# A new instrument for measuring the permeability of paper machine clothing

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*On a newsprint machine, a felt's permeability to water steadily declined during its lifetime. A new method to evaluate the performance of press felts is based on water permeability.*

Clothing in the wet-end of a paper machine has two functions. First, it supports and carries the wet, weak fiber web. Second, it provides a pathway for water to escape. The ability of the felt to transmit water, or its permeability, is determined by the machine operating conditions and by the design and condition of the clothing.

The methods conventionally used to measure felt permeability are based on measuring the air flow rate through felts held stationary or running on the paper machine. A new method gives a more accurate picture of felt performance because it is based on measuring the flow rate of water injected into the felt. In this new method, the permeability is measured without being affected by the moisture held in the felt.

## Press felt design and operation

Press felts are designed to have enough void space to accommodate water pressed out of paper in the nip (*1–3*). However, during their lifetimes, felts are exposed to mechanical and chemical conditions that alter their properties. A typical felt on the first press of a newsprint machine goes through 2.4 million compression cycles during its lifetime (*4*) and accepts white water equal in quantity to a column 255 m high (5). Solids dispersed in white water can gradually fill the void space within the felt or can glue together felt filaments, reducing permeability. Felt degradation is usually more rapid on machines that use secondary fibers, operate with a closed white water system, or use wet-end additives.

Felt structure can be partially restored by cleaning with high- and low-pressure showers, washing with chemicals, and dewatering over suction boxes (1, 4). Modern press felts are seldom removed because they are worn out; rather, they are replaced because their loss of permeability limits performance (*4*). If the felt resists the flow of water in the press nip or if it does not have enough void space to accept water from the wet paper, a large hydraulic pressure is created, and press dewatering falls off. In extreme cases, the machine-direction (MD) hydraulic pressure gradient can disrupt the web structure or cause crushing (*6*).

Expenses associated with press felts are a substantial part of production costs. These expenses can rise if an unscheduled shutdown is required for a felt change, if a plugged felt limits machine speed, or if substandard dewatering in the press section is compensated for by increased steam consumption in the dryer section (*7*). Although felts have an important influence on machine operation, their effect can be obscured by other papermaking variables. To evaluate felt performance, machine operators have had to rely on measurements based on air permeability, water content, or total mass (*8*). Although the usefulness of air permeability is limited, it is at least occasionally measured on about half of the newsprint machines in Canada (*4*).

The permeability of a forming fabric is sometimes used as a criterion for selecting new fabrics. The air permeability gauge is commonly used to characterize fabrics, but the performance characteristics such as drainage and retention are probably related to water permeability.

## Limitations of air permeability measurements

The instruments commonly used to evaluate felt permeability are based on running felts at a pressure differential of about 0.1 kPa (0.5 in. water column). Examples of air permeability testers for running felts include Port-a-Perm by Albany International, the Huyck-Smith Porosity Tester (*8, 9*), and the ILPI Permeability Tester by Tamfelt. The Frazier Air Permeability Machine and the Frank Permeability Tester are used to measure felt permeability under static conditions.

The air permeability measurement was originally developed for evaluating garment textiles, and only later was it adopted for paper machine clothing. Although air permeability is a convenient test, there are some important

