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Mouth Insertion Depths in Canadian Smokers*

by

A. Porter and P. Dunn,

Imperial Tobacco Ltd,
Montreal,
Canada.

SUMMARY

There is the potential for smokers of ventilated cigarettes to block the ventilation holes either accidentally or deliberately thereby altering the smoke deliveries from those obtained by standardized machine smoking. One way in which the holes can be blocked is by inserting the cigarette into the mouth so that the holes are partially or completely blocked by the lips of the smoker. We have assessed to what extent this occurs amongst Canadian smokers by measuring the saliva patterns on 2756 cigarette butts collected in Montreal, Toronto and Vancouver. The butts were a cross-section of brands smoked in Canada. Saliva stains were visualized by treating the tipping paper with ninhydrin solution. The insertion depth was assumed to be the maximum extent of the saliva stain from the mouth end of the tipping. The brand of each cigarette butt was identified where possible as well as whether the filter was ventilated and if so, the distance of the vent holes from the mouth end. The butt lengths were also determined. Of the 2756 butts collected, 2232 had lip imprint patterns that could be visualized with ninhydrin solution. 56.2 % of the butts with measurable insertion depths, and which could be identified by brand, were ventilated. There was no significant difference between the average insertion depths for ventilated and non-ventilated brands (10.6 ±3.6 and 11.0 ± 3.6 mm respectively). It was estimated that for the ventilated brands between 3.7 – 10.3 % of the butts could have had the vents blocked completely for at least one puff, 13.8 – 20.4 % of the butts had vents that could have been partially blocked and 75.9 % of the butts showed no sign of any vent blockage during smoking.

ZUSAMMENFASSUNG

Es besteht die Möglichkeit, dass beim Rauchen ventilierter Cigaretten die Ventilationslöcher zufällig oder absichtlich verdeckt werden, was dazu führt, dass die Inhaltsstoffe des Tabakrauchs über den auf der Packung angegebenen Werten liegen. Das Blockieren der Löcher kann u.a. dadurch erfolgen, dass die Cigarette so in den Mund eingeführt wird, dass die Ventilationslöcher ganz oder teilweise von den Lippen des Rauchers verdeckt werden. Anhand von 2756 in Montreal, Toronto und Vancouver eingesammelten Cigarettenstummeln haben wir durch Vermessung der Speichelspur untersucht, in welchem Maße dies bei kanadischen Rauchern der Fall ist. Die Cigarettenstummel bildeten einen repräsentativen Querschnitt der in Kanada gerauchten Cigarettenmarken. Die Speichelspur auf dem Mundstück wurde durch Behandlung mit Ninhydrin-Reagenz sichtbar gemacht. Als Einstecktiefe wurde der Abstand zwischen dem mundseitigen Cigarettenende und dem äußersten Punkt des Speichelabdrucks angenommen. Die Cigarettenmarke jedes Stummels wurde soweit

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möglich bestimmt; ferner wurde festgestellt, ob es sich um einen ventilierten oder nicht ventilierten Filter handelte. Bei ventilierten Filtern wurde außerdem der Abstand zwischen dem mundseitigen Cigarettenende und den Ventilationslöchern bestimmt. Schließlich wurde noch die Länge jedes Stummels gemessen. Von den 2756 eingesammelten Cigarettenstummeln konnten auf 2232 Stummeln mit Hilfe der Ninhydrin-Lösung Lippenspuren visualisiert werden. Von den Stummeln, bei denen die Einstecktiefe gemessen und die Marke bestimmt werden konnte, waren 56,2 % ventilierte Filter. Es konnte kein signifikanter Unterschied zwischen der mittleren Einstecktiefe bei Cigaretten mit und ohne ventiliertem Filter festgestellt werden (10,6 ± 3,6 mm bzw. 11,0 ± 3,6 mm). Es wurde geschätzt, dass bei den ventilierten Marken in 3,7 – 10,3 % der Fälle die Möglichkeit bestanden haben könnte, dass die Ventilationslöcher mindestens für die Dauer von einem Zug vollständig verdeckt waren. Bei 13,8 – 20,4 % der Stummel bestand die Möglichkeit einer partiellen Abdeckung, während bei 75,9 % der Cigarettenstummel keinerlei Anzeichen einer Abdeckung der Ventilationslöcher beim Rauchen festgestellt werden konnte.

