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Selected Constituents in the Smokes of U.S. Commercial Cigarettes: "Tar", Nicotine, Carbon Monoxide and Carbon Dioxide

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OAK RIDGE NATIONAL LABORATORY
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Analytical Chemistry Division

Tobacco Smoke Research Program

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HIGHLIGHTS

One hundred twenty-one brands of United States commercial cigarettes were analyzed for their deliveries of "tar", nicotine, carbon monoxide and carbon dioxide under standard analytical smoking conditions. The sample included both filter and non-filter cigarettes. Comparisons of carbon monoxide deliveries over the range of observed "tar" deliveries indicated a very high correlation between CO and "tar" for filter cigarettes, but non-filter cigarettes tended to produce much less CO than would have been predicted from their "tar" deliveries. Comparison of ORNL nicotine values for specific brands with those determined by the Federal Trade Commission yield no statistically significant differences between laboratories.

INTRODUCTION

In October, 1978, the Director, Office of Smoking and Health, DHEW, requested the Tobacco Smoke Research Program of Oak Ridge National Laboratory, as an extension of its NCI Smoking and Health Program activities, to provide values for carbon monoxide deliveries of the smokes of U.S. commercial cigarettes. One hundred twenty (120) brands were chosen by the Director as potential candidates for analysis. The brands were chosen to include both the most popular selling brands and those representative of both low and high "tar" cigarettes.

EXPERIMENTAL

Cigarettes

Samples of U.S. commercial cigarettes were obtained through Mr. Harold Pillsbury of the Federal Trade Commission. At least 30 cigarettes of each brand were made available for study. Two cigarette packs, from which five cigarettes each had been removed, were selected at random from the current supplies at the FTC cigarette storage facility and returned to ORNL during November, 1978. Cigarettes were stored frozen (-22°C) in double plastic bags until use. After thawing, the bags were opened, each cigarette brand was given a numbered designation, and the cigarettes were conditioned for at least 48 hours at 60 ± 2% relative humidity and 74°F. Because of the limited sample size, the usual weight and resistance-to-draw selection procedures (1) were not used. Instead, an attempt was made to select cigarettes for smoking which were representative of the apparent average weight of the sample. "Resistance-to-draw" (2) of the selected cigarettes was meas-

ured with a Filtrona Pressure Drop Tester (3), but not used as a selection criterion. Smoke generation and analyses were carried out in November and December, 1978.

Reference Cigarette

Analytical procedures were periodically tested by application to the smoke generated by the 1R1 Kentucky Reference Cigarette (4). Seven separate generations resulting in 28 analyses of the smokes from 112 individual 1R1 cigarettes were performed during this study. The deliveries of specific smoke constituents by this cigarette have been measured and documented previously (1).

Smoking

Cigarettes were smoked, four to six per pad, through standard Cambridge filter assemblies (5) using a four port version of the Phipps and Bird Analytical Smoking Machine (6) (Philip Morris design produced by Phipps and Bird, Inc., Richmond, VA) under standard (7) smoking conditions of 35 ± 0.2 ml puff volume, 2 ± 0.2 second puff duration, and one puff/minute frequency to a 23 mm butt length for non-filter cigarettes or to within 3 mm of the filter overwrap for filtered cigarettes.

Air dilution filters are becoming increasingly popular, especially on low-"tar" cigarettes. The dilution holes act to diminish smoke constituent deliveries primarily by reducing the effective puff volume through the cigarette firecone. Because of the low visibility of the dilution holes, great care had to be taken to insure that the holes

were not covered by the cigarette holders during the analytical smoking procedures. In two samples obtained from the FTC, Raleigh Lights and Silva Thins (Codes 127 and 140, respectively), some cigarettes were found to possess air dilution holes in the filters, while others did not. Samples of the brands were segregated into two groups according to filter type and smoked separately. An additional pack of Silva Thins was purchased locally, and the cigarettes were found to have air dilution holes.

Total Particulate Matter (TPM), Water, Nicotine, and "Tar"

TPM was determined (2) to be the increase in weight of the Cambridge filter pad following the smoking procedure. The particulate matter was extracted with dioxane, and an aliquot of the extract was analyzed (8) for water content by gas-solid chromatograph. Nicotine was determined (9) on a separate aliquot of the extract by gas-liquid chromatography. "Tar" was taken to be the weight of TPM less the weight of water and nicotine thus determined.

Carbon Monoxide (CO) and Carbon Dioxide (CO_2)

During the analytical smoking procedure, the entire gas phase delivery of the cigarette was expelled into a Saran gas sampling bag attached to each exhaust channel of the Phipps and Bird smoking machine. Following smoking of the requisite cigarettes, six clearing puffs were taken by the machine to flush the contents of the machine dead volume into the Saran bag. An aliquot of the contents of the bag was then analyzed for carbon monoxide and carbon dioxide concentrations by gas-solid chromatography (10). Because of the importance of the CO

values in this work, CO and CO_2 deliveries were determined by comparison with two standard gas mixtures, which had been analyzed by two independent laboratories.

RESULTS AND DISCUSSION

The average weight, resistance-to-draw (RTD) and number of puffs required to smoke to the standard butt length for the individual brands are given in Table 1. Generally, the "light" variety of a given brand exhibits a lower RTD than does the standard variety, primarily because of the presence of air dilution holes in the filter of the "light" variety.

The quantities of carbon monoxide, "tar", nicotine and carbon dioxide produced per cigarette are summarized in Table 2. Quantities produced per puff, computed by dividing the quantities produced per cigarette by the number of puffs required to consume the cigarette, are summarized in Table 3. Actual quantities per puff depend on the particular puff number, with the first puffs producing less and the latter puffs producing more of each constituent (11).

As illustrated in Figures 1-4, there is a good correlation between CO and either "tar" or nicotine for lower "tar" cigarettes ($\leq$13 mg per cigarette) but a poorer correlation for the higher "tar" cigarettes (>13 mg per cigarette). For example, for CO vs "tar", per cigarette, the correlation coefficient (R) was 0.905 for lower "tar" varieties, whereas R = 0.359 for the higher "tar" brands. Generally, there was no important correlation between cigarette physical characteristics (weight, RTD) and smoke constituent deliveries. In Table 4 are tabu-

Table 1. Brand Description and Physical Characteristics of Selected U.S. Commercial Cigarettes

Brand	Description	ORNL/FTC Number	Cigarette Wt., mg	Cigarette Resistance to Draw mm H_2O	Number of Puffs
Belair	85 mm, sp, f,m	4	982	105	8.0
Belair	100 mm, sp, f, m	5	1166	117	10.2
Benson & Hedges	70 mm, hp, f	6	966	76	7.1
Benson & Hedges 100's	100 mm, hp, f	8	1102	132	8.9
Benson & Hedges 100's	100 mm, hp, f, m	9	1114	121	9.1
Benson & Hedges 100's	100 mm, sp, f	10	1078	115	8.4
Benson & Hedges Lights	100 mm, sp, f	12	1126	109	9.4
Benson & Hedges Lights	100 mm, sp, f, m	13	1139	113	9.1
Bull Durham	85 mm, sp, f	14	1180	83	11.5
Camel	70 mm, sp, nf	15	910	75	7.6
Camel	85 mm, sp, f	16	975	130	8.6
Camel Lights	85 mm, sp, f,	17	958	118	8.3
Carlton	85 mm, sp, f	19	788	115	7.1
Carlton	85 mm, sp, f, m	20	779	110	6.9
Carlton 100's	100 mm, sp, f, m	22	929	98	9.2
Chesterfield	70 mm, sp, nf	23	898	75	7.8
Chesterfield	85 mm, sp, nf	24	1050	87	9.6
Chesterfield	85 mm, sp, f	25	941	107	8.2
Chesterfield	101 mm, sp, f	26	1118	142	9.2
Decade	85 mm, sp, f, m	28	891	76	8.3
Doral	85 mm, sp, f	31	1128	83	9.4
Doral	85 mm, sp, f, m	32	1098	84	8.5

Table 1. (Cont'd)

Brand	Description	ORNL/FTC Number	Cigarette Wt., mg	Cigarette Resistance to Draw mm H_2O	Number of Puffs
DuMaurier	85 mm, sp, f	33	1032	122	8.8
English Ovals	85 mm, hp, nf	35	1105	77	9.9
Eve	100 mm, sp, f	36	1056	113	8.5
Eve	100 mm, sp, f,m	37	1082	116	8.9
Iceberg 100's	100 mm, sp, f,m	46	950	122	8.6
Kent	80 mm, hp, f	47	946	130	7.9
Kent Golden Lights	85 mm, sp, f	49	920	104	7.4
Kent Golden Lights	85 mm, sp, f, m	50	934	92	8.6
Kent Micronite II	100 mm, sp, f	51	1077	100	9.4
Kent Golden Lights	100 mm, sp, f	52	1047	120	8.5
Kent	100 mm, sp, f, m	53	1055	106	8.5
Kent Golden Lights	100 mm, sp, f, m	54	1170	112	9.2
Kool	80 mm, hp, f, m	56	947	111	8.1
Kool Milds	85 mm, sp, f, m	58	985	118	8.0
Kool Super Lights	85 mm, sp, f, m	59	1008	102	8.5
Kool	100 mm, sp, f, m	60	1151	134	10.5
Kool Super Lights	100 mm, sp, f, m	61	1206	120	9.8
L&M	80 mm, hp, f	62	905	121	8.1
L&M	85 mm, sp, f	63	951	123	7.9
L&M Lights	85 mm, sp, f	64	882	92	8.4
L&M Lights	100 mm, sp, f	66	1030	94	9.0
L&M	100 mm, sp, f, m	67	1102	129	9.8

Table 1. (Cont'd)