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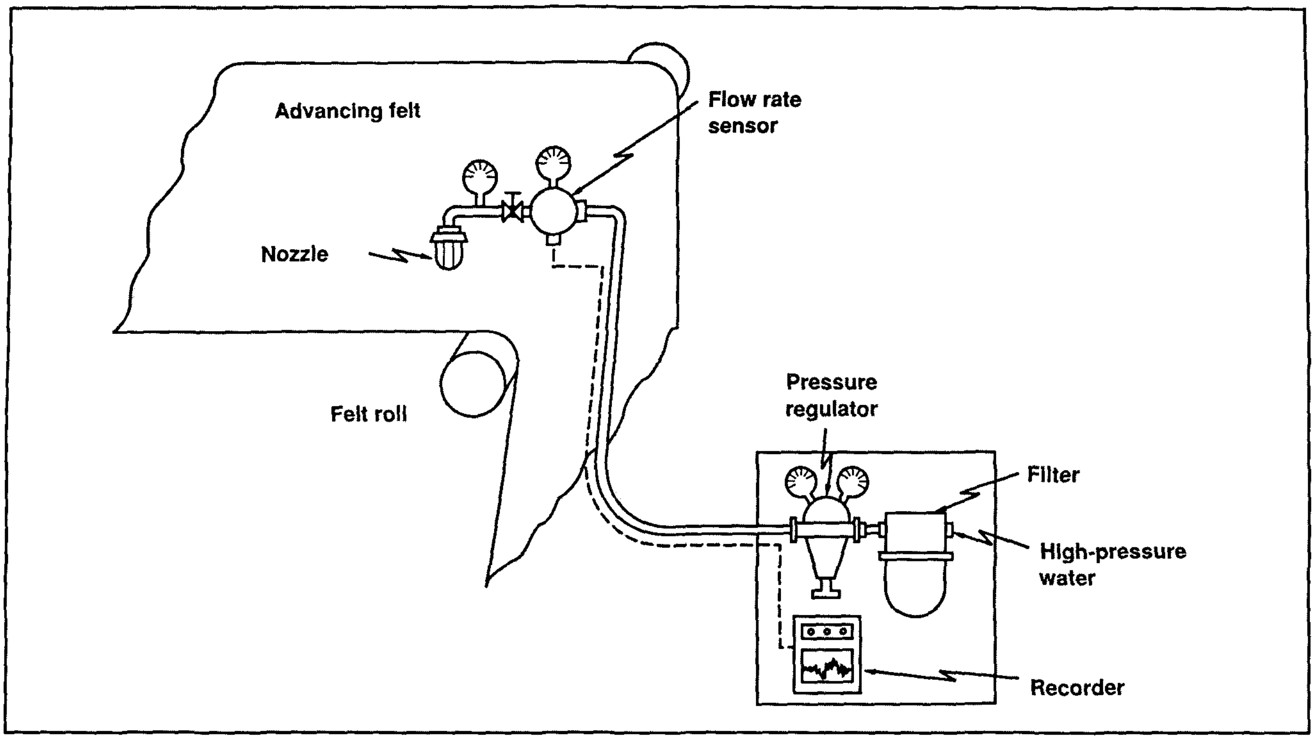
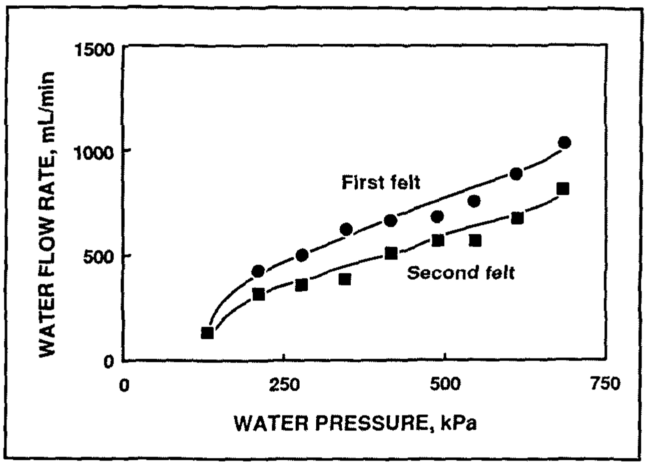
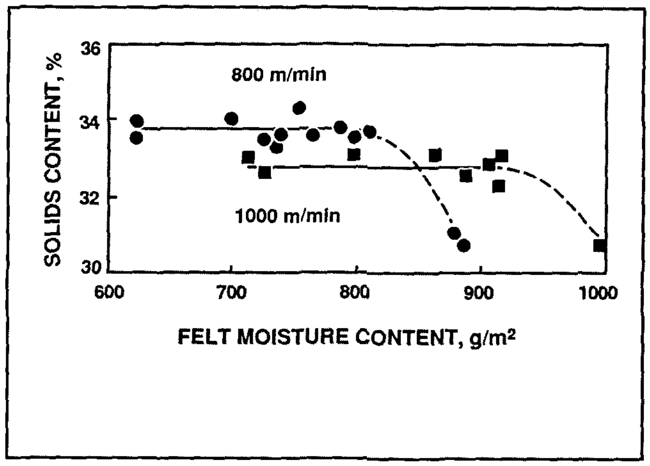
1. Diagram of the water permeability tester




2. Above 200 kPa, the water flow rate into the two felts increased approximately linearly with the water pressure. The machine was operated at 800 m/min.




3. The solids content of the web pressed in the first press remained unchanged, while the felt moisture content increased from 620 g/m² to 800 g/m² at 800 m/min and from 720 g/m² to 920 g/m² at 1000 m/min. Based on data reported elsewhere (*15*).




differences between the conditions of the air permeability test and the function of the felt.

First, in the press nip, the felt receives water rather than air. Second, the air permeability is measured on unrestrained clothing, whereas water from the paper enters the felt compressed between two rolls to pressures which, on a newsprint machine, could range from 40 to 80 kPa at mid-nip. At this pressure, the felt is more dense, which makes it less permeable (*2, 3, 10*).