RESUME

Il peut arriver que les fumeurs puissent - accidentellement ou intentionnellement - obstruer les trous de ventilation de leurs cigarettes et de ce fait, accroître le débit de fumée au-delà des valeurs déclarées. Il suffit de placer la cigarette dans la bouche de façon que les lèvres obstruent les trous - partiellement ou complètement. On a évalué l'ampleur du phénomène parmi des fumeurs canadiens en mesurant les résidus de salive sur 2756 mégots de cigarettes recueillis à Montréal, Toronto et Vancouver. Les mégots provenaient d'un échantillon représentatif de marques fumées au Canada. On a pu apercevoir les taches de salive en traitant le papier de bout avec une solution de ninhydrine. On a supposé que la profondeur d'insertion représentait l'ampleur maximale de la tache de salive prélevée sur la partie du papier de bout à placer dans la bouche. Lorsqu'il était possible, on a identifié la marque de chaque mégot; on a également déterminé si le filtre était ventilé et le cas échéant, la distance des trous de ventilation de la partie à placer dans la bouche. La longueur des mégots a également été déterminée. En utilisant la solution de ninhydrine, on a pu noter des traces d'empreintes de lèvres sur 2232 des 2756 mégots recueillis. Un pourcentage de 56,2 % des mégots ayant une profondeur d'insertion mesurable - et qui ont pu être identifiés par marques - étaient ventilés. Il n'existait aucune différence importante entre la profondeur d'insertion moyenne des marques ventilées et celle des marques qui ne l'étaient pas (10,6 ± 3,6 et 11,0 ± 3,6 mm, respectivement.) On a évalué que dans le cas des marques de cigarettes ventilées, les orifices de 3,7 – 10,3 % des mégots auraient pu être complètement obstrués, le temps de tirer une bouffée; les orifices de 13,8 – 20,4 % des mégots auraient pu être partiellement obstrués et; 75,9 % des mégots ne démontraient aucune trace d'obstruction des orifices en cours de fumage.

INTRODUCTION

Several reports over the last 20 years have claimed that a large proportion of smokers block or partially block the ventilation holes of cigarettes with their lips, thereby increasing the amount of smoke that they get from the cigarette (1–4). These claims have been based largely on analyzing the smoke staining patterns on the ends of discarded cigarette filters. The reported degrees of partial or complete vent blocking were in the range 32–69 %.
In 1984 a study of 647 butts (41.4 % ventilated) collected from three shopping malls in the Montreal area was carried out by McBride (5). The maximum depths of insertion were determined by visualizing the lip imprints via the residual saliva amylase remaining on the tipping. Although the proportion of blocked vents was not determined in this study, there was no significant difference between the insertion depths of the ventilated (11.1 ± 4.8 mm) and non-ventilated cigarettes (11.0 ± 4.6 mm).

The present study was carried out to see if the extent of vent blocking could be estimated from insertion depth measurements such as those described above. A secondary objective was to assess whether there had been any significant changes in insertion depth since the initial study was carried out 13 years ago. During this time period, sales weighted average smoke deliveries have decreased significantly and the proportion of ventilated cigarettes has increased. It was felt that with a larger sample it might also be possible to determine whether overall cigarette length or tipping length had any association with depth of insertion.

EXPERIMENTAL

Sample collection

Discarded cigarette butts were collected in Montreal, Toronto and Vancouver from shopping malls and bars by representatives of the Canadian tobacco industry.
The butts were sent to a private laboratory (Novamann (Ontario), Inc., Mississauga, Canada) for the

analyses. At all times during collection and analysis, gloves were worn to avoid additional contamination.

Identification

The butts were cut axially and assigned a unique laboratory number. For each butt, the butt length, tipping length, filter length, distance of the start of ventilation zone from the mouth end (where applicable), and circumference were measured (all in mm). Using these data as well as a template consisting of examples of all the domestic brands and brand lengths available in Canada, the butts were identified as to the brands from which they most likely derived. Based on these identifications the butts were categorised into one of the length categories available on the Canadian market: regular length: 72 ± 1 mm, king size: 84 ± 1 mm and 100's: 100 ± 1 mm.