Brand	Description	ORNL/FTC Number	Cigarette Wt., mg	Cigarette Resistance to Draw mm H_2O	Number of Puffs
Lark	85 mm, sp, f	68	1112	132	9.0
Lark II	85 mm, sp, f	69	844	90	7.4
Lark	100 mm, sp, f	70	1123	119	9.6
Lucky Strike	70 mm, sp, nf	73	958	71	8.0
Lucky Ten	85 mm, sp, f	74	979	139	8.0
Marlboro	80 mm, hp, f	78	946	108	8.2
Marlboro	80 mm, hp, f, m	79	931	113	8.0
Marlboro	85 mm, sp, f	80	1002	131	8.6
Marlboro Lights	85 mm, sp, f	81	1121	89	8.0
Marlboro	100 mm, hp, f	83	1108	126	9.2
Marlboro	100 mm, sp, f	84	1126	116	9.8
Marlboro Lights	100 mm, sp, f	85	1155	128	9.9
Max	120 mm, sp, f	86	1020	151	10.7
Max	120 mm, sp, f, m	87	1019	151	11.1
Merit	85 mm, sp, f	88	1002	136	8.3
Merit	85 mm, sp, f, m	89	1010	136	8.1
Merit 100's	100 mm, sp, f	90	1216	130	10.0
Merit 100's	100 mm, sp, f, m	91	1151	112	9.1
More	120 mm, sp, f	93	1038	187	15.6
More	120 mm, sp, f m	94	1097	176	16.3
Multifilter	85 mm, sp, f	95	1149	76	7.6

Table 1. (Cont'd)

Brand	Description	ORNL/FTC Number	Cigarette Wt., mg	Cigarette Resistance to Draw mm H_2O	Number of Puffs
Newport	80 mm, hp, f, m	97	923	132	8.2
Newport Lights	85 mm, sp, f, m	99	925	119	8.6
Newport	100 mm, sp, f, m	100	1068	122	9.7
Now	85 mm, hp, f	101	792	108	7.4
Now	85 mm, hp, f, m	102	800	115	7.1
Now	85 mm, sp, f	103	810	108	7.8
Old Gold Filters	85 mm, sp, f	107	949	126	7.6
Old Gold Lights	85 mm, sp, f	108	920	117	8.6
Old Gold 100's	100 mm, sp, f	109	1140	120	9.6
Pall Mall	85 mm, sp, nf	110	1125	71	10.3
Pall Mall Extra Light	85 mm, sp, f	112	991	107	8.8
Pall Mall	100 mm, sp, f	113	1159	111	10.1
Parliament	80 mm, hp, f	115	970	123	7.3
Parliament	85 mm, sp, f	116	1004	123	7.7
Parliament 100's	100 mm, sp, f	117	1328	154	10.0
Philip Morris	70 mm, sp, nf	118	861	54	7.2
Philip Morris Commander	85 mm, sp, nf	119	1030	61	9.3
Picayune	70 mm, sp, nf	122	862	85	7.1
Players	70 mm, hp, nf	124	1032	71	8.0
Raleigh	85 mm, sp, nf	125	1137	85	9.8

Table 1. (Cont'd)

Brand	Description	ORNL/FTC Number	Cigarette Wt., mg	Cigarette Resistance to Draw mm H_2O	Number of Puffs
Raleigh	85 mm, sp, f	126	1030	128	8.6
Raleigh Lights*-FTC	85 mm, sp, f, w/adh	127	1033	129	8.3
Raleigh Lights*-FTC	85 mm, sp, f, w/o adh	127	1010	110	8.4
Raleigh	100 mm, sp, f	128	1198	146	9.9
Real	85 mm, sp, f	129	927	105	8.0
Real	85 mm, sp, f, m	130	964	103	8.0
Salem	80 mm, hp, f, m	133	903	137	9.0
Salem	85 mm, sp, f, m	134	1000	126	8.9
Salem Lights	85 mm, sp, f, m	135	990	123	8.4
Salem	100 mm, sp, f, m	136	1164	122	10.2
Salem Long Lights	100 mm, sp, f, m	137	1212	122	11.0
Saratoga	120 mm, hp, f	138	1080	176	11.8
Saratoga	120 mm, hp, f, m	139	1110	155	11.2
Silva Thins*-FTC	120 mm, sp, f, w/adh	140	914	100	9.2
Silva Thins*-Knoxville, TN	120 mm, sp, f, w/adh	140	942	114	9.0
Silva Thins*-FTC	120 mm, sp, f w/o adh	140	910	119	8.9

Table 1. (Cont'c)

Brand	Description	ORNL/FTC Number	Cigarette Wt., mg	Cigarette Resistance to Draw mm H_2O	Number of Puffs
Spring 100's	100 mm, sp, f, m	142	1125	111	9.1
Tareyton	85 mm, f p, f	147	1094	107	9.2
Tareyton L·ghts	85 mm, sp, f	·48	1105	99	8.8
Tareyton Low-Tar	85 mm, sp, f, m	149	1017	103	8.1
Tareyton Long Light	100 mm, sp, f	151	1174	124	10.0
True Blue 5's	85 mm, sp, f	153	851	75	6.9
True Green 5's	85 mm, sp, f, m	154	848	73	7.5
True 100's	100 mm, sp, f	155	1050	140	10.9
True 100's	100 mm, sp, f, m	156	1095	115	9.8
Twist	100 mm, sp, f, l/m	157	1134	126	10.4
Vantage	85 mm, sp, f	158	1197	129	7.6
Vantage	85 mm, sp, f, m	159	1135	128	8.3
Vantage	100 mm, sp, f	160	1262	114	10.0
Viceroy	85 mm, sp, f	161	1014	122	8.5
Viceroy Lights	85 mm, sp, f	162	1024	105	8.4
Viceroy	100 mm, sp, f	163	1217	121	10.1
Virginia Slims	100 mm, sp, f	164	966	130	8.3

Table 1. (Cont'd)

Brand	Description	ORNL/FTC Number	Cigarette Wt., mg	Cigarette Resistance to Draw mm H_2O	Number of Puffs
Winston	80 mm, hp, f	166	1012	124	10.0
Winston	85 mm, sp, f	167	1115	112	9.3
Winston Lights	85 mm, sp, f	168	986	105	8.7
Winston 100's	100 mm, sp, f	169	1046	116	10.1
Winston Lights 100's	100 mm, sp, f	170	1133	109	9.9
Winston	100 mm, sp, f, m	171	1174	132	10.4

*Two types of filters were found in samples of Raleigh Lights and Silva Thins. Some filters possessed air dilution holes, some did not. Samples of these brands were segretated according to filter type and smoked separately. See Text.

f = filter
hp = hard pack
l/m = lemon menthol
m = menthol
nf = nonfilter
sp = soft pack
w/adh = with air dilution holes
w/o adh = without air dilution holes

Table 2. Tar, Nicotine, Carbon Monoxide, and Carbon Dioxide Deliveries of Selected U.S. Commercial Cigarettes
RESULTS PER CIGARETTE

Brand	Description	Deliveries, Mean (mg) ± Standard Deviation (mg)			
		Tar	Nicotine	Carbon Monoxide	Carbon Dioxide
Belair	85 mm, sp, f,m	13.6 ± 0.5	0.98 ± .04	15.6± 0.1	53.8± 0.7
Belair	100 mm, sp, f, m	15.6 ± 0.7	0.97 ± .03	17.0± 0.6	58.2± 1.4
Benson & Hedges	70 mm, hp, f	1.1 ± 0.1	0.11 ± .01	1.2± 0.1	8.0± 0.5
Benson & Hedges 100's	100 mm, hp, f	18.3 ± 0.3	0.99 ± .03	21.9± 0.4	60.5± 1.0
Benson & Hedges 100's	100 mm, hp, f, m	17.3 ± 0.8	1.03 ± .05	19.0± 1.4	56.9 ± 3.5
Benson & Hedges 100's	100 mm, sp, f	17.3 ± 0.8	0.98 ± .03	18.4 ± 0.6	54.8 ± 1.1
Benson & Hedges Lights	100 mm, sp, f	11.7 ± 0.5	0.74 ± .02	11.8± 0.4	39.0 ± 1.2
Benson & Hedges Lights	100 mm, sp, f, m	11.5 ± 0.1	0.73 ± .02	8.4± 0.2	36.8 ± 0.3
Bull Durham	85 mm, sp, f	35.5 ± 0.6	1.97 ± .08	28.6± 0.5	83.0 ± 1.7
Camel	70 mm, sp, nf	28.0 ± 2.0	1.69 ± .05	17.8± 0.2	53.5 ± 0.7
Camel	85 mm, sp, f	22.0 ± 0.6	1.26 ± .03	19.7 ± 0.8	60.5 ± 1.9
Camel Lights	85 mm, sp, f,	10.2 ± 0.1	0.84 ± .01	13.1 ± 0.2	44.0 ± 0.3
Carlton	85 mm, sp, f	1.0 ± 0.2	0.12 ± .01	2.1 ± 0.2	12.9 ± 0.5
Carlton	85 mm, sp, f, m	0.5 ± 0.1	0.07 ± .01	1.1 ± 0.1	7.0 ± 0.2
Carlton 100's	100 mm, sp, f, m	4.4 ± 0.4	0.40 ± .01	5.2 ± 0.3	24.6 ± 0.6
Chesterfield	70 mm, sp, nf	24.0 ± 1.1	1.31 ± .11	14.7 ± 0.5	50.3 ± 1.2
Chesterfield	85 mm, sp, nf	30.2 ± 1.2	1.29 ± .04	17.6 ± 0.9	59.9 ± 2.2
Chesterfield	85 mm, sp, f	16.4 ± 0.4	0.93 ± .02	14.5 ± 0.6	48.0 ± 1.6
Chesterfield	101 mm, sp, f	16.8 ± 0.3	1.00 ± .03	18.5 ± 0.7	59.2 ± 1.9
Decade	85 mm, sp, f, m	4.4 ± 0.6	0.38 ± .02	2.4 ± 0.4	17.1 ± 1.4
Doral	85 mm, sp, f	11.2 ± 0.4	0.80 ± .03	10.2 ± 0.4	42.5 ± 1.0
Doral	85 mm, sp, f, m	14.5 ± 0.2	0.78 ± .02	14.0 ± 0.8	47.4 ± 2.3

