NEW HEAD FOR CIGARETTE FILTER ROD PRESSURE DROP INSTRUMENT

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A new head for a cigarette filter rod pressure drop instrument was designed. With this new head, the pressure differential across the plugwrap of a filter rod is minimized; consequently, the amount of air that permeates the plugwrap (while measuring the pressure drop of a cigarette filter rod) is very small. Since the amount of air permeating the plugwrap is reduced to a negligible fraction of the total flow, the variations caused by variations in plugwrap porosity are eliminated. These variations are sometimes falsely attributed to tow quality. Because air flow is limited to a single component which traverses the entire length of the filter rod, pressure drop is related linearly to filter rod length, making the estimate of tip pressure drop from rod pressure drop measurements a straightforward calculation.

INTRODUCTION

Filter rod pressure drop is normally measured by passing air through the filter rod at a constant flow rate (usually 17.5 ml/sec) and determining the pressure differential across the filter rod. This technique is very rapid and the reproducibility is very good; however, it has a distinct disadvantage based on the following considerations.

The total air flow through the filter is comprised of two components as illustrated in **Figure 1**. Component A traverses the entire length of the filter. Component B enters the filter through the paper plugwrap where it mixes with Component A. The amount of air in Component B is directly related to the pressure differential across the plugwrap, the exposed area of the plugwrap, and the permeability of the plugwrap. The pressure differential across the plugwrap ranges from 0 at the upper end of the filter in **Figure 1** to nearly the total filter rod pressure drop at the point where the filter rod enters the rubber dam. The exposed area is nearly the total area of the plugwrap. The permeabilities of most plugwraps used in commerce are such that a significant portion of the total air flow enters the instrument via Component B. Since Component B does not traverse the entire rod, rod pressure drop is not a linear function of rod length.

After the filter rods are cut into filter tips (usually six tips/rod), Component B is essentially eliminated and Component A is increased. Consequently, the sum of the pressure drops of the filter tip is greater than the pressure drop of the filter rod from which they are cut. In order to estimate filter tip pressure drop from filter rod pressure drop, a factor must be used. This factor is dependent on rod dimensions, rod pressure drop, and plugwrap permeability. Plugwrap permeability varies from bobbin to bobbin and sometimes within bobbins causing variations in pressure drop which are often falsely attributed to the filter tow or to the filter rod manufacturing process.

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One means of eliminating the errors in pressure drop measurement caused by air permeating the plugwrap is to completely encapsulate the filter rod with an air impermeable rubber tubing during the measurement. Several devices have been proposed for this purpose, and some perform fairly well; however, the rubber tubing tends to compress the rods slightly causing the pressure drop measurements to be slightly high. The amount of compression varies with the firmness of the filter rod and with the elastic properties of the tubing.

A new filter rod pressure drop head has now been designed which eliminates many of the aforementioned problems. The advantages and limitations of this new head are described in this paper.

MATERIALS AND METHODS

Apparatus

A drawing of the new pressure drop head is shown in **Figure 2**. The bottom section is fitted with two standard taper connectors. The male 10/30 S connector fits into the pressure drop apparatus. Rubber dams (with 4-mm holes) are placed on both ends of the top section of the apparatus, then this section is inserted into the lower section. For pressure drop measurements, the filter rod is inserted through the two dental dams until it touches the indentation in the lower section of the pressure drop head. The dimensions shown are for filter rods about 120 mm long. For filter rods that are shorter than about 100 mm, or longer than about 130 mm, a top section with slightly different dimensions is used. The distance between rubber dams should be about one half the length of the filter rod, and the distance from the bottom rubber dam to the indentation should be about one fourth the length of the filter rod.

The encapsulating head used in the experiments described consisted of a cylindrical rubber diaphragm inside a glass tube. The ends of the diaphragm were sealed to the ends of the glass tube. The diaphragm was a 125 mm length of ¼-in. Penrose Drain tubing (Davol, Inc., Point and Eddy Streets, Providence, RI 02901). A vacuum source was attached to the apparatus so that the air between the diaphragm and the inside of the glass tube could be evacuated to stretch the diaphragm peripherally. With the diaphragm in the stretched state, the filter rod was inserted, then the apparatus was vented and the diaphragm collapsed around the filter rod.

The head under evaluation was attached to a cigarette filter pressure drop instrument that draws air through the filter at a flow rate of 17.5 ml/sec.

Paper permeability was determined by measuring air flow rate through a 2-cm² sample subjected to a pressure differential of 100 mm of water.

EXPERIMENTAL

Comparison of Methods for Measuring Pressure Drop

Three sets of filter rods, 25 rods/set, were selected randomly from a batch of rods made from a 3.3 den./fil,

Table 1—Comparison of methods for measuring pressure drop.