Because of these differences, the air permeability of an uncompressed press felt at a small pressure differential might not be related to the water permeability of a compressed felt in the press nip. In addition to problems with interpreting the results, it is difficult to obtain reliable air permeability data on a running paper machine. With conventional instruments that have an air nozzle several centimeters wide, felt drag interferes with establishing good contact between the running felt and the hand-held probe. Lack of contact results in air leaks and in variations in air flow.

## Characterizing flow through a porous medium

Permeability is a measure of the capacity of a porous substance to permit a fluid to pass through it under specified conditions. The rate of liquid flow through a porous bed is described by d'Arcy's law (*11*):

$$V = K A P t / (\mu L) \quad (1)$$

where

$V$ = volume of liquid

$t$ = time

$A$ = area of the bed

$P$ = pressure drop

$\mu$ = viscosity

$L$ = thickness

$K$ = permeability.

The permeability of compressible materials such as felts is not a simple constant, because the void volume changes with pressure. This dependence can be expressed by applying the Kozeny-Carman equation (*12, 13*):

$$K = \epsilon^2 g / \mathrm{k}\, S^2 (1 - \epsilon^2) \quad (2)$$

where

$\epsilon$ = void fraction, dimensionless

k = Kozeny constant, usually with a value close to 5 for fibrous structures, dimensionless

$g$ = acceleration due to gravity

$S$ = hydrodynamic specific surface.

In an operating environment, it would be difficult to obtain information required to use Eq. 2, on the hydrodynamic specific surface and the void fraction under compression. In practice, we avoid this problem by conducting all measurements at a pre-determined pressure drop.

Kershaw (*10*) used specific flow resistance (the inverse of permeability) as a means of characterizing felts (Eq. 3).

$$\text{Specific flow resistance} = (1/v)\,(dP/dx) \quad (3)$$

where

$v$ = the approach velocity of water

$x$ = the felt thickness.

While the specific flow resistance might allow an insight into the properties of the felt materials, it might not be the best criterion for comparing different felts. For example, two felts with the same specific flow resistance but with different thickness will have different permeabilities.

For the practical evaluation of felt or fabric performance, a better criterion than the specific flow resistance or specific permeability is the volumetric water flow through a defined area at a specified water pressure (Eq. 4). We define this quantity as the felt permeability.

$$dv/dt = (\mathrm{K/L})\,(AP/\mu) \quad (4)$$

where

$dv/dt$ = felt permeability

K/L = a constant of the felt

$A$ = nozzle area

$\mu$ = viscosity

$P$ = water pressure.

Changes in the permeability of the felt installed on a paper machine can be evaluated by periodic measurements of the water flow rate $dv/dt$ under fixed conditions for $A$, $P$, and $\mu$.

## Measuring water permeability in a felt

A new on-line method to measure the permeability of paper machine clothing has been developed. The method is based on the measuring of water flow through a nozzle held in firm contact with the clothing.

**Figure 1** shows the design of the instrument. Filtered water is brought at a regulated pressure through a flexible hose to a hand-held measuring head. The head has flow and pressure indicators and a valve for adjusting the water pressure. The nozzle is rounded to make the instrument less sensititve to the contact angle between the felt and the nozzle, and it is polished to keep it from damaging the clothing. During operation, the nozzle is brought into firm contact with the fabric. The water flow obtained under these conditions is a measure of felt permeability and is expressed in units of mL/min for a specified water pressure and nozzle size.

From Eq. 4, it follows that in the measurement of a felt's water permeability, three parameters can be selected arbitrarily—the water pressure $P$, the area of orifice $A$, and water viscosity $\mu$. We have examined the effect of each one of these parameters to determine appropriate values for this instrument.

## Evaluation of the water permeability tester

### Experimental details

The effects of water pressure, nozzle diameter, and water temperature on the measured permeability was studied using several first-press and second-press felts and two forming fabrics on the Institute's paper machine, at speeds ranging from 400 m/min to 1200 m/min. Most of the felts were similar to those used on modern newsprint machines, but several were constructed specifically for other pressing experiments (*14*).

The moisture content of the felts was controlled by regulating the vacuum in the felt suction boxes and by adjusting the moisture of the incoming web or, in runs during which the former was not operated, by adjusting the water from the cleaning showers. A Scanpro instrument was used to measure felt water content, and felt air permeability was determined using the Port-a-Perm instrument (Albany Engineered Systems).

### Effect of water pressure

The flow rate was measured for 22°C water at various pressures through a 2.57-mm nozzle into the first and second felt. The machine was operated at 800 m/min and the two press nips were loaded to 45 and 90 kN/m. Both felts had a similar construction (100% synthetic, batt-on-mesh, "Di-lock" manufactured by Niagara Lockport). The first felt had a basis weight of 1264 g/m² and was used for 39 runs. The second felt had a basis weight of 1367 g/m² and was previously used in more than 20 runs.