Table 2. (Cont'd)

Brand	Description	Deliveries, Mean (mg) ± Standard Deviation (mg)			
		Tar	Nicotine	Carbon Monoxide	Carbon Dioxide
DuMaurier	85 mm, sp, f	16.6 ± 0.2	1.11 ± 0.5	21.7 ± 0.4	65.6 ± 1.1
English Ovals	85 mm, hp, nf	28.9 ± 0.6	1.74 ± .02	14.0 ± 0.2	52.5 ± 0.5
Eve	100 mm, sp, f	15.8 ± 0.5	1.08 ± .04	18.0 ± 0.6	55.8 ± 1.2
Eve	100 mm, sp, f,m	18.0 ± 0.6	0.97 ± .02	19.4 ± 0.4	58.3 ± 0.6
Iceberg 100's	100 mm, sp, f,m	2.1 ± 0.1	0.24 ± .01	3.7 ± 0.2	20.0 ± 0.3
Kent	80 mm, hp, f	17.7 ± 0.2	1.00 ± .02	20.3 ± 0.3	56.7 ± 0.8
Kent Golden Lights	85 mm, sp, f	9.9 ± 0.3	0.66 ± .03	11.7 ± 0.2	37.9 ± 0.2
Kent Golden Lights	85 mm, sp, f, m	9.3 ± 0.2	0.76 ± .03	11.9 ± 0.2	40.5 ± 0.4
Kent Micronite II	100 mm, sp, f	15.3 ± 0.1	1.02 ± .02	17.5 ± 0.4	53.3 ± 1.2
Kent Golden Lights	100 mm, sp, f	12.5 ± 0.7	0.83 ± .02	13.2 ± 0.5	47.1 ± 1.4
Kent	100 mm, sp, f, m	19.5 ± 1.0	1.13 ± .02	19.6 ± 0.9	6.30 ± 1.0
Kent Golden Lights	100 mm, sp, f, m	10.5 ± 0.1	0.66 ± .03	11.2 ± 0.3	43.3 ± 0.6
Kool	80 mm, hp, f, m	18.0 ± 0.7	1.18 ± .03	18.4 ± 0.2	54.9 ± 0.7
Kool Milds	85 mm, sp, f, m	14.4 ± 0.5	0.95 ± .10	19.4 ± 0.3	61.8 ± 1.0
Kool Super Lights	85 mm, sp, f, m	10.2 ± 0.4	0.74 ± .03	13.0 ± 0.6	49.1 ± 1.3
Kool	100 mm, sp, f, m	14.5 ± 0.1	1.07 ± .02	15.3 ± 0.3	51.7 ± 0.7
Kool Super Lights	100 mm, sp, f, m	10.3 ± 0.1	0.74 ± .01	12.7 ± 0.5	49.2 ± 1.4
L&M	80 mm, hp, f	20.8 ± 0.2	1.05 ± .04	19.8 ± 0.3	56.6 ± 0.5
L&M	85 mm, sp, f	17.6 ± 1.6	0.89 ± .03	17.7 ± 0.8	56.0 ± 1.0
L&M Lights	85 mm, sp, f	9.0 ± 0.3	0.68 ± .02	5.7 ± 0.2	28.0 ± 1.0
L&M Lights	100 mm, sp, f	8.1 ± 0.3	0.66 ± .02	5.6 ± 0.3	29.5 ± 0.9
L&M	100 mm, sp, f, m	18.9 ± 0.6	1.06 ± .02	21.5 ± 0.5	64.4 ± 1.6

Table 2. (Cont'd)

Brand	Description	Deliveries, Mean (mg) ± Standard Deviation (mg)			
		Tar	Nicotine	Carbon Monoxide	Carbon Dioxide
Lark	85 mm, sp, f	18.6 ± 0.2	1.14 ± .02	20.6 ± 0.9	66.3 ± 2.2
Lark II	85 mm, sp, f	7.8 ± 0.8	0.68 ± .05	8.7 ± 0.4	33.7 ± 1.1
Lark	100 mm, sp, f	19.5 ± 0.2	1.04 ± .05	21.2 ± 0.5	64.8 ± 1.6
Lucky Strike	70 mm, sp, nf	26.9 ± 1.3	1.46 ± .06	26.1 ± 0.8	54.0 ± 2.2
Lucky Ten	85 mm, sp, f	9.6 ± 0.4	0.72 ± .03	11.6 ± 0.3	41.3 ± 0.7
Marlboro	80 mm, hp, f	19.0 ± 0.3	1.04 ± .02	14.8 ± 0.2	42.6 ± 0.2
Marlboro	80 mm, hp, f, m	14.3 ± 0.4	0.87 ± .02	13.5 ± 0.3	46.1 ± 1.0
Marlboro	85 mm, sp, f	18.3 ± 1.4	0.93 ± .03	20.9 ± 0.8	57.2 ± 1.6
Marlboro Lights	85 mm, sp, f	14.0 ± 0.1	0.81 ± .01	15.1 ± 0.9	47.1 ± 1.3
Marlboro	100 mm, hp, f	19.2 ± 0.4	1.00 ± .03	20.2 ± 0.5	61.4 ± 1.5
Marlboro	100 mm, sp, f	19.2 ± 0.9	0.90 ± .02	17.1 ± 0.5	57.1 ± 1.5
Marlboro Lights	100 mm, sp, f	12.1 ± 0.6	0.76 ± .02	14.4 ± 0.6	49.5 ± 0.9
Max	120 mm, sp, f	18.8 ± 1.3	1.08 ± .03	16.3 ± 1.0	53.2 ± 2.4
Max	120 mm, sp, f, m	21.0 ± 1.0	1.31 ± .02	22.9 ± 1.1	61.6 ± 2.5
Merit	85 mm, sp, f	9.1 ± 0.2	0.62 ± .02	11.0 ± 0.5	41.2 ± 1.4
Merit	85 mm, sp, f, m	8.4 ± 0.2	0.67 ± .02	10.1 ± 0.5	39.6 ± 1.5
Merit 100's	100 mm, sp, f	12.4 ± 0.3	0.87 ± .02	13.1 ± 0.9	49.6 ± 2.8
Merit 100's	100 mm, sp, f, m	10.6 ± 0.6	0.75 ± .02	11.7 ± 0.4	45.0 ± 1.2
More	120 mm, sp, f	25.6 ± 0.3	1.91 ± .03	25.7 ± 0.9	78.7 ± 2.7
More	120 mm, sp, f m	24.8 ± 1.7	1.71 ± .03	25.7 ± 1.7	80.5 ± 6.7
Multifilter	85 mm, sp, f	14.4 ± 0.1	0.84 ± .03	14.0 ± 0.4	45.8 ± 1.1

Table 2. (Cont'd)

Brand	Description	Deliveries, Mean (mg) ± Standard Deviation (mg)			
		Tar	Nicotine	Carbon Monoxide	Carbon Dioxide
Newport	80 mm, hp, f, m	20.1 ± 0.6	1.03 ± .02	20.3 ± 0.8	58.3 ± 2.2
Newport Lights	85 mm, sp, f, m	12.9 ± 0.3	0.82 ± .04	14.4 ± 0.3	50.6 ± 1.6
Newport	100 mm, sp, f, m	23.4 ± 0.2	1.37 ± .03	19.1 ± 0.4	60.4 ± 0.8
Now	80 mm, hp, f	1.7 ± 0.1	0.16 ± .01	2.5 ± 0.1	11.6 ± 0.2
Now	85 mm, hp, f, m	2.2 ± 0.1	0.16 ± .01	2.4 ± 0.3	11.5 ± 1.0
Now	85 mm, sp, f	1.9 ± 0.1	0.16 ± .01	2.4 ± 0.1	11.6 ± 0.6
Old Gold Filters	85 mm, sp, f	17.5 ± 1.0	0.95 ± .03	15.8 ± 0.6	49.8 ± 1.0
Old Gold Lights	85 mm, sp, f	16.3 ± 0.9	0.91 ± .02	13.4 ± 0.5	48.0 ± 0.6
Old Gold 100's	100 mm, sp, f	21.8 ± 0.8	1.47 ± .14	20.6 ± 0.7	63.8 ± 2.6
Pall Mall	85 mm, sp, nf	28.2 ± 0.4	1.66 ± .05	17.1 ± 0.5	58.4 ± 1.1
Pall Mall Extra Light	85 mm, sp, f	5.7 ± 0.4	0.51 ± .01	6.3 ± 0.2	31.5 ± 0.7
Pall Mall	100 mm, sp, f	19.3 ± 0.5	1.37 ± .03	18.5 ± 0.7	61.2 ± 2.2
Parliament	80 mm, hp, f	10.0 ± 0.4	0.62 ± .03	12.0 ± 0.3	40.2 ± 0.7
Parliament	85 mm, sp, f	10.4 ± 0.1	0.64 ± .02	12.3 ± 0.3	41.8 ± 0.8
Parliament 100's	100 mm, sp, f	13.0 ± 0.7	0.82 ± .02	12.6 ± 0.4	49.8 ± 1.7
Philip Morris	70 mm, sp, nf	21.4 ± 0.3	1.12 ± .05	11.8 ± 0.5	40.6 ± 1.2
Philip Morris Commander	85 mm, sp, nf	26.8 ± 1.2	1.55 ± .15	17.0 ± 0.3	54.2 ± 0.3
Picayune	70 mm, sp, nf	23.0 ± 2.2	1.21 ± .10	17.8 ± 1.1	52.0 ± 2.2
Players	70 mm, hp, nf	26.8 ± 1.1	1.79 ± .05	14.7 ± 0.9	48.7 ± 2.0
Raleigh	85 mm, sp, nf	24.2 ± 0.6	1.25 ± .06	16.6 ± 0.6	57.1 ± 1.1