Determination of insertion depth

The tippings were mounted on TLC spray racks, 8 at a time. They were sprayed to saturation with a 5 % w/w aqueous ninhydrin solution. The ninhydrin solution was made by dissolving 5 g of ninhydrin (Sigma Chemical Company, St.Louis, Missouri) in 95 ml of water. The saturated tippings were heated for 2 minutes at 200 °C which revealed the lip imprint as a pink coloration. The distance in mm between the mouth end of the tipping and the last evidence of lip imprint was measured. This was defined as the *maximum* insertion depth of the butt into the smokers' mouth.

Data analysis

The raw data were transferred to an Excel (Microsoft Inc.,Version 5.0) spreadsheet for determination of means and standard deviations and for construction of the histograms.

RESULTS AND DISCUSSION

A total of 2756 butts was collected. Of the total butts collected, 524 (19 %) produced no measurable lip imprints with the ninhydrin method. This is consistent with results from our earlier (1984) study of insertion depth (5) which used salivary amylase as a marker, where a slightly larger proportion of butts (23 %) produced no measurable imprints.
Of the remaining 2232 butts, a further 47 (2.1 %) could not be identified and were therefore not included in the analysis. The distribution of identified butts with measurable lip imprints by ventilation status and cigarette length is shown in Table 1.
There was a larger proportion of ventilated cigarettes in the present study (54.8 %) than in the 1984 study (41.4 %). This reflects the trend towards lower delivery products over this time period.
To ensure that the sample was representative of the Canadian market, it was compared to the three month average relative sales of all regular, king size and 100 mm length cigarettes in the provinces where the butts were collected. As illustrated in Table 2 the distribution of length categories in the sample falls within the ranges of the sales in the three provinces.

Insertion depths

The maximum insertion depths are summarized in Table 3. The average insertion depths for the non-ventilated samples (11.0 ± 3.6 mm) and for the ventilated samples (10.6 ± 3.6 mm) were not significantly different. These results are consistent with those of the smaller 1984 study of Canadian butts (5) in spite of a decrease of approximately 3 mg in the sales weighted average tar delivery over this time period (after allowing for the change in smoking regime from the Canadian standard to ISO in 1990).

Table 1.
Distribution of identified, measurable butts by ventilation status and cigarette length.

Cigarette	Regular	King size	100's	Total
Ventilated	341	739	118	1198 (54.8 %)
Non-ventilated	634	353	0	987 (45.2 %)
Total	975 (44.6 %)	1092 (50.0 %)	118 (5.4 %)	2185 (100 %)

Table 2.
Average sales during October-December 1996, by cigarette length in the sampled regions.

Region	Regular	King size	100's
Ontario	38.6 %	53.5 %	7.9 %
Quebec	49.0 %	47.8 %	3.2 %
British Columbia	45.9 %	45.7 %	8.4 %
Collected butts	44.6 %	50.0 %	5.4 %

Table 3.
Average maximum insertion depths by cigarette length and by filter ventilation.

Cigarette length	Average maximum insertion depth in mm (± SD)		
	Ventilated	Non-ventilated	Combined
Regular length	10.3 (± 3.7)	10.6 (± 3.7)	
King size	10.8 (± 3.8)	11.7 (± 3.4)	
100's	10.4 (± 2.4)	10.3 (± 4.5)	
All brands	10.6 (± 3.6)	11.0 (± 3.6)	10.8 (± 3.6)

In the present study there was no significant effect of cigarette length on insertion depth. Since cigarette size and tipping length are closely related, smokers are clearly not using either cigarette length or tipping length as cues to adjust their depth of insertion.

Distributions of maximum insertion depths for the total sample and for the ventilated and non-ventilated brands are shown in Figure 1. Insertion depths vary from 3 mm to more than 24 mm with the distribution similar for the non-ventilated and ventilated cigarettes. The maximum at 8 mm appears to be an unusual deviation from the pattern. Presently we can offer no explanation for this observation.

For the ventilated brands the distributions of maximum insertion depths according to cigarette length are shown in Figure 2. For the regular and 100's the numbers of butts are small and the distributions are not smooth. The unevenness of the distributions makes it difficult to make meaningful comparisons between the distributions for the different cigarette lengths.

Position of the ventilation zone

For the ventilated brands the average distance of the start of the ventilation zone from the end of the filter was 12.2 ± 0.8 mm. Compared with the results from 1984, the distance has increased from 11.8 mm.

Butt lengths

The butt lengths of the sample (33.2 ± 9.9 mm) were on average considerably longer than the butt lengths defined for standard machine smoking (usually 24 mm for regular length, 28 mm for king size, and 33 mm for 100's). There was no significant difference between the butt lengths for ventilated (33.8 ± 9.9 mm) and for non-ventilated brands (32.4 ± 9.9 mm).

