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DETERMINATION OF THE WATER VAPOUR RESISTANCE AND THERMAL RESISTANCE OF SAMPLE MATERIALS USING A SWEATING HOT PLATE

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**DETERMINATION OF THE WATER  
VAPOUR RESISTANCE AND  
THERMAL RESISTANCE OF  
SAMPLE MATERIALS USING A  
SWEATING HOT PLATE**

W. R. Dyck  
J. B. Cain  
C. Moses

Defence and Civil Institute of Environmental Medicine  
1133 Sheppard Avenue West, P.O. Box 2000  
North York, Ontario  
Canada M3M 3B9

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## Executive Summary

The following report describes two independent sets of measurements of the water vapour and thermal resistance of several materials being studied in a round-robin evaluation of sweating hot plate apparatuses as part of Operating Assignment 09 of TTCP PTP-3. Central to the hardware set-up used in this investigation is a Sweating Hot Plate (SHP) made in Canada (SEA Engineering, Dartmouth, N.S., Canada). The method used was adapted from the International Organization for Standardization method for sweating hot plates, ISO 11092. The SHP was operated in a room whose temperature and relative humidity were controlled. A wind tunnel was constructed to fit over the test surface to control the air flow over the sample. Once proper operating characteristics were achieved, the water vapour and thermal resistance of eight samples (3 from Australia, 3 from the United Kingdom, and 2 from Canada) were measured.

The same textile properties were measured with devices more commonly used for making such measurements. These values are compared to the ones obtained on the SHP, and although most values compared well, some differences were noted. A few further tests were performed in an attempt to explain these differences. It was concluded that the differences in results were attributed to air penetration of the samples in the presence of air flow. Because of the effect air flows have on the determination of water vapour resistance and thermal resistance, sweating hot plate results cannot be directly compared to other test methods not using air flows over samples. It was also concluded, that the sweating hot plate was not suited to determining the thermal resistance of thin materials.

## Abstract

A round-robin determination of certain textile properties has been proposed as part of a TTCP PTP3 effort to facilitate the exchange of data between countries using different apparatuses. The objective of the study, Operating Assignment 9, is to see if the measured values of thermal and water vapour resistance of various fabrics are comparable between the SEA Sweating Hot Plate (used by Australia and Canada) and the Hohenstein Sweating Hot Plate (used by the United Kingdom and the United States). Several fabric samples were submitted for testing by each nation taking part in the round-robin tests. All nations tested the samples independently using their own equipment and test methods. The work presented here is a detailed description of the test method used by Canada and the results achieved.

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## 1.0 Introduction

The following report describes an independent set of measurements of the water vapour and thermal resistance of several materials being studied in a round-robin evaluation of sweating hot plate apparatuses as part of Operating Assignment 09 of TTCP PTP-3. Materials were submitted by Australia, the United Kingdom, and Canada, and the above material properties were measured by all countries using their respective sweating hot plates. Because Australia and Canada use the SEA sweating hot plate (SEA Engineering, Dartmouth, N.S., Canada), and the UK uses a Hohenstein sweating hot plate (Hohenstein Institute, Federal Republic of Germany), and because the methods on each hot plate may differ, it was decided that a comparison of results of water vapour and thermal resistance measurements would be of interest to each country. The results reported herein are those obtained at the Defence and Civil Institute of Environmental Medicine on behalf of Canada in this international study. A compilation of all test results will be published by TTCP.

A separate set of tests was also performed by DCIEM using apparatuses more traditionally used in determining the above mentioned material properties. The apparatuses used in this investigation were specifically designed to measure thermal and water vapour resistance and should thus provide an accurate benchmark for comparison of the other methods.

## 2.0 Materials

The following is a description of the materials submitted by each nation participating in the round-robin tests. Three samples were submitted by Australia. A1 is a 50/50 cotton/polyester disruptive pattern material weighing  $170 \text{ g/m}^2$ . A2 and A3 are 100% cotton disruptive pattern materials of two different weights; namely  $228$  and  $294 \text{ g/m}^2$ , respectively.

The UK submitted three samples with quite different characteristics. UK1 is a polyester fleece pile with a disruptive pattern; UK2 is a sleeping bag panel with a polyester batting; and UK3 is a disruptive pattern nylon/MVP (moisture vapour permeable)/nylon material.

Canada submitted two materials for testing. C1 is a cloth, Melton wool, with a mass of 375 g/m<sup>2</sup>, 88% wool and 12% nylon (new) staple. C2 is a polyester batting laminated on both sides with a nylon textile, with a mass of 365 g/m<sup>2</sup>, and a nominal thickness of 10 mm.

### 3.0 Methods

#### 3.1 Sweating Hot Plate Tests

In order to determine the water vapour and thermal resistance of each of the sample materials, it was decided to employ the conditions described in the International Organization for Standardization test method, ISO 11092 [1]. The most important reason for adopting this method was to standardise the conditions of each test. The sweating hot plate (SHP) was placed in an 8' x 8' x 8' room in which the temperature and humidity were controlled, and the air in the room was continuously mixed by several fans located around the room. If no sample protection or airflow standardisation of the test surface was employed, air currents over the test samples varied widely and unpredictably. Since it was not known whether results depended on air flows over samples, a wind tunnel was built to produce an air flow of 1 m/s at a height of 1.5 cm above the test sample.

##### *Wind Tunnel*

A small wind tunnel was built, and tests showed it was able to produce and maintain an air speed of 1 m/s, 1.5 cm above the centre of the measuring surface, with a drift not exceeding  $\pm 0.05$  m/s over the duration of a test. The main part of the tunnel (Fig 1) was 1.00 m long, 0.13 m high and 0.365 m wide. A rectangular horn, with an opening of 0.69 m by 0.40 m, was attached to the air intake end of the tunnel. The horn reduced variability of the air speed in the tunnel, over the test surface.