Table 2. (Cont'd)

Brand	Description	Deliveries, Mean (mg) ± Standard Deviation (mg)			
		Tar	Nicotine	Carbon Monoxide	Carbon Dioxide
Raleigh	85 mm, sp, f	17.7 ± 0.7	1.06 ± .04	18.4 ± 0.8	60.9 ± 1.9
Raleigh Lights*-FTC	85 mm, sp, f, w/adh	11.0 ± 0.2	0.87 ± .05	14.3 ± 0.1	48.5 ± 0.1
Raleigh Lights*-FTC	85 mm, sp, f, w/o adh	13.5 ± 0.9	0.91 ± .08	15.4 ± 0.1	52.7 ± 0.9
Raleigh	100 mm, sp, f	17.2 ± 1.2	1.02 ± .02	20.0 ± 0.7	68.4 ± 2.1
Real	85 mm, sp, f	9.0 ± 0.6	0.72 ± .03	9.5 ± 0.3	38.6 ± 0.7
Real	85 mm, sp, f, m	9.6 ± 0.2	0.74 ± .01	9.1 ± 0.3	38.1 ± 0.6
Salem	80 mm, hp, f, m	17.2 ± 1.0	1.15 ± .03	19.8 ± 0.4	63.1 ± 0.3
Salem	85 mm, sp, f, m	17.2 ± 0.1	1.12 ± .03	19.5 ± 0.4	60.5 ± 1.2
Salem Lights	85 mm, sp, f, m	11.3 ± 0.2	0.79 ± .02	15.8 ± 0.6	50.3 ± 1.6
Salem	100 mm, sp, f, m	20.3 ± 0.5	1.36 ± .10	22.7 ± 0.8	66.6 ± 1.6
Salem Long Lights	100 mm, sp, f, m	12.4 ± 1.9	0.94 ± .08	16.2 ± 0.3	58.0 ± 0.5
Saratoga	120 mm, hp, f	18.8 ± 1.4	1.09 ± .04	19.4 ± 0.7	65.5 ± 1.5
Saratoga	120 mm, hp, f, m	19.9 ± 1.3	1.16 ± .05	25.2 ± 0.7	70.8 ± 1.5
Silva Thins*-FTC	120 mm, sp, f, w/adh	13.1 ± 0.7	0.86 ± .01	11.8 ± 0.6	44.0 ± 1.7
Silva Thins*-Knoxville, TN	120, mm, sp, f, w/adh	13.8 ± 0.9	1.01 ± .04	12.3 ± 0.4	45.7 ± 1.3
Silva Thins*-FTC	120 mm, sp, f, w/o adh	17.1 ± 1.2	1.03 ± .07	13.8 ± 0.1	47.7 ± 0.5
Spring 100's	100 mm, sp, f, m	20.1 ± 0.1	1.08 ± .02	17.9 ± 0.2	58.1 ± 0.1

Table 2. (Cont'd)

Brand	Description	Deliveries, Mean (mg) ± Standard Deviation (mg)			
		Tar	Nicotine	Carbon Monoxide	Carbon Dioxide
Tareyton	85 mm, sp, f	18.7 ± 0.1	1.12 ± .2	13.7 ± 0.3	47.8 ± 0.9
Tareyton Lights	85 mm, sp, f	6.3 ± 0.2	0.56 ± .02	8.6 ± 0.5	37.4 ± 1.5
Tareyton Low-Tar	85 mm, sp, f, m	7.2 ± 0.1	0.57 ± .01	13.1 ± 1.4	43.0 ± 2.3
Tareyton Long Lights	100 mm, sp, f	10.6 ± 0.4	0.73 ± .02	13.4 ± 0.5	48.3 ± 1.7
True Blue 5's	85 mm, sp, f	5.9 ± 0.1	0.46 ± .08	6.9 ± 0.3	28.3 ± 0.9
True Green 5's	85 mm, sp, f, m	4.5 ± 0.3	0.33 ± .04	4.4 ± 0.2	22.7 ± 0.8
True 100's	100 mm, sp, f	15.2 ± 0.1	0.87 ± .01	18.1 ± 0.8	63.3 ± 1.6
True 100's	100 mm, sp, f, m	16.6 ± 0.9	0.83 ± .03	19.2 ± 0.1	57.8 ± 0.4
Twist	100 mm, sp, f, l/m	14.6 ± 1.0	1.01 ± .02	17.0 ± 0.5	59.4 ± 0.5
Vantage	85 mm, sp, f	10.7 ± 0.2	0.75 ± .02	15.3 ± 0.3	48.1 ± 0.7
Vantage	85 mm, sp, f, m	10.8 ± 0.2	0.81 ± .02	16.8 ± 0.2	56.8 ± 0.7
Vantage	100 mm, sp, f	13.4 ± 0.8	0.81 ± .02	17.2 ± 0.8	55.4 ± 1.2
	85 mm, sp, f	15.2 ± 0.3	1.08 ± .03	19.8 ± 0.4	59.6 ± 1.1
Viceroy	100 mm, sp, f	16.4 ± 0.1	1.10 ± .02	18.6 ± 0.2	64.1 ± 0.9
Virginia Slims	100 mm, sp, f	17.5 ± 0.9	0.82 ± .04	16.9 ± 1.0	53.0 ± 2.0
Winston	80 mm, hp, f	20.0 ± 2.7	1.20 ± .03	15.1 ± 0.8	57.9 ± 1.6
Winston	85 mm, sp, f	20.8 ± 0.9	1.55 ± .13	19.7 ± 0.5	59.1 ± 0.5
Winston Lights	85 mm, sp, f	14.0 ± 0.4	0.82 ± .01	15.0 ± 0.5	47.6 ± 0.9
Winston 100's	100 mm, sp, f	20.7 ± 0.5	1.23 ± .03	19.0 ± 0.5	63.0 ± 1.0
Winston Lights 100's	100 mm, sp, f	15.0 ± 0.2	1.02 ± .02	16.6 ± 0.6	56.5 ± 1.4
Winston	100 mm, sp, f, m	19.8 ± 0.4	1.13 ± .02	17.7 ± 0.5	64.1 ± 0.9

Table 2. (Cont'd)

*Two types of filters were found in samples of Raleigh Lights and Silva Thins. Some filters possessed air dilution holes, some did not. Samples of these brands were segregated according to filter type and smoked separately. See Text.

f = filter
hp = hard pack
l/m = lemon menthol
m = menthol
nf = nonfilter
sp = soft pack
w/adh = with air dilution holes
w/o adh = without air dilution holes

Table 3. Tar, Nicotine, Carbon Monoxide, and Carbon Dioxide Deliveries of Selected U.S. Commercial Cigarettes
RESULTS PER PUFF

Brand	Description	Deliveries			
		Tar mg	Nicotine mg	Carbon Monoxide mg	Carbon Dioxide mg
Belair	85 mm, sp, f,m	1.7	0.12	2.1	6.7
Belair	100 mm, sp, f, m	1.53	0.095	1.67	5.71
Benson & Hedges	70 mm, hp, f	0.15	0.015	0.17	1.1
Benson & Hedges 100's	100 mm, hp, f	2.1	0.11	2.5	6.8
Benson & Hedges 100's	100 mm, hp, f, m	1.9	0.11	2.1	6.2
Benson & Hedges 100's	100 mm, sp, f	2.1	0.12	2.2	6.5
Benson & Hedges Lights	100 mm, sp, f	1.2	0.079	1.3	4.1
Benson & Hedges Lights	100 mm, sp, f, m	1.3	0.080	0.92	4.0
Bull Durham	85 mm, sp, f	3.09	0.171	2.49	7.22
Camel	70 mm, sp, nf	3.7	0.22	2.3	7.0
Camel	85 mm, sp, f	2.6	0.15	2.3	7.0
Camel Lights	85 mm, sp, f,	1.2	0.10	1.6	5.3
Carlton	85 mm, sp, f	0.14	0.017	0.30	1.8
Carlton	85 mm, sp, f, m	0.07	0.010	0.16	1.0
Carlton 100's	100 mm, sp, f, m	0.48	0.043	0.56	2.7
Chesterfield	70 mm, sp, nf	3.1	0.17	1.9	6.4
Chesterfield	85 mm, sp, nf	3.1	0.13	1.8	6.2
Chesterfield	85 mm, sp, f	2.0	0.11	1.8	5.9
Chesterfield	101 mm, sp, f	1.8	0.11	2.0	6.4
Decade	85 mm, sp, f, m	0.53	0.046	0.29	2.1

Table 3. (Cont'd)