Estimation of vent blockage

The distribution of insertion depths for ventilated filters (Figure 1) shows that some smokers inserted their cigarettes beyond the start of the ventilation zone.

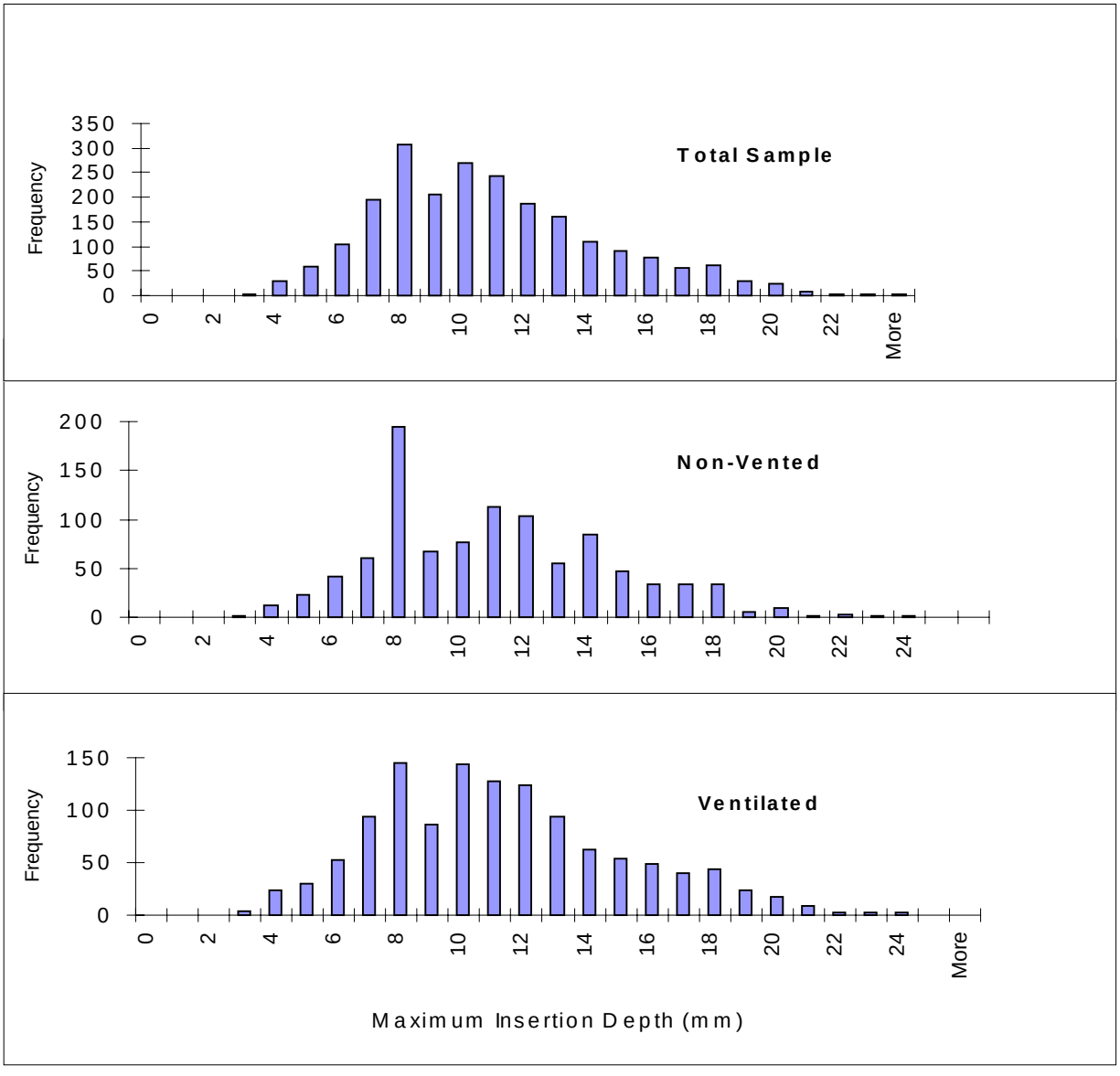


Figure 1.
Distribution of maximum insertion depths for the total sample and for non-ventilated and ventilated brands.