As expected from Eq. 4, the flow rate increased linearly with water pressure between 200 and 700 kPa (**Fig. 2**). Below this range, the relationship between flow rate and pressure is no longer linear. Water at pressures above this range might be less readily available, and more robust instrumentation would be required.

To simulate the porosity of a felt compressed in the press nip, water injected by the tester should penetrate the felt rather than spread only on the surface, and the amount of water should be sufficient to fill all voids throughout the entire thickness of the felt. With a nozzle diameter of 2.57 mm and a machine speed of 1000 m/min, the felt residence time over the orifice is about 0.15 ms. Assuming that a wet felt compressed by the nozzle is 2 mm thick and that it contains a void volume of about 15% (*10, 14*), then it would be completely saturated by a column of water 0.3 mm high.

In the example shown in **Fig. 3**, about 700 mL/min was delivered to a typical felt at 550 kPa (80 lb/in.$^2$) through a 2.57-mm-diameter nozzle. This corresponds to a water column 0.36 mm high. Based on these considerations and the data in Fig. 2, water pressure between 300 kPa and 700 kPa seems to be sufficient for this measurement. A pressure of 550 kPa (80 lb/in.$^2$) has been chosen as a convenient value for the measurements on our pilot paper machine.

### Effect of orifice diameter and machine speed

Three nozzles with diameters of 1.10, 2.57, and 4.00 mm were tested on two felts on the Institute's pilot paper machine, using a water pressure of 550 kPa.

The felts were similar to those commonly used on newsprint machines and are described in **Table I.** The press section was operated at speeds from 300 m/min to 1200 m/min, the presses were loaded to 45 and 90 kN/m, and both felts were conditioned by a shower and suction box. Under these conditions, the moisture content of the felts at first increased with machine speed but remained steady at speeds above 750 m/min.

The data in Table I indicate a slight dependence of water permeability on machine speed; however, within the range of normal operating speeds, the effect is negligible. The differences between individual readings on the same felts are in part a result of the cross-machine direction variations in felt permeability.

All three nozzles tested could distinguish between the permeability of the first and the second felt. As expected from Eq. 4, about twice as much water flowed through the 4.00-mm nozzle than through the 2.57-mm nozzle. Compared with these two nozzles, the flow rate through the 1.10-mm nozzle was greater than would be expected from Eq. 4.

A portion of water emerging from the nozzle will disperse sideways, rather than penetrate deeper into the felt, and the proportion could be greater for a small-diameter nozzle. A nozzle with a nominal diameter of 2.5 mm appears to be convenient for felt permeability tests and has been routinely used in our tests, but smaller or larger nozzles could also be used.

### Effect of water temperature

The tests for the effect of water temperature were conducted at 800 m/min using the 2.5-mm nozzle, a water pressure of 550 kPa, and nip loads of 45 kN/m and 90 kN/m. The results are shown in **Table II**.

D'Arcy's law indicates that the water flow should be inversely proportional to viscosity. The viscosity of pure water decreases with temperature from 0.093 Pa·s at 23°C to 0.035 Pa·s at 80°C which, from Eq. 4, should increase the water flow by 166%. In our tests, we did not observe such an increase in the flow (Table II).

The observed insensitivity of the flow rate to water jet temperature might indicate that the heat capacity of the water jet is small in comparison with the heat capacity of the relevant area of the wet felt. Therefore, the temperature of the whole system might be little affected by jet temperature during the 0.15 ms that the nozzle contacts the felt.

## Comparison of permeability measurements with air and water

This new method to measure felt permeability offers numerous advantages over the conventional method. Measuring the permeability with water rather than air makes the results more relevant to the felt function. Felt tension, water pressure, and pressure exerted by the nozzle will compress the felt under the nozzle, which means that permeability is measured under conditions closer to those in the press nip.

The permeability measurement with water is more relevant to felt operation, easier to perform, and more accurate. A relatively small pressure, for example, is sufficient to establish good contact between the felt and the small-diameter water nozzle. Once good contact has been established, increasing the pressure further does not affect the instrument reading.

Since the pressure is slight and the nozzle is rounded, the running felt exerts only a minor drag on the head. Because the felt is extensible, it tends to wrap the nozzle, and water is injected into the felt, even if the nozzle is not precisely perpendicular to the plane of the felt. The result is that the water pressure and water permeability reading remain steady, making the measurement easier, more accurate, and more reproducible than the air method. In measuring air permeability, by contrast, small air leaks around the head cause wide fluctuations in air pressure and air flow rates.

