | 3.5 | 10 | NSD | 51.1 | 2.8 | 8 | NSD |

¹95% C.L. for Significant Difference (SD); 85% C.L. for Directional Difference (DD); No Significant Difference = NSD

7. RESEARCH BOOTH PANEL EVALUATION OF BANDED GOLDEN LIGHTS

| | Golden Lights Control | Banded (Max Overlap) L-12984-G | ND | Analysis |
|-----------------------|--------------------------|--------------------------------------|----|-----------------|
| TEST NO. 2089 | | | | |
| Preference | 17 | 16 | 7 | NSD (0.13 C.L.) |
| Milder | 15 | 18 | 7 | NSD (0.36 C.L.) |
| Better Overall Flavor | 16 | 16 | 8 | NSD (0.00 C.L.) |

8. DEVELOPMENT EXPERT PANEL EVALUATION OF BANDED GOLDEN LIGHTS (L-12984-G)
vs. UNBANDED GOLDEN LIGHTS

| Item | Unbanded Control | Mean | S | # Resp. | Analysis ¹ |
|------------------|------------------|------|-----|---------|-----------------------|
| Blend | 49 | 51.1 | 4.1 | 10 | DD |
| Aroma Quality | 49 | 50.7 | 4.4 | 10 | NSD |
| Mildness | 50 | 53.2 | 3.4 | 10 | SD |
| Overall Opinion | 49 | 50.9 | 4.5 | 10 | NSD |
| Stemmy Taste | 51 | 52.0 | 3.2 | 10 | NSD |
| Nasal Sting | 51 | 50.7 | 2.7 | 10 | NSD |
| Throat Harshness | 51 | 51.9 | 3.2 | 11 | NSD |
| Nicotine Effect | 50 | 51.1 | 1.9 | 10 | DD |
| Burley Taste | 50 | 52.7 | 2.8 | 11 | SD |
| Flue-Cured Taste | 50 | 49.4 | 3.5 | 11 | NSD |
| Turkish Taste | 50 | 50.4 | 2.0 | 11 | NSD |

¹95% C.L. for Significant Difference (SD); 85% C.L. for Directional Difference (DD);
No Significant Difference = NSD

9. RESEARCH BOOTH PANEL EVALUATION OF EXPERIMENTAL CIGARETTES, L-12985-A
vs. L-12985-B

| | Banded L-12985-A | Long-Tipping L-12985-B | ND | Analysis |
|-----------------------|---------------------|---------------------------|----|-----------------|
| <hr/> | | | | |
| TEST NO. 2106 | | | | |
| Preference | 14 | 19 | 7 | NSD (0.57 C.L.) |
| Milder | 16 | 19 | 5 | NSD (0.36 C.L.) |
| Better Overall Flavor | 14 | 20 | 6 | NSD (0.66 C.L.) |
| TEST NO. 2110 | | | | |
| Preference | 17 | 14 | 9 | NSD (0.36 C.L.) |
| Milder | 14 | 16 | 10 | NSD (0.25 C.L.) |
| Better Overall Flavor | 18 | 13 | 9 | NSD (0.57 C.L.) |
| <hr/> | | | | |

10. DEVELOPMENT EXPERT PANEL EVALUATION OF EXPERIMENTAL CIGARETTES, L-12985-A (BANDED) vs. L-12985-B (LONG TIPPING)

| Item | (L-12985-B) Control | Mean | S | # Resp. | Analysis ¹ |
|------------------|------------------------|------|-----|---------|-----------------------|
| Blend | 49 | 49.4 | 4.9 | 8 | NSD |
| Aroma Quality | 49 | 48.0 | 4.9 | 8 | NSD |
| Mildness | 50 | 48.3 | 3.4 | 8 | NSD |
| Overall Opinion | 49 | 49.7 | 5.4 | 8 | NSD |
| Stemmy Taste | 51 | 50.3 | 5.8 | 8 | NSD |
| Nasal Sting | 51 | 48.9 | 3.2 | 8 | DD |
| Throat Harshness | 51 | 48.3 | 3.7 | 8 | DD |
| Nicotine Effect | 50 | 48.6 | 3.2 | 8 | NSD |
| Burley Taste | 50 | 47.7 | 2.6 | 8 | SD |
| Flue-Cured Taste | 50 | 49.7 | 4.9 | 8 | NSD |
| Turkish Taste | 50 | 49.7 | 3.3 | 8 | NSD |

¹95% C.L. for Significant Difference (SD); 85% C.L. for Directional Difference (DD);
No Significant Difference = NSD