Depending on the width of the ventilation zone and the lip shape these smokers could have partially or completely blocked the vents. The extent to which partial ventilation blockage by the smoker's lips affects the level of ventilation and hence smoke deliveries has been discussed by BAKER and LEWIS in their review (6 and references therein).

Since lip imprints reveal only the maximum depth of insertion it is unknown whether the smoker held the cigarette in his or her mouth at this depth before the cigarette was smoked, or for just one puff or for many puffs. Therefore we can only use this measurement to estimate an upper limit to the extent of lip blockage. To assess the proportion of smokers who block or partially block the vent holes with their lips, the calculations given by BAKER and LEWIS (6) were used. The shape of the lip imprint during a puff is shown in Figure 3a. Measurements of the distances from the front to back of the lip pattern have been reported previously and are, on average, 4 mm (6). The shape of the lips means that even when the maximum insertion depth is beyond the position of the vent holes, the holes are still only partially blocked as illustrated in Figure 3b.

The width of the ventilation zone will also influence the extent of hole blockage. The majority of ventilated cigarettes on the Canadian market use tipping that is pre-

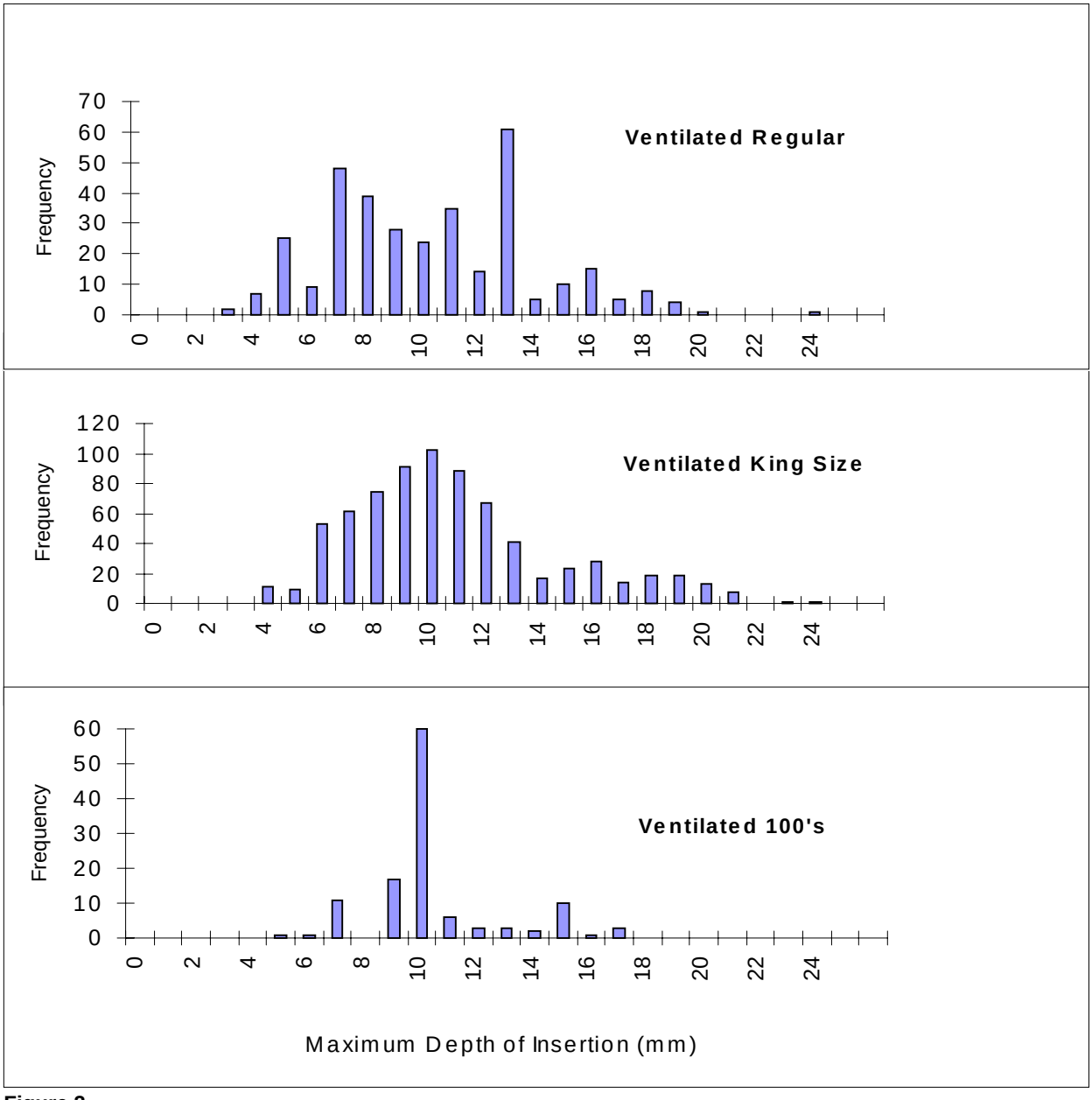


Figure 2.
Distribution of maximum insertion depths for ventilated cigarettes, by length.

perforated either in the form of an electrostatically perforated zone or as a discrete series of laser perforated rows. For zone perforated tipping the width of the zone used on Canadian brands is either 2 or 3 mm while laser perforated tipping usually has 1 or 2 rows of holes, the latter spaced 1 mm apart (7). Thus the width of the ventilation zone can vary from close to 0 for a single row of laser perforations to 3 mm for an electrostatically perforated tipping. Figure 3 illustrates the various degrees of lip blockage when the ventilation zone is 2 mm wide. In this case a completely blocked filter will occur when the maximum