Within a normal operating range, the moisture content of press felts does not diminish water removal from the wet web (*15, 16*), as Fig. 3 demonstrates. Since the felt performance is independent of felt moisture content, a true measure of permeability should be independent of felt moisture. The air permeability tester operates with very low air pressure. In the short time this air resides over a particular area, it cannot blow out water contained in the felt. The water partially fills interstices between the fibers and comprises the accuracy of the measured felt permeability. The water permeability tester employs a water jet at hydraulic pressure similar to that which occurs in the press nip. The jet displaces water contained in the felt, which makes the measurement insensitive to felt moisture.

The sensitivity of the air and water permeability testers to felt moisture content is shown in **Fig. 4**. The measurements were made on the first felt of the pilot paper machine

**I.** Water flow from three nozzles into two different felts at various machine speeds and moisture contents

| Machine speed, m/min | Moisture content, g/m² | Felt permeability in mL/min at nozzle diameters of 1.10 mm | 2.57 mm | 4.00 mm |
|---|---|---|---|---|
| First felt[a] | | | | |
| 300 | 480 | 279 | 770 | 1624 |
| 450 | 590 | 260 | 770 | 1509 |
| 600 | 650 | 221 | 711 | 1480 |
| 750 | 680 | 260 | 692 | 1461 |
| 900 | 700 | 163 | 702 | 1393 |
| 1050 | 700 | 192 | 759 | 1336 |
| 1200 | 690 | 202 | 730 | 1451 |
| | Average | 225 | 733 | 1464 |
| Second felt[b] | | | | |
| 300 | 500 | 183 | 634 | 1201 |
| 450 | 630 | 202 | 653 | 1221 |
| 600 | 710 | 125 | 548 | 1163 |
| 750 | 680 | 135 | 606 | 1125 |
| 900 | 680 | 125 | 509 | 1057 |
| 1050 | 700 | 125 | 557 | 1076 |
| 1200 | 710 | 125 | 519 | 1125 |
| | Average | 146 | 575 | 1139 |
| Permeability ratio, first/second felt | | 1.54 | 1.27 | 1.28 |

[a]Duroflo, Albany Int., 1063 g/m².
[b]Di-lock, Niagara-Lockport, 1060 g/m².
Both felts were used previously in about 20 runs.

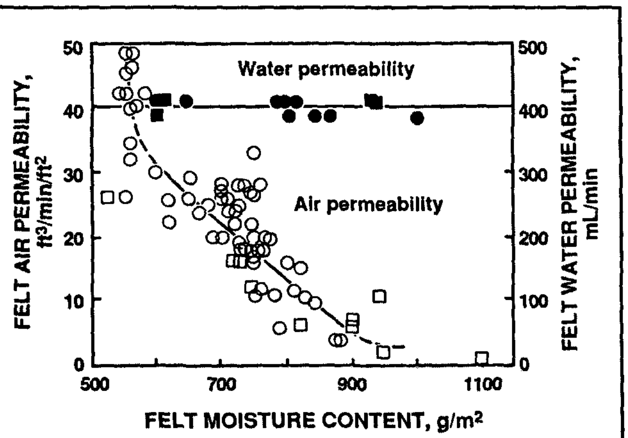
**II.** Flow rates in mL/min at different water temperatures

| Felt | Water temperatures, °C 22 | 30 | 40 | 50 | 60 | 70 | 80 |
|---|---|---|---|---|---|---|---|
| First | 990 | 1070 | 990 | 1020 | 942 | 884 | 952 |
| Second | 711 | 701 | 740 | 779 | 779 | 779 | 701 |

**III.** Water permeability of five press felts

| Felt code | Position | Base weave | Basis weight, g/m² | Void space at 5.5 MPa, % | Permeability to water, mL/min |
|---|---|---|---|---|---|
| | First | Double layer | 920 | 38.2 | 1350 |
| | First | Triple layer | 1040 | 38.2 | 550 |
| A | Second | Triple layer | 1070 | 29.1 | 310 |
| B | Second | Double layer | 1200 | 33.8 | 500 |
| C | Second | Double layer | 1340 | 27.5 | 540 |

**4.** Results of air permeability measurements for the first felt were scattered and strongly dependent on the felt moisture content. Water permeability data were more reproducible and independent of felt moisture. The machine was producing newsprint at 600 m/min ○ ● or 800 m/min □, ■ and the first press nip load was 45 kN/m.




(Duraflo from Albany International) during six consecutive runs. The felt moisture was modified by adjusting the water flow of the cleaning showers and the vacuum level in the suction box.

A notable feature of Fig. 4 is the wide scatter of the air permeability data. These data were collected by two experienced operators under conditions more favorable than those found in some mills. Scatter in air permeability data can be expected to be similar to or wider than this when the measurements are made in a mill. A portion of this scatter reflects machine-direction and cross-direction variation of felt properties, but a large portion of it arises from difficulties in handling the instrument.