Method	Pressure Drop (mm) Sample A[5]	Sample B	Sample C
W[1] Rod	360	360	368
Rod/6	60	60	61
T[2] Rod	324	324	326
Rod/6	54	54	54
E[3] Rod	382	374	378
Rod/6	64	62	63
M[4] Rod	359	359	362
Rod/6	60	60	60

[1] *Wrapped rods.*
[2] *Conventional (single rubber dam).*
[3] *Encapsulated.*
[4] *New head (double rubber dam).*
[5] *Samples A, B, and C were each 25 rods from same lot.*

Table 2—Effect of plugwrap permeability on pressure drop as measured by the four methods.

Type Plugwrap	Ecusta 492	Schweitzer 248	Schweitzer 322	Ecusta 612
Paper permeability ml/min/cm[2]	6	2.5	1.5	150+
Tow item	3.3/39,000-10	2.9/41,000 70	2.9/44,000-70	1.6/52,000-Reg.
Rod length (mm)	120	120	120	120
Pressure drop (mm)				
Method W[1] Rod	368	331	463	617
Rod/6	61	55	77	103
Measured filter tip	62	57	78	104
Method T[2] Rod	326	320	444	97
Rod/6	54	53	74	16
Method E[3] Rod	378	349	468	592
Rod/6	63	58	78	99
Method M[4] Rod	362	334	459	267
Rod/6	60	56	77	45

[1] *Wrapped rods.*
[2] *Conventional (single rubber dam).*
[3] *Encapsulated.*
[4] *New head (double rubber dam).*

39,000 total-denier tow. The rods were 24.8 mm in circumference, 120 mm long and were wrapped with Ecusta 492 plugwrap. The average pressure drop of each set of rods was determined first using the conventional single dam head (Method T), then with the modified head described earlier (Method M), and finally with the encapsulating head. Each rod was then carefully wrapped with an impermeable polyester tape, and the average pressure drop of each set was again measured with a conventional single dam head (Method W). The average rod pressure drop data collected by the four methods are shown in **Table 1**. Ninety additional rods were selected randomly from the original batch, and one filter tip was cut from each rod. The average pressure drop of these tips was 61 mm of water.

Effect of Plugwrap Permeability on Pressure Drop as Measured by the Four Methods

One set of 25 filter rods was selected randomly from each of four batches of rods. The dimensions of the rods are shown in **Table 2**. The rods were wrapped with four types of plugwrap. Three of these wraps are used on conventional type filters; the fourth (Ecusta 612) is an extremely permeable plugwrap recommended for use with vented filters. The average pressure drop of each set of rods and the average pressure drop of filter tips cut from the rods are shown in Table 2. The filter tips with the Ecusta 612 plugwrap were wrapped with polyester tape before the measurement.

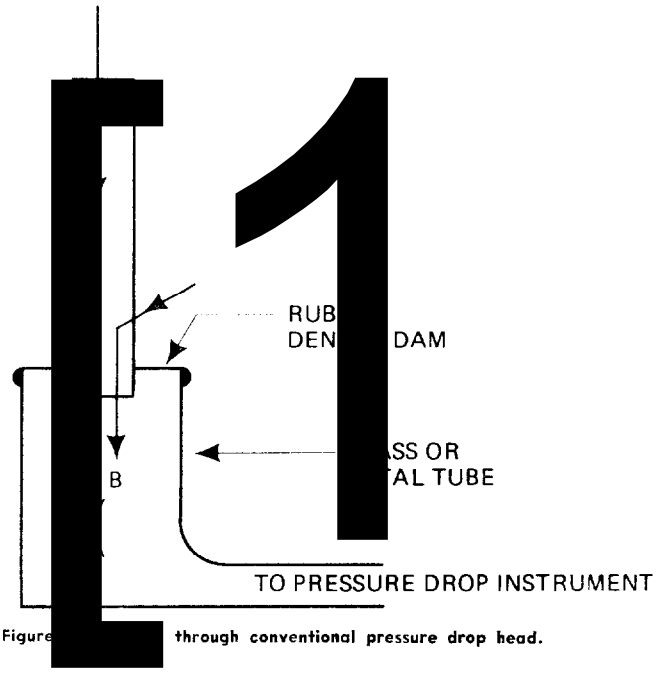

Figure through conventional pressure drop head.