Brand	Description	Deliveries Per Puff			
		Tar mg	Nicotine mg	Carbon Monoxide mg	Carbon Dioxide mg
Doral	85 mm, sp, f	1.2	0.085	1.1	4.5
Doral	85 mm, sp, f, m	1.7	0.092	1.6	5.6
DuMaurier	85 mm, sp, f	1.9	0.13	2.5	7.5
English Ovals	85 mm, hp, nf	2.9	0.18	1.4	5.3
	100 mm, sp, f	1.9	0.13	2.1	6.6
Eve	100 mm, sp, f,m	2.0	0.11	2.2	6.6
Iceberg 100's	100 mm, sp, f,m	0.24	0.028	0.43	2.3
Kent	80 mm, hp, f	2.2	0.13	2.6	7.2
Kent Golden Lights	85 mm, sp, f	1.3	0.089	1.6	5.1
Kent Golden Lights	85 mm, sp, f, m	1.1	0.088	1.4	4.7
Kent Micronite II	100 mm, sp, f	1.6	0.11	1.9	5.7
Kent Golden Lights	100 mm, sp, f	1.5	0.098	1.6	5.5
Kent	100 mm, sp, f, m	2.3	0.13	2.3	6.6
Kent Golden Lights	100 mm, sp, f, m	1.1	0.072	1.2	4.7
Kool	80 mm, hp, f, m	2.2	0.15	2.3	6.8
Kool Milds	85 mm, sp, f, m	1.8	0.12	2.4	7.7
Kool Super Lights	85 mm, sp, f, m	1.2	0.086	1.5	5.7
Kool	100 mm, sp, f, m	1.38	0.102	1.46	4.92
Kool Super Lights	100 mm, sp, f, m	1.1	0.076	1.3	5.0

Table 3. (Cont'd)

Brand	Description	Deliveries Per Puff			
		Tar mg	Nicotine mg	Carbon Monoxide mg	Carbon Dioxide mg
L&M	80 mm, hp, f	2.6	0.13	2.4	7.0
L&M	85 mm, sp, f	2.2	0.11	2.2	7.1
L&M Lights	85 mm, sp, f	1.1	0.081	0.68	3.3
L&M Lights	100 mm, sp, f	0.90	0.073	0.62	3.3
L&M	100 mm, sp, f, m	1.9	0.11	2.2	6.6
Lark	85 mm, sp, f	2.1	0.13	2.3	7.4
Lark II	85 mm, sp, f	1.1	0.092	1.2	4.6
Lark	100 mm, sp, f	2.0	0.11	2.2	6.8
Lucky Strike	70 mm, sp, nf	3.4	0.18	2.0	6.8
Lucky Ten	85 mm, sp, f	1.2	0.090	1.4	5.2
Marlboro	80 mm, hp, f	2.3	0.13	1.8	5.2
Marlboro	80 mm, hp, f, m	1.8	0.11	1.7	5.8
Marlboro	85 mm, sp, f	2.1	0.11	2.4	6.7
	100 mm, hp, f	2.1	0.11	2.2	6.7
Marlboro	100 mm, sp, f	2.0	0.092	1.7	5.8
Max	120 mm, sp, f	1.76	0.101	1.52	4.97
Max	120 mm, sp, f, m	1.89	0.118	2.06	5.55
Merit	85 mm, sp, f	1.1	0.075	1.3	5.0
Merit	85 mm, sp, f, m	1.0	0.083	1.2	4.9
Merit 100's	100 mm, sp, f	1.24	0.087	1.31	4.96
Merit 100's	100 mm, sp, f, m	1.2	0.082	1.3	4.9

Table 3. (Cont'd)

Brand	Description	Deliveries Per Puff			
		Tar mg	Nicotine mg	Carbon Monoxide mg	Carbon Dioxide mg
More	120 mm, sp, f	1.64	0.122	1.65	5.04
More	120 mm, sp, menthol	1.52	0.105	1.58	4.94
Multifilter	85 mm, sp, f	1.9	0.11	1.8	6.0
Newport	80 mm, hp, f, menthol	2.5	0.13	2.5	7.1
Newport Lights	85 mm, sp, f, menthol	1.5	0.095	1.7	5.9
Newport	100 mm, sp, f, menthol	2.4	0.14	2.0	6.2
Now	80 mm, hp, f	0.23	0.022	0.34	1.6
Now	85 mm, hp, f, menthol	0.31	0.023	0.34	1.6
Now	85 mm, sp, f	0.24	0.021	0.31	1.5
Old Gold Filters	85 mm, sp, f	2.3	0.12	2.1	6.6
Old Gold Lights	85 mm, sp, f	1.9	0.11	1.6	5.6
Old Gold 100's	100 mm, sp, f	2.3	0.15	2.1	6.6
Pall Mall	85 mm, sp, nf	2.74	0.161	1.66	5.67
Pall Mall Extra Light	85 mm, sp, f	0.65	0.058	0.72	3.6
Pall Mall	100 mm, sp, f	1.91	0.136	1.83	6.06
Parliament	80 mm, hp, f	1.4	0.085	1.6	5.5
Parliament	85 mm, sp, f	1.4	0.083	1.6	5.4
Parliament 100's	100 mm, sp, f	1.30	0.082	1.26	4.98
Philip Morris	70 mm, sp, nf	3.0	0.16	1.6	5.6
Philip Morris Commander	85 mm, sp, nf	2.9	0.17	1.8	5.8

Table 3. (Cont'd)

Brand	Description	Deliveries Per Puff			
		Tar mg	Nicotine mg	Carbon Monoxide mg	Carbon Dioxide mg
Picayune	70 mm, sp, nf	3.2	0.17	2.5	7.3
Players	70 mm, hp, nf	3.4	0.22	1.8	6.1
Raleigh	85 mm, sp, nf	2.5	0.13	1.7	5.8
Raleigh	85 mm, sp, f	2.1	0.12	2.1	7.1
Raleigh Lights*-FTC	85 mm, sp, f, w/adh	1.3	0.10	1.7	5.8
Raleigh Lights*-FTC	85 mm, sp, f, w/o adh	1.6	0.11	1.8	6.3
Raleigh	100 mm, sp, f	1.7	0.10	2.0	6.9
Real	85 mm, sp, f	1.1	0.090	1.2	4.8
Real	85 mm, sp, f, m	1.2	0.092	1.1	4.8
Salem	80 mm, hp, f,m	1.9	0.13	2.2	7.0
Salem	85 mm, sp, f, m	1.9	0.13	2.2	6.8
Salem Lights	85 mm, sp, f, m	1.3	0.094	1.9	6.0
Salem	100 mm, sp, f, m	1.99	0.133	2.22	6.53
Salem Long Lights	100 mm, sp, f, m	1.13	0.085	1.47	5.27
Saratoga	120 mm, hp, f	1.59	0.0924	1.64	5.55
Saratoga	120 mm, hp, f, m	1.78	0.104	2.25	6.32

Table 3. (Cont'd)

Brand	Description	Deliveries Per Puff			
		Tar mg	Nicotine mg	Carbon Monoixde mg	Carbon Dioxide mg
Silva Thins*-FTC	120 mm, sp, f, w/adh	1.4	0.093	1.3	4.8
Silva Thins*-Knoxville, TN	120, mm, sp, f, w/adh	1.5	0.11	1.4	5.1
Silva Thins*-FTC	120 mm, sp, f, w/o adh	1.9	0.12	1.6	5.4
Spring 100's	100 mm, sp, f, m	2.2	0.12	2.0	6.4
Tareyton	85 mm, sp, f	2.0	0.12	1.5	5.2
Tareyton Lights	85 mm, sp, f	0.72	0.064	0.98	4.2
Tareyton Low-Tar	85 mm, sp, f, m	0.89	0.070	1.6	5.3
Tareyton Long Lights	100 mm, sp, f	1.06	0.073	1.34	4.83
True Blue 5's	85 mm, sp, f	0.86	0.067	1.0	4.1
True Green 5's	85 mm, sp, f, m	0.60	0.044	0.59	3.0
True 100's	100 mm, sp, f	1.39	0.080	1.66	5.81
True 100's	100 mm, sp, f, m	1.7	0.085	2.0	5.9
Twist	100 mm, sp, f, l/m	1.40	0.0971	1.63	5.71
Vantage	85 mm, sp, f	1.4	0.099	2.0	6.3
Vantage	85 mm, sp, f, m	1.3	0.098	2.0	6.8
Vantage	100 mm, sp, f	1.34	0.081	1.72	5.54

Table 3. (Cont'd)

Brand	Description	Deliveries Per Puff			
		Tar mg	Nicotine mg	Carbon Monoixde mg	Carbon Dioxide mg
Viceroy	85 mm, sp, f	1.8	0.13	2.3	7.0
Viceroy Lights	85 mm, sp, f	1.7	0.12	1.9	6.3
Viceroy	100 mm, sp, f	1.62	0.109	1.84	6.34
Virginia Slims	100 mm, sp, f	2.1	0.099	2.0	6.4
Winston	80 mm, hp, f	2.00	0.120	1.51	5.79
Winston	85 mm, sp, f	2.2	0.17	2.1	6.4
Winston Lights	85 mm, sp, f	1.6	0.094	1.7	5.5
Winston 100's	100 mm, sp, f	2.05	0.122	1.88	6.24
Winston Lights 100's	100 mm, sp, f	1.5	0.10	1.7	5.7
Winston	100 mm, sp, f, m	1.90	0.109	1.70	6.16

*Two types of filters were found in samples of Raleigh Lights and Silva Thins. Some filters possessed air dilution holes, some did not. Samples of these brands were segregated according to filter type and smoked separately. See Text.

f = filter
hp = hard pack
l/m = lemon menthol
m = menthol
nf = nonfilter
sp = soft pack
w/adh = with air dilution holes
w/o adh = without air dilution holes