Figure 4 shows that the air permeability of the felt was strongly affected by the felt moisture content. The permeability was high—close to 50 ft³/min/ft²—at low moisture content, but it approached zero at high moisture content. Similar web solids contents were measured at all felt moisture values below 1000 g/m² (Fig. 3) (*15*), which indicates that the air permeability of a felt does not necessarily reflect its dewatering characterisitcs. A Canadian survey of pressing on paper machines indicated that felt permeability was measured regularly on 24% of

**IV.** The effect of felt permeability on water removal in the second press

| Felt code | Permeability, mL/min | Nip load, kN/m 60 | 90 | 120 | Nip load, kN/m 60 | 90 | 120 |
|---|---|---|---|---|---|---|---|
| | | | | Solids content before press, % | | | |
| | | 34.1 | 35.7 | 36.9 | 27.3 | 28.4 | 28.8 |
| | | | | Solids content after press, % | | | |
| A | 310 | 41.7 | 43.3 | 44.9 | 37.8 | 40.1 | 40.8 |
| B | 500 | 42.0 | 43.5 | 45.1 | ... | ... | ... |
| C | 540 | 41.7 | 43.4 | 45.0 | 39.5 | 41.4 | 42.3 |

Permeability was measured with a 2.57-mm nozzle at 550 kPa. The machine was operated at 800 m/min.

the newsprint machines (4). Our study indicates that air permeability measurements might lead to incorrect conclusions about felt conditions.

The water permeability data shown in Fig. 4 were obtained with a 1.10-mm nozzle and a water pressure of 550 kPa. A similar horizontal line, at around 800 mL/min, was obtained with a 2.57-mm nozzle. Measured with either nozzle, felt permeability to water was independent of felt moisture content. The water permeability data were also more consistent, which reflects smaller accidental error in using this method.

## Application

The purpose of measuring felt permeability is to evaluate felt performance. On a commercial machine, the influence of a single felt on water removal might be hard to evaluate because it is masked by variations of other parameters. Recently, we carried out a careful study of the effect of felt design on water removal on our pilot paper machine, using five different felt types constructed specifically for this purpose (14). Some characteristics of these felts are shown in **Table III**. The range of water permeability values measured for the five felts shows that the technique could detect the differences between them.

Selected results from these trials are shown in **Table IV**. When paper with a relatively high solids content entered the second nip, all three second press felts removed an equal amount of water, and the solids contents of pressed webs were equal within the range of experimental variation. However, when a wetter web entered the press and the felts had to handle a large amount of water, Felt "A" with lower water permeability yielded a wetter pressed web than the more permeable Felt "C." These results indicated that a low water permeability can decrease the press section water removal, especially if the press handles more water.

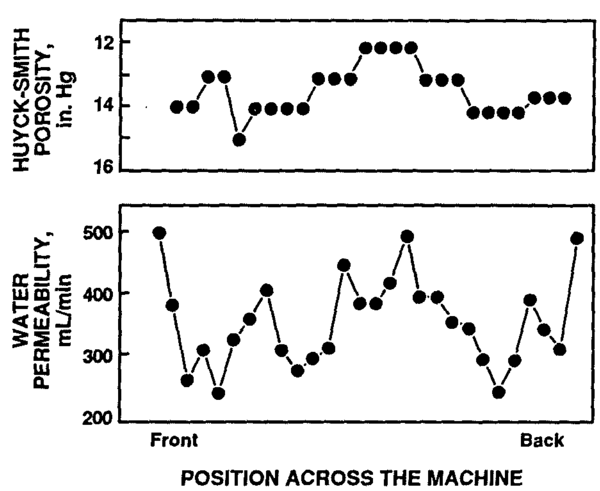
The prototype of the instrument was tested on the bottom felt of a Tri-nip press on a commercial newsprint machine. This double-layer, batt-on-mesh felt had a unit weight of