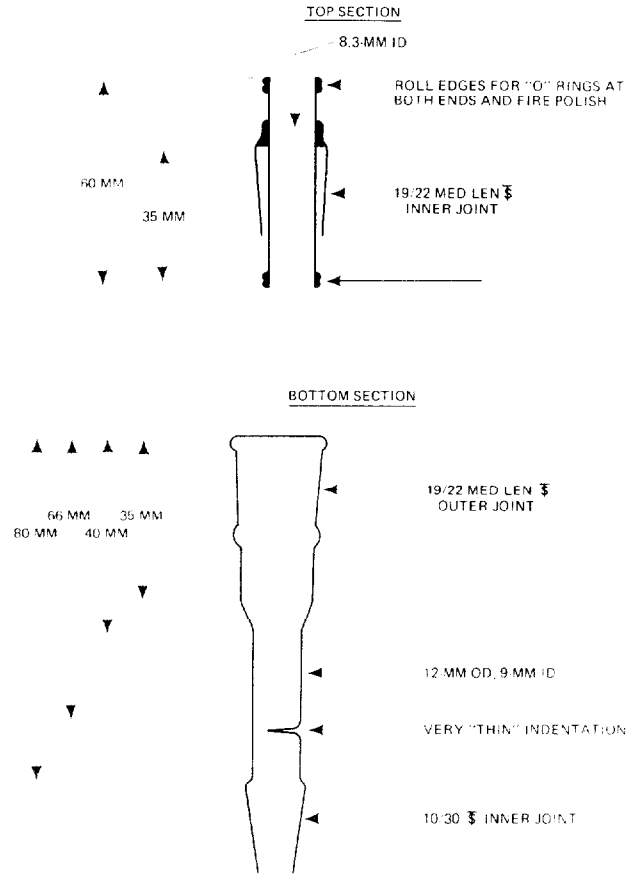

Figure 2. New pressure drop head.

RESULTS AND DISCUSSION

Air flow through a filter rod mounted in the new head is illustrated by **Figure 3**. Some air permeates the plugwrap (Component B), but with normal plugwraps, Component B is a very small portion of the total flow since: (1) the maximum pressure differential across the plugwrap is only one fourth the pressure drop of the rod; and (2) the effective cross-sectional area of the plugwrap is only one fourth that of the filter rod. Therefore, Component B in **Figure 3** is only about 1/16 as much as Component B in **Figure 1** (a head that is used extensively).

Experimental verification of this hypothesis is illustrated by the data in **Table 1** where rod pressure drops measured by four different methods are shown. The rods

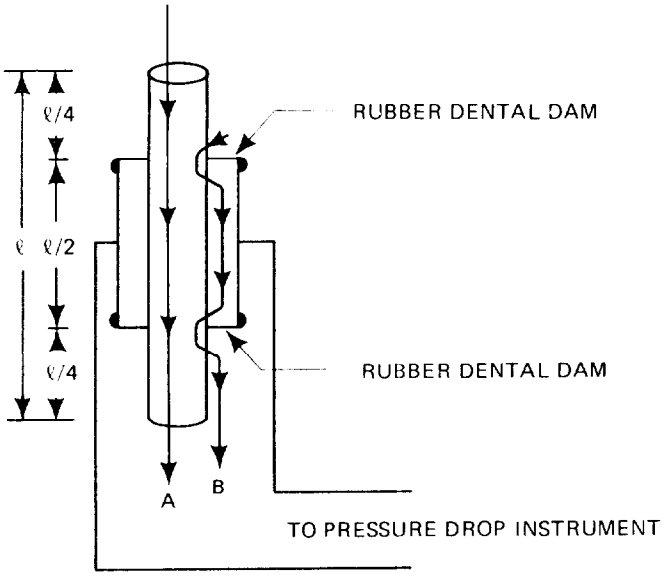

Figure 3. Air flow through new pressure drop head.

wrapped with polyester tape were considered standards. Although this technique of wrapping the rods is not practical to use as a quality control method, it is a reliable laboratory means for eliminating Component B without compressing the filter rod. The pressure drops of the three sets of rods wrapped with polyester tape ranged from 360 to 368 mm. Filter tip pressure drops estimated by dividing rod pressure drop by six were 60 to 61 mm, which was the same as the measured value for tips cut from these rods.

Filter rod pressure drops obtained by a conventional method (Method T) were highly reproducible, but the estimated tip pressure drop was only 54 mm, whereas measured tip pressure drop was 61 mm.

The encapsulating method (Method E) produced rod pressure drops that were slightly higher than those obtained with the wrapped filters. Estimated filter tip pressure drops were 62 to 64 mm compared to the 61-mm measured value. The high values are believed to be a result of a slight compression of the filter periphery caused by the rubber encapsulating tube.

When the same sets of rods were measured with the new "double-dam" pressure drop head (Method M), pressure drops ranged from 359 to 362 mm, which is not significantly different from the values obtained with the wrapped rods. The estimated filter tip pressure drop was 60 mm compared to the measured value of 61 mm.

A limitation of the new pressure drop head is illustrated by the data in **Table 2**. Three types of filter rods wrapped with typical plugwraps (permeability 1.5 to 6 ml/min/cm^2) gave good results—estimated filter tip pressure drops agreed with measured values. However, meaningful results were not obtained when the rods were wrapped with an extremely porous paper (150+ ml/min/cm^2). Only the encapsulating method gave acceptable results for filters made with the highly porous paper.

In conclusion, a new pressure drop head has been developed which eliminates some of the disadvantages of the heads that are currently used. With this new head, the measured pressure drop of filter rods wrapped with typical plugwraps is a linear function of rod length. Therefore, tip pressure drop can be estimated by a simple straightforward calculation.