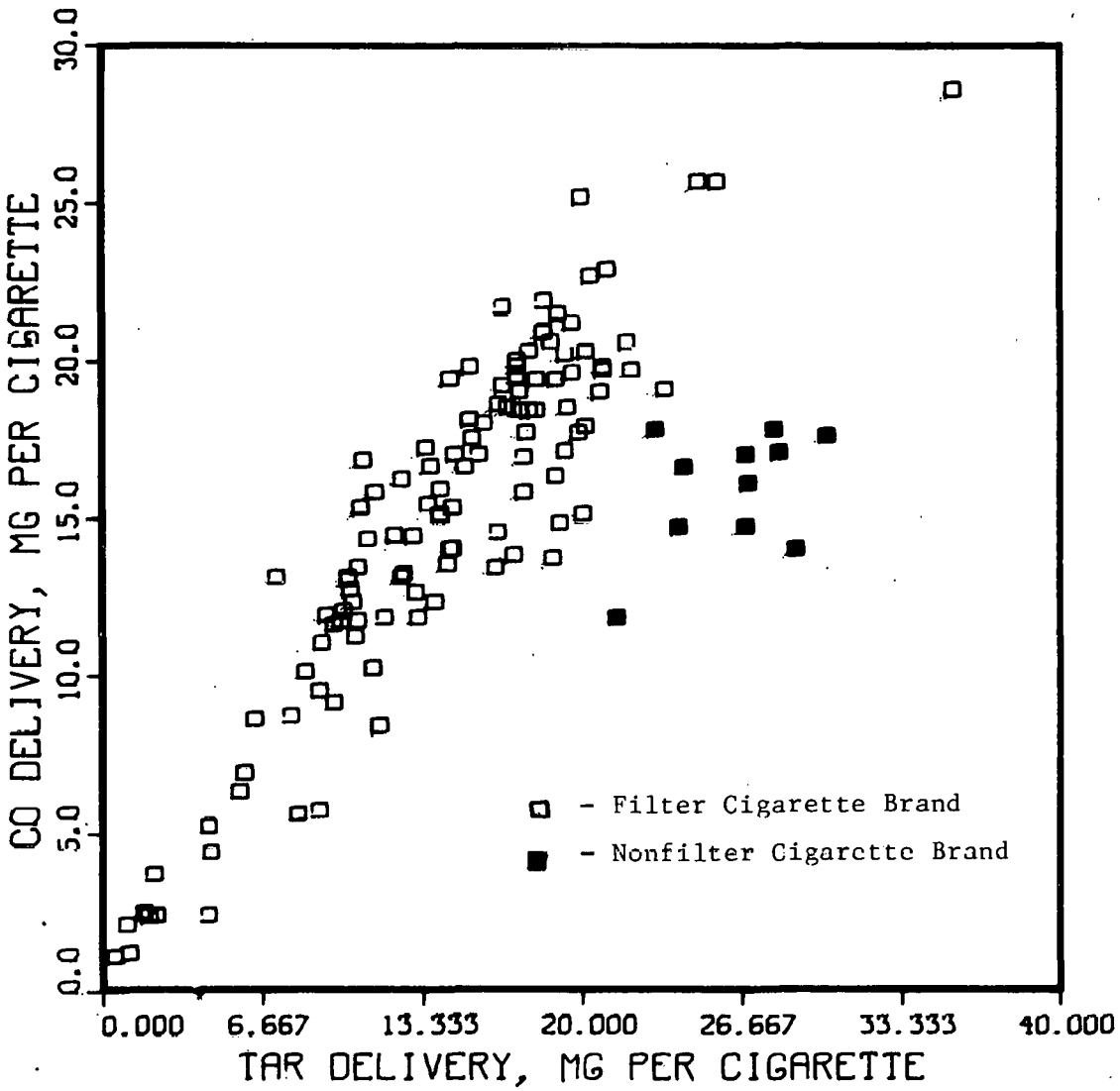

Figure 1. Carbon monoxide delivery as a function of "tar" delivery. Per cigarette basis. U.S. Commercial Cigarettes.

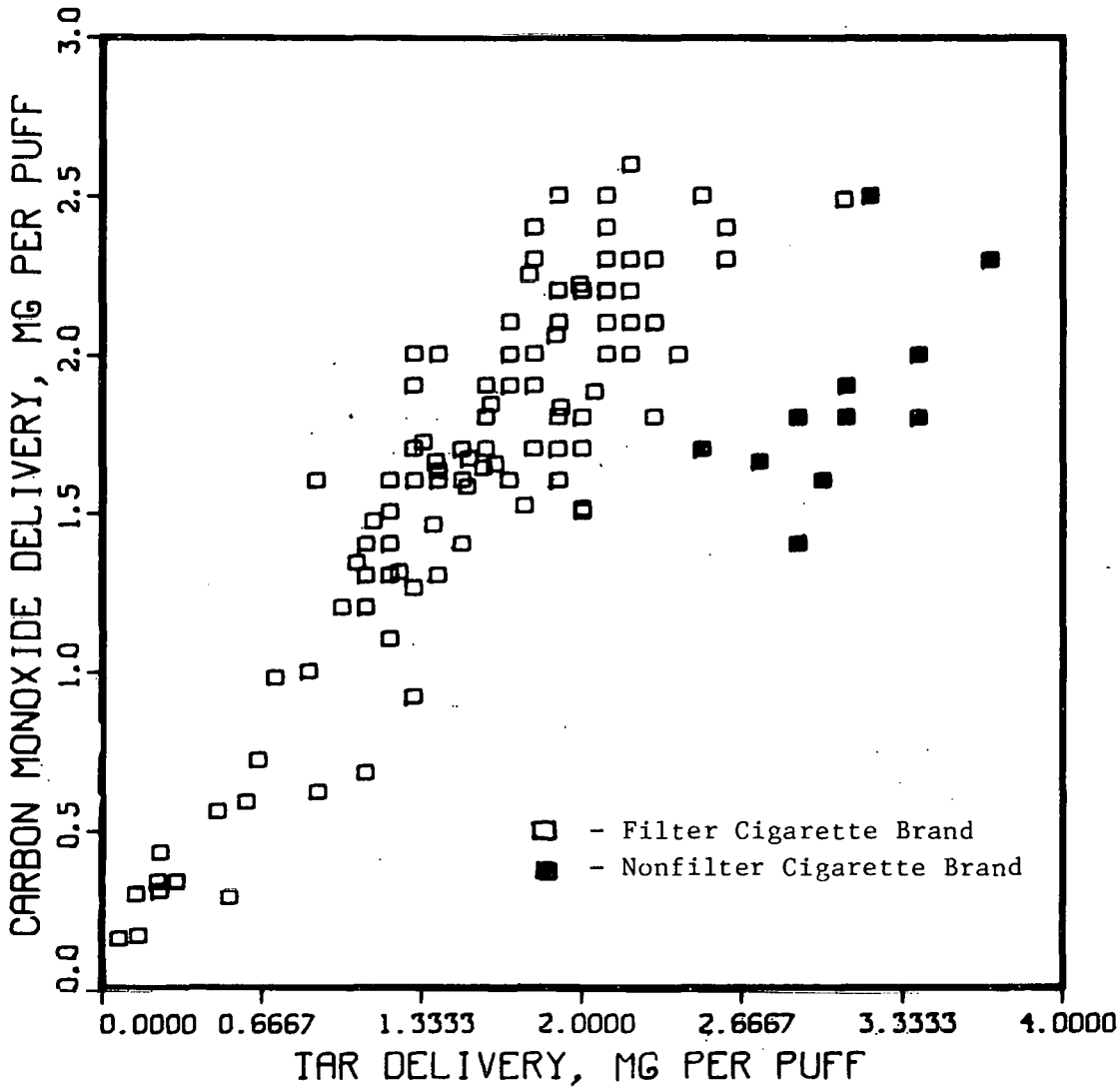

Figure 2. Carbon monoxide delivery as a function of "tar" delivery. Per puff basis. U.S. Commercial Cigarettes.