**V.** Averaged properties as determined by the supplier

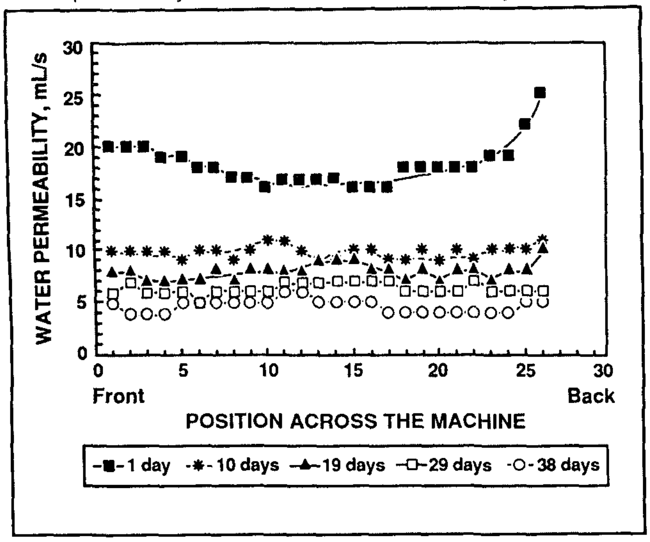
| | New | Removed |
|---|---|---|
| Grammage, g/m$^2$ | 1439 | 1378 |
| Permeability, ft$^3$/min/ft$^2$ | 88 | 19* |
| Thickness, mm | 3.00 | 1.78 |
| Void volume, % | 58 | 32 |
| Pitch and tar, % | ... | 1.34 |
| Stock and fines, % | ... | 2.04 |

*Measured by Frazier air permeability machine.

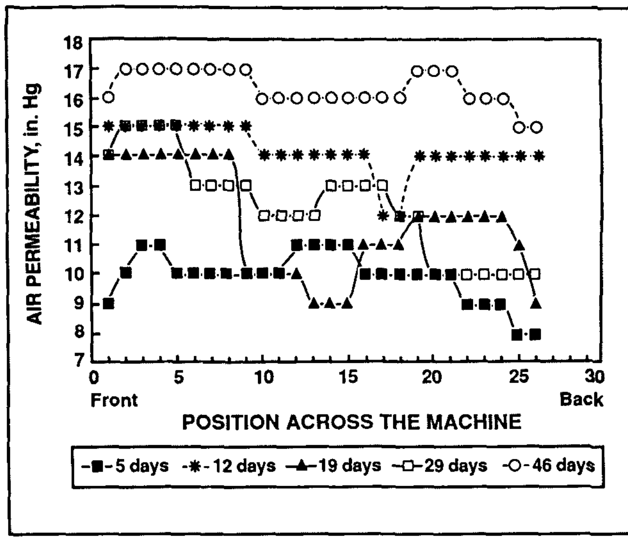
**5.** Huyck-Smith porosity and water permeability profiles of a felt operating on a commercial newsprint machine



**6.** Felt permeability to water measured on different days




**7.** Huyck-Smith porosity of a felt measured on different days




1190 g/m$^2$, a length of 25 m, and a width of 8.4 m. The supplier reported its air permeability to be 96 ft$^3$/min/ft$^2$. Prior to the evaluation, the felt had run at a speed of 1000 m/min and a press nip load of 70 kN/m for 27 days.

**Figure 5** shows the water permeability profile of this felt, and the air permeability profile measured with a Huyck-Smith Porosity Tester. Even though similar numbers of readings were obtained with the two instruments, the individual measurements were not necessarily carried out at identical points across the machine.

While the two profiles have some similar features, the water permeability measurement appears to be more sensitive to variations. Using this technique, we were able to detect very narrow streaks of low permeability. For example, the streak located near the front of the machine with a permeability of 230 mL/min (Fig. 5) was only about 3 cm wide. A high water permeability, close to 600 mL/min, was measured at both edges where the felt did not contact the paper.

### A long-term mill trial

A prototype instrument built by Noram was tested during the entire life of a felt at Quebec and Ontario Paper Co.'s Thorold mill. The permeability of the third press felt in a heavily loaded nip of a newsprint machine was measured at regular intervals by the Huyck-Smith Porosity Tester and the water permeability tester. After 38 days, the felt was removed and analyzed by its supplier, Huyck Canada. **Table V** shows some data reported by the supplier for the felt as new and after being removed.

The felt permeability was measured at 26 points across the machine. The water permeability was determined on 15 different days, and the air permeability (Huyck-Smith) was determined on 14 different days over the life of the felt. **Figure 6** shows that the permeability of felt to water was fairly stable across the machine after the first day of operation and that it gradually declined. A remarkable feature of the water permeability test was its ability to detect reproducibly even very narrow streaks of low permeability, sometimes only one to several centimeters wide.

The Huyck-Smith apparatus measures the vacuum in a nozzle placed in contact with the felt. The more porous the felt, the lower is the measured vacuum. **Figure 7** shows that this method also detected a decline in the felt permeability during its life. The air permeability apparatus showed the five-day-old felt to be more permeable than after 39 days, but the results are more scattered and less consistent than with the water permeability method. For example, the felt as measured after 12 days appeared to be less air permeable than when measured after 19 or 29 days of use.

A comparison of Figs. 6 and 7 indicates that the water permeability test is a consistent means for evaluating felt quality. The average permeability to water dropped rapidly in the first days of the felt's use, and a slow decline then continued throughout the felt life (**Fig. 8**). The measurement on the 27th day was conducted while the high-pressure showers were being used to clean the felt, which might explain the high permeability measured on this occasion.