insertion depth is 6 mm or more beyond the start of the ventilation zone as shown in Figure 3c. Partially blocked vents occur when the maximum insertion depth lies between the start of the vent zone and up to 6 mm beyond. Using these criteria for completely and partially blocked vents, our data give the proportion of blocked vents as 5.2 % (63/1229) and the proportion of partially blocked vents as 18.9 % (233/1229). In other words 75.9 % of the butts show no evidence of any vent blocking at all.

Calculations based on the other potential ventilation zone widths are given in Table 4. The proportion of clear ventilation holes (75.9 %) is unaffected by the ventilation zone width. The proportion of blocked vents increases from 3.7 % with a 3 mm wide ventilation zone to 10.3 % for a single row of holes. Since there are examples of all the above types of ventilation on the Canadian market the best estimate of the proportion of blocked vents is between 3.7 – 10.3 %.

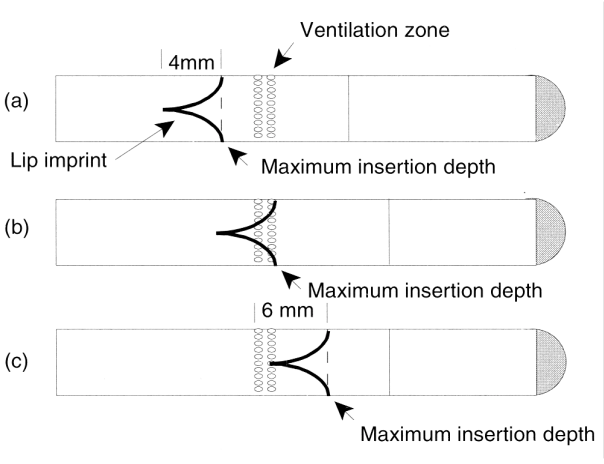


Figure 3.
Lip patterns on the filter with (a) vents uncovered, (b) partially covered vents and (c) completely blocked vents. The ventilation zone is 2 mm wide.

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Table 4.
Calculated extent of ventilation hole coverage based on the width of the ventilation zone for different types of ventilated tipping used on the Canadian market.

	Width (in mm) and type of ventilation zone			
	0 (Single Row)	1 (Double Row)	2 (Zone, Triple Row)	3 (Zone)
Clear	933 (75.9%)	933 (75.9%)	933 (75.9%)	933 (75.9%)
Partially covered	169 (13.8%)	196 (15.9%	233 (18.9%)	251(20.4%)
Completely blocked	127 (10.3%)	100 (8.1%)	63 (5.2%)	45 (3.7%)

These estimates of the prevalence of vent blocking, although upper limits, are considerably lower than those reported earlier by KOZLOWSKI's group (1–4). A possible explanation for this may be the reported problems with the filter staining technique used by KOZLOWSKI's group to determine insertion depth (6).

Address for correspondence:

Andrew Porter
Imperial Tobacco Limited/Limitée,
3810, rue St-Antoine Street,
Montréal, P.Q. H4C 1B5, Canada.