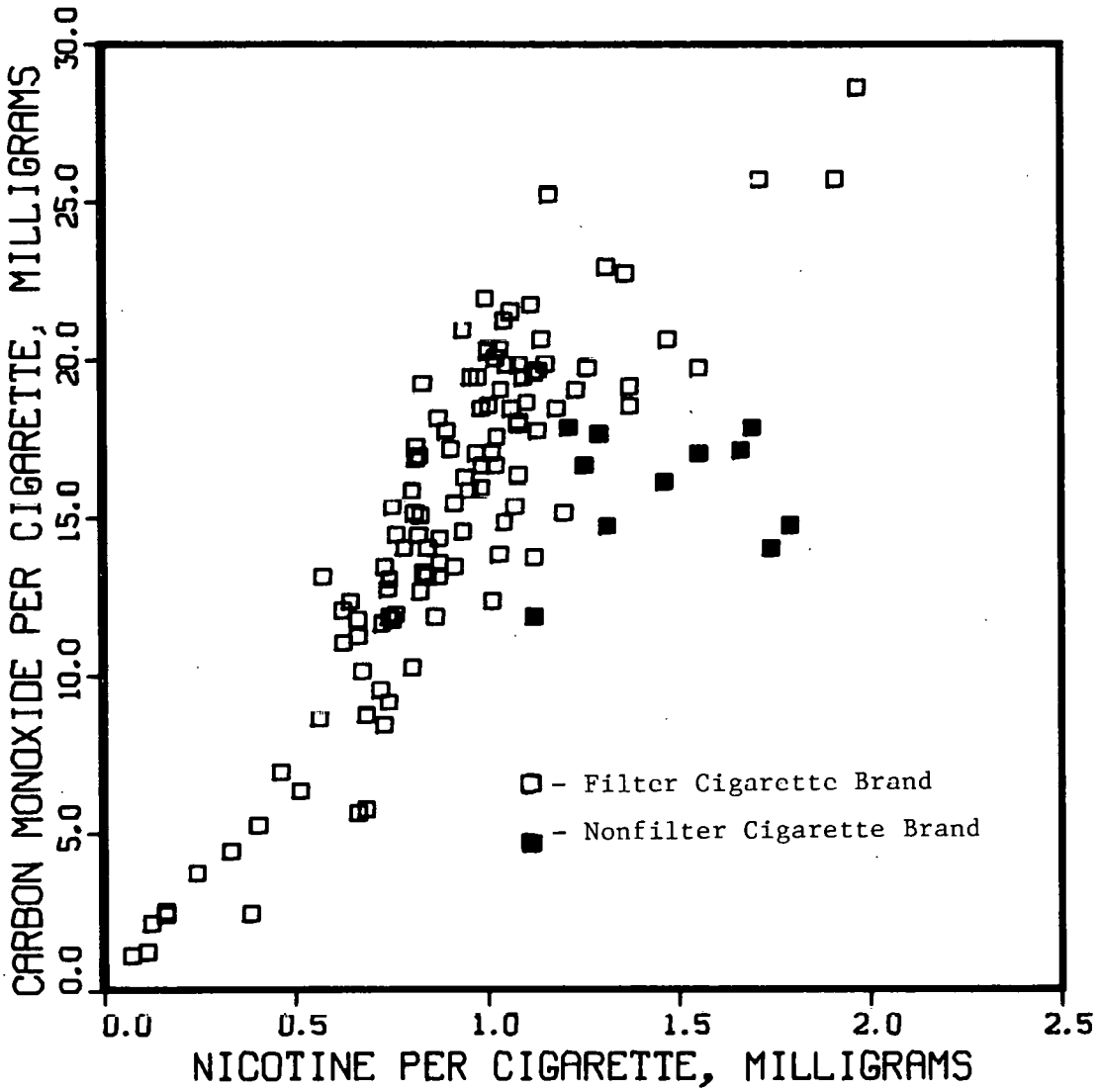

Figure 3. Carbon monoxide delivery as a function of nicotine delivery. Per cigarette basis. U.S. Commercial Cigarettes.

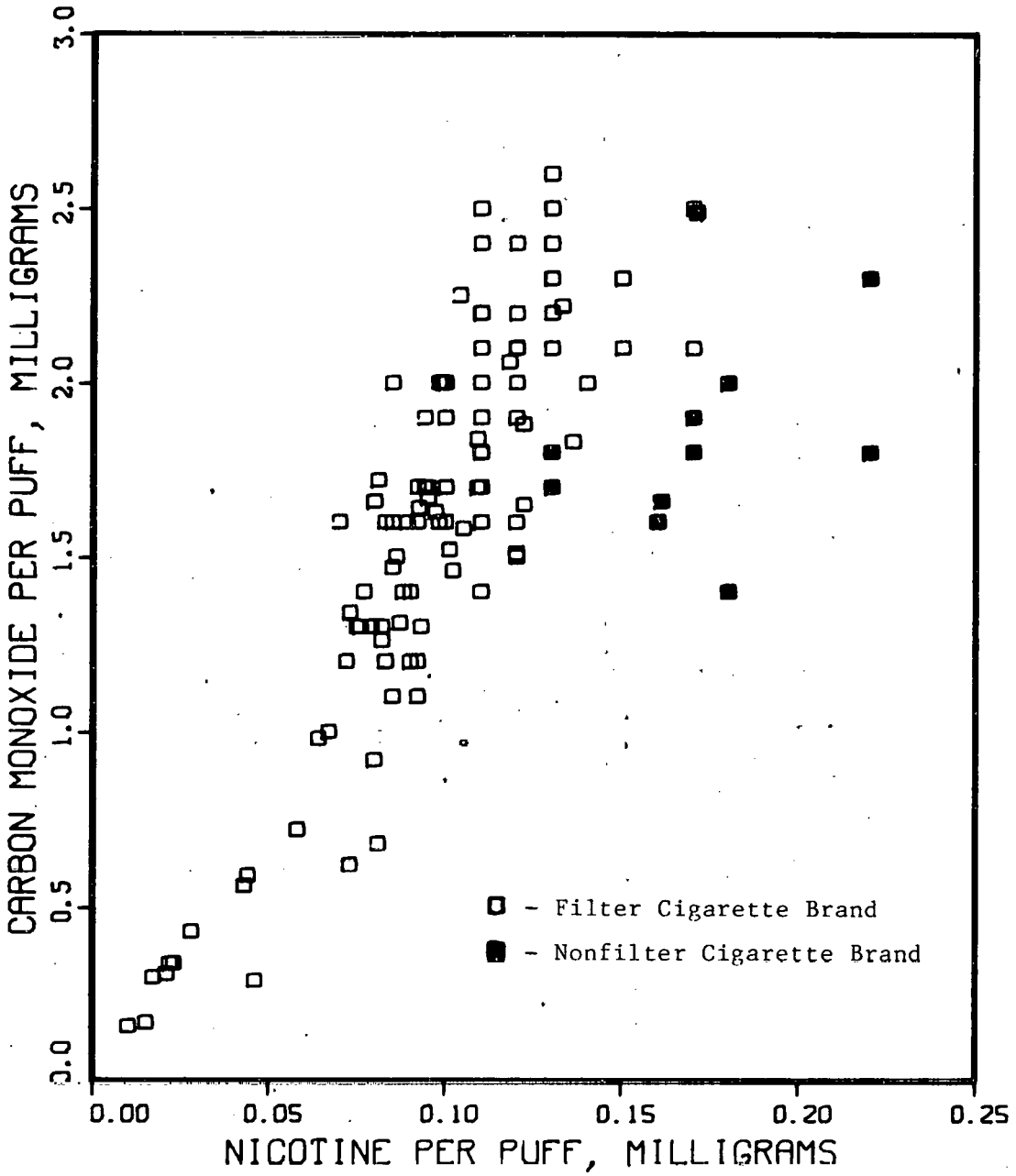

Figure 4. Carbon monoxide delivery as a function of nicotine delivery. Per puff basis. U.S. Commercial Cigarettes.

Table 4. Correlations Between Carbon Monoxide and Particulate Phase Components

	Correlation Coefficient (R), Carbon Monoxide with:	
	Filter Cigarettes Only	Filter and Non-Filter Cigarettes
"Tar", per cigarette	0.917	0.803
Tar, per puff	0.900	0.771
Nicotine, per cigarette	0.887	0.797
Nicotine, per puff	0.867	0.760

lated correlation coefficients (R) between CO and either "tar" or nicotine for the cigarettes considered in this report. The correlations are better across the range of observed "tar" deliveries for filter cigarettes alone than for the entire set of cigarettes analyzed. This is because the nonfiltered varieties tend to produce less carbon monoxide than would be predicted from the "tar" or nicotine content of their smokes. The amount of CO generated during smoking is dependent on a number of factors, one being the amount of tobacco burned. In this study, all of the unfiltered cigarettes exhibit a fairly high (greater than 20 mg per cigarette) "tar" delivery. Because there is no filter to remove "tar" from the smoke, this fairly high "tar" delivery can be achieved by burning a relatively smaller amount of tobacco. The production of an equivalent tar delivery from a filtered cigarette requires that more tobacco be burned. Since CO is not trapped in significant quantities by the filter, a filtered cigarette of a given tar delivery will generally produce more CO than an unfiltered cigarette of the same "tar" delivery. Thus, for filtered cigarettes, there is a fairly strong correlation between CO and "tar" production. However, cases (compare Saratoga Menthol with Winston - Code 166) do exist where filtered varieties delivering the same quantities of "tar" differ substantially in carbon monoxide deliveries.

Nicotine is determined via gas chromatographic methods at ORNL, whereas FTC reported values are based on the determination of nicotine as total alkaloids via a Griffith steam distillation and colorimetric analysis. For reference or experimental cigarettes, the results are

usually quite comparable. A comparison of our nicotine values for the commercial cigarette smokes with those most recently reported by the FTC (12) yielded a correlation coefficient (R) of 0.949. Paired t-testing of the sets of values suggested that the FTC values averaged 0.11 mg per cigarette higher, but the difference was not significant at the 5% level. We consider this correlation quite good considering the small sample size upon which the ORNL data is based. There was one notable difference between the FTC and ORNL values: the nicotine delivery of the Players cigarette was determined to be ∿1.8 mg, whereas the FTC reported a delivery of 2.5 mg in May, 1978. A package of Players was purchased locally, and the nicotine delivery was determined to be 1.65 mg per cigarette, suggesting that the 1.8 mg value was probably more representative of Players cigarettes available at the time of the ORNL study. A change in the tobacco blend since the last FTC analysis may be responsible for the reported difference.

The only publicly available data for carbon monoxide deliveries of commercial cigarettes with which to compare ORNL results was generated by Foster D. Snell Laboratories and published during October 1976 in Readers' Digest (13). Comparative data for twenty-three brands is given on Table 5. Note that the ORNL data for this table is reported in milliliters (volume) of carbon monoxide, instead of milligrams (weight). This is to facilitate comparison with the F. D. Snell data, which was originally reported in milliliters per pack of twenty cigarettes. There is not particularly good agreement between the two sets of data, with the ORNL values averaging ∿2 ml per cigarette greater.