Our ealier results have shown that, when the permeability to water is below a critical value, the water removal from the wet web can be reduced (Table IV). Therefore, the water permeability data might provide useful guidelines for the selection, cleaning practice, and removal of felts.

### Permeability of forming fabrics

Although the function of forming fabrics is to retain fibers and transmit water, these fabrics are commonly evaluated in terms of the air permeability. We used the new instrument to measure the permeability of forming fabrics.

The tests were conducted on the top and bottom fabrics on the Institute's pilot paper machine. Triple-layer fabrics with a plain weave top layer and a three-over-one bottom layer (Sensotex by Albany) were installed on both machine positions. Both the top- and bottom-layer meshes of the fabrics were 70 × 56, and the air permeability quoted by the supplier was 450 $ft^3/min/ft^2$ at 0.5 in. $H_2O$. No paper was produced during the operation of the former. Water flow rates through a 1-mm nozzle at a series of machine speeds and water pressures are summarized in **Table VI.**

According to the supplier's specification, the two fabrics were similar when they were made. From the results in Table VI, it now appears that the bottom fabric was less permeable than the top fabric. Table VI also reveals that the water flow increased with the water pressure but was independent of machine speed. The variability of the results appears to be greater than that found for press felts.

The hydraulic pressure that develops in the forming zone of a roll-type former is determined primarily by the tension of the forming fabrics and the radius of the forming roll (*17*).

$$P = T/R \qquad (5)$$

where

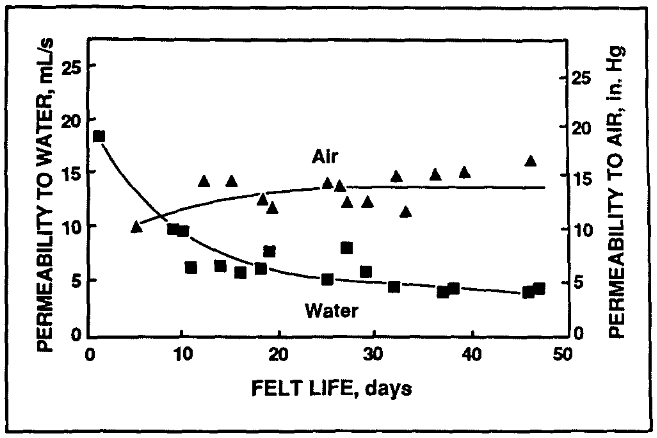
$T$ = fabric tension, N/m

$R$ = roll diameter, m.

For example, the hydraulic pressure in the forming zone of a paper machine with a 1-m diameter forming roll and operating with fabric tension of 6 kN/m will be about 6 kPa.

Since these pressures are not very high, it appears that low-pressure water flow could also be used for testing the permeability of forming fabrics. Additional work will be required to optimize this technique for the evaluation of forming fabrics.

**8.** The decline of the average water permeability of a felt during its life




**VI.** Flow rate in mL/s through the top and bottom forming fabrics as a function of machine speed and water pressure

| *Water pressure, kPa* | *Felt permeability in mL/min at machine speeds of* 0 | *300* | *600* | *900* | *1200* |
|---|---|---|---|---|---|
| Top fabric | | | | | |
| 34 | 0 | 0 | 0 | 0 | 0 |
| 20 | 4.81 | 4.65 | 4.97 | 4.49 | 4.00 |
| 103 | 5.29 | 6.57 | 7.21 | 5.77 | 5.29 |
| 138 | 7.21 | 7.05 | 7.21 | 5.77 | 5.29 |
| 345 | 10.73 | 9.45 | 9.45 | 10.89 | 10.73 |
| 690 | 11.53 | 13.46 | 13.76 | 14.58 | 12.17 |
| Bottom fabric | | | | | |
| 34 | 0 | 0 | 0 | 0 | 0 |
| 20 | 4.65 | 4.49 | 4.49 | 4.49 | 3.68 |
| 103 | 5.13 | 5.29 | 5.13 | 4.81 | 4.33 |
| 138 | 5.61 | 6.25 | 5.76 | 6.75 | 4.97 |
| 345 | 7.85 | 8.33 | 8.17 | 10.09 | 9.13 |
| 690 | 10.41 | 10.89 | 11.05 | 10.89 | 10.41 |

## Conclusions

A new method has been developed for evaluating the water permeability of press felts and forming fabrics while the machine is running. The method is based on measuring water flow through a nozzle that is in contact with the felt or fabric of an operating machine. The results collected in a long mill trial suggest that this method could be used to establish a felt cleaning schedule and to determine when a felt should be replaced.☐

## Literature cited

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