Table 5. Comparison of Carbon Monoxide Deliveries, F. D. Snell Laboratories[a] and ORNL

Brand[b]	ORNL/FTC Code	Carbon Monoxide ml/cigarette	
		F. D. Snell	ORNL
Kool Filter 100's	60	16.1	13.7
L&M Filter King	63	15.6	15.6
Kool Filter King	56	15.4	16.3
Winston Filter King	167	15.4	17.4
Marlboro Filter 100's	84	15.3	15.1
Tareyton Filter King	147	15.3	12.1
Benson & Hedges Filter (Menthol) 100's	9	15	17.0
Winston Filter 100's	169	15	16.8
Salem Filter King	134	14.9	17.4
Salem Filter 100's	136	14.6	20.1
Kent Filter King	47	14.4	18.1
Raleigh Filter King	126	14.3	16.2
Pall Mall Filter 100's	113	13.8	16.3
Benson & Hedges Filter 100's	8	13.5	19.5
Viceroy Filter King	161	13.4	17.6
Marlboro Filter King	80	13.1	18.4
Pall Mall King	110	12.8	15.4
Camel	15	12.7	15.7
Lucky Strike	73	11	14.2
Vantage Filter King	158	11	13.5
Merit King	88	8.4	9.7
Kent Golden Lights King	49	7.5	10.4
Now King	103	2.3	2.1

[a]Reference 11.

[b]F. D. Snell Laboratories designation. In some cases, hard or soft pack was not specified.

Since no information is available on the analytical procedures used by F. D. Snell, it is difficult to speculate as to the reasons for the differences in the data.

SUMMARY

The deliveries of selected smoke constituents from one-hundred twenty-one domestic commercial cigarette brands have been reported. Rounded values for "tar", nicotine, and carbon monoxide deliveries are summarized in Table 6. For filter cigarettes there is a fairly strong correlation between CO and "tar" deliveries.

Table 6. Summary
"Tar", Nicotine, and Carbon Monoxide Deliveries (Rounded)
of Selected U.S. Commercial Cigarettes

Brand	Description	Deliveries, mg/cig. "Tar"	Nicotine	CO
Belair	85 mm, sp, f, m	14	1.0	17
Belair	100 mm, sp, f, m	16	1.0	17
Benson & Hedges	70 mm, hp, f	1	0.1	1
Benson & Hedges 100's	100 mm, hp, f	18	1.0	22
Benson & Hedges 100's	100 mm, hp, f, m	17	1.0	19
Benson & Hedges 100's	100 mm, sp, f	17	1.0	18
Benson & Hedges Lights	100 mm, sp, f	12	0.7	12
Benson & Hedges Lights	100 mm, sp, f, m	12	0.7	8
Bull Durham	85 mm, sp, f	36	2.0	29
Camel	70 mm, sp, nf	28	1.7	18
Camel	85 mm, sp, f	22	1.3	20
Camel Lights	85 mm, sp, f	10	0.8	13
Carlton	85 mm, sp, f	1	0.1	2
Carlton	85 mm, sp, f, m	1	0.1	1
Carlton 100's	100 mm, sp, f, m	4	0.4	5
Chesterfield	70 mm, sp, nf	24	1.3	15
Chesterfield	85 mm, sp, nf	30	1.3	18
Chesterfield	85 mm, sp, f	16	1.0	14
Chesterfield	101 mm, sp, f	17	1.0	18
Decade	85 mm, sp, f, m	4	0.4	2
Doral	85 mm, sp, f	11	0.8	10
Doral	85 mm, sp, f, m	14	0.8	14
DuMaurier	85 mm, hp, f	17	1.1	22
English Ovals	85 mm, hp, nf	29	1.7	14
Eve	100 mm, sp, f	16	1.1	18
Eve	100 mm, sp, f, m	18	1.0	19
Iceberg 100's	100 mm, sp, f, m	2	1.2	4
Kent	80 mm, hp, f	18	1.0	20
Kent Golden Lights	85 mm, sp, f	10	0.7	12
Kent Golden Lights	85 mm, sp, f, m	9	0.8	12
Kent Micronite II	100 mm, sp, f	15	1.0	18
Kent Golden Lights	100 mm, sp, f	12	0.8	13
Kent	100 mm, sp, f, m	20	1.1	20
Kent Golden Lights	100 mm, sp, f, m	10	0.7	11

Table 6. (Cont'd)

Brand	Description	Deliveries, mg/cig. "Tar"	Nicotine	CO
Kool	80 mm, hp, f, m	18	1.2	18
Kool Milds	85 mm, sp, f, m	14	1.0	19
Kool Super Lights	85 mm, sp, f, m	10	0.7	13
Kool	100 mm, sp, f,m	14	1.1	15
Kool Super Lights	100 mm, sp, f, m	10	0.7	13
L&M	80 mm, hp, f	21	1.0	20
L&M	85 mm, sp, f	18	0.9	18
L&M Lights	85 mm, sp, f	9	0.7	6
L&M Lights	100 mm, sp, f	8	0.7	6
L&M	100 mm, sp, f, m	19	1.1	22
Lark	85 mm, sp, f	19	1.1	21
Lark II	85 mm, sp, f	8	0.7	9
Lark	100 mm, sp, f	20	1.0	21
Lucky Strike	70 mm, sp, nf	27	1.5	16
Lucky Ten	85 mm, sp, f	10	0.7	12
Marlboro	80 mm, hp, f	19	1.0	15
Marlboro	80 mm, hp, f, m	14	0.9	14
Marlboro	85 mm, sp, f	18	0.9	21
Marlboro Lights	85 mm, sp, f	14	0.8	15
Marlboro	100 mm, hp, f	19	1.0	20
Marlboro	100 mm, sp, f	19	0.9	17
Marlboro Lights	100 mm, sp, f	12	0.8	14
Max	120 mm, sp, f	19	1.1	16
Max	120 mm, sp, f, m	21	1.3	23
Merit	85 mm, sp, f	9	0.6	11
Merit	85 mm, sp, f, m	8	0.7	10
Merit 100's	100 mm, sp, f	12	0.9	13
Merit 100's	100 mm, sp, f, m	11	0.8	12
More	120 mm, sp, f	26	1.9	26
More	120 mm, sp, f, m	25	1.7	26
Multifilter	85 mm, sp, f	14	0.8	14
Newport	80 mm, hp, f, m	20	1.0	20
Newport Lights	85 mm, sp, f, m	13	0.8	14
Newport	100 mm, sp, f, m	23	1.4	19
Now	80 mm, hp, f	2	0.2	2
Now	85 mm, hp, f, m	2	0.2	2
Now	85 mm, sp, f	2	0.2	2

Table 6. (Cont'd)

Brand	Description	Deliveries, mg/cig. "Tar"	Nicotine	CO
Old Gold Filters	85 mm, sp, f	18	1.0	16
Old Gold Lights	85 mm, sp, f	16	0.9	13
Old Gold 100's	100 mm, sp, f	22	1.5	21
Pall Mall	85 mm, sp, nf	28	1.7	17
Pall Mall Extra Light	85 mm, sp, f	6	0.5	6
Pall Mall	100 mm, sp, f	19	1.4	18
Parliament	80 mm, hp, f	10	0.6	12
Parliament	85 mm, sp, f	10	0.6	12
Parliament 100's	100 mm, sp, f	13	0.8	13
Philip Morris	70 mm, sp, nf	21	1.1	12
Philip Morris Commander	85 mm, sp, nf	27	1.6	17
Picayune	70 mm, sp, nf	23	1.2	18
Players	70 mm, hp, nf	27	1.8	15
Raleigh	85 mm, sp, nf	24	1.3	17
Raleigh	85 mm, sp, f	18	1.1	18
Raleigh Lights	85 mm, sp, f, w/adh	11	0.9	14
Raleigh	100 mm, sp, f	17	1.0	20
Real	85 mm, sp, f	9	0.7	10
Real	85 mm, sp, f, m	10	0.7	9
Salem	80 mm, hp, f, m	17	1.2	20
Salem	85 mm, sp, f, m	17	1.1	20
Salem Lights	85 mm, sp, f, m	11	0.8	16
Salem	100 mm, sp, f, m	20	1.4	23
Salem Long Lights	100 mm, sp, f, m	12	0.9	16
Saratoga	120 mm, hp, f	19	1.1	19
Saratoga	120 mm, hp, f, m	20	1.2	25
Silva Thins	120 mm, sp, f, w/adh	13	0.9	12
Spring 100's	100 mm, sp, f, m	20	1.1	18
Tareyton	85 mm, sp, f	19	1.1	14
Tareyton Lights	85 mm, sp, f	6	0.6	9
Tareyton Low-Tar	85 mm, sp, f, m	7	0.6	13
Tareyton Long Lights	100 mm, sp, f	11	0.7	13

Table 6. (Cont'd)

Brand	Description	Deliveries, mg/cig. "Tar"	Nicotine	CO
True Blue 5's	85 mm, sp, f	6	0.5	7
True Green 5's	85 mm, sp, f, m	4	0.3	4
True 100's	100 mm, sp, f	15	0.9	18
True 100's	100 mm, sp,f, m	17	0.8	19
Twist	100 mm, sp, f, l/m	15	1.0	17
Vantage	85 mm, sp, f	11	0.8	15
Vantage	85 mm, sp, f, m	11	0.8	17
Vantage	100 mm, sp, f	13	0.8	17
Viceroy	85 mm, sp, f	15	1.1	20
Viceroy Lights	85 mm, sp, f	14	1.0	16
Viceroy	100 mm, sp, f	16	1.1	19
Virginia Slims	100 mm, sp, f	18	0.8	17
Winston	80 mm, hp, f	20	1.2	15
Winston	85 mm, sp, f	21	1.6	20
Winston Lights	85 mm, sp, f	14	0.8	15
Winston 100's	100 mm, sp, f	21	1.2	19
Winston Lights 100's	100 mm, sp, f	15	1.0	17
Winston	100 mm, sp, f, m	20	1.1	18

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f =filter
hp = hard pack
ks = king size
l/m = lemon menthol
m = menthol
nf = nonfilter
sp = soft pack
w/adh = with air dilution holes
w/o adh = without air dilution holes

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