A box with four muffin fans built into the sides was attached to the other end of the tunnel to pull air through the tunnel. The speed of the fans was controlled from outside the test room with a variable voltage supply. The side of the fan box attached to the tunnel had a thin, air

permeable material covering it, to help equalize the negative pressure over the end of the wind tunnel opening. The wind tunnel was placed over the SHP such that the test surface just fit through a hole cut in the bottom of the wind tunnel, level with the bottom of the tunnel wall.

To better understand the airflow profile of the wind tunnel and the stability of the air flow over the SHP test surface, a hot-wire anemometer (TSI Willer Eng. Model 1610) was used to measure the air flows at various heights within the tunnel. The anemometer probe was inserted into the air stream at six locations, through holes drilled into the sides of the tunnel, 2.5 cm apart, from 0.5 cm above the test surface of the SHP. The air flow was adjusted to approximately 1 m/s midway up the tunnel, and the air speed was measured at each height for approximately 1.0 h. The air speed required frequent adjustments at the start of each run until steady state was achieved (usually within 1 hr).

#### *Water Vapour Resistance (WVR)*

A computer, situated outside the test room, was used to control the test and guard surface temperatures, and control the sweat rate at the test surface. It also measured all the SHP temperatures as well as ambient temperature, and the power supplied to the heaters used to calculate the heat flux at the test surface. Air speed was measured using a hot wire anemometer (TSI Willer Eng. model 1610), and the relative humidity was measured using a humidity transmitter (Vaisala Inc., Woburn, MA. model HMP233). The top surface of the test sample was set to be approximately level with the bottom of the wind tunnel, and the anemometer was placed approximately 1.5 cm above the test sample. The relative humidity and ambient temperature sensors were placed in the wind tunnel, just above and downwind of the sample. The sample was held in place by a thin metal ring that was firmly bolted to the SHP. In the case of the samples where compression was a factor, the ring was allowed to rest on the sample with only the force of gravity holding it down, which minimised compression.

Goretex<sup>TM</sup> was used to provide a waterproof, water vapour permeable layer between the test sample and the wet surface of the hot plate. Several different materials were tested and it was found that Goretex<sup>TM</sup> had the lowest resistance to water vapour flow, and even at a high sweat rate of 0.20 g/m<sup>2</sup>/s, no water pooled under the layer. This series of tests was done without any other material (test sample) placed over the Goretex<sup>TM</sup>. A sweat rate of 0.20 g/m<sup>2</sup>/s was thus

chosen as the one to be used throughout these tests. Goretex™ I is also slightly air permeable so any air in the sweat tubes at the start of a test, could be purged through the Goretex™ I layer, without causing air bubbles on the test surface.

It was also found that the air in the SHP under the test surface, containing the sweat tubes, developed steady state temperatures higher than 35° C. It was thought that conduction of heat from surrounding equipment contributed to this undesirable condition. A circulating water bath was used to circulate 20°C water through Tygon™ tubing attached to the outside of the housing. Proper regulation of the temperature in the sweat tube housing was thus achieved.

Samples were placed directly on the Goretex™ 1 layer covering the test surface. Both were firmly attached to the test surface, using a metal ring and four bolts, after being pressed flat to remove any wrinkles. The two samples containing batting, UK2 and C2, were tested without being flattened and bolted; i.e. the metal ring was placed over the sample and only gravity kept the sample in place. The wind tunnel was then placed over the test surface so that the top of the sample was level with the bottom of the wind tunnel and the anemometer was approximately 1.5 cm above the sample. It should be noted that the test samples were cut large enough that when placed on the SHP test surface, excess material hung over the sides. In the case of UK2 and C2, the edges were taped to minimise any air flow into the batting from the sides.

The SHP and associated instruments were turned on and the experiment was set to run for 120 min per sample. A 30-60 min drying period, no sweating, was performed between samples if more than one sample was tested, to identify the end of one test and the beginning of another. This usually produced 45-60 min of steady state heat flux recordings. The relative humidity in the test chamber was set to 40%. The test surface temperature was set to run at 35°C (as was the ambient temperature) while the sweat rate was set to 0.2 g/m<sup>2</sup>/s. The test surface heat flux was calculated and recorded. Throughout the beginning of the experiment, the air speed was continuously adjusted until a steady state of 1.0 ±0.1 m/s was obtained. The heat flux reported herein was obtained by averaging the values during steady state conditions, which was found to correspond with a completely wetted surface. The water vapour resistance was calculated as per ISO 11092.

To confirm that the SHP was operating within normal operating limits, a no-sample (only the Goretex™ 1 layer) test was done before and after each country's samples.

### *Thermal Resistance*

The apparatus was set up similar to the WVR tests, except that there was no Goretex™ I layer. The room was set to 20°C and the relative humidity was set to 65%. The thermal resistance tests were then performed with the SHP test surface set to 35°C. Each sample was tested for approximately 1-2 hours. The average heat flux was obtained and the thermal resistance was calculated as per ISO 11092.

## **3.2 Other Tests**

Additional tests on the sample materials using apparatuses specifically designed for such tests included: thickness, mass per unit area, water vapour resistance and thermal resistance. Each of the tests is described briefly and the results of the tests are reported in the following section. For the thickness, mass per unit area and thermal resistance measurements, a single sample, typically 30 cm by 30 cm square ( $\pm 0.2$  cm), was cut from each material supplied, while a separate sample was cut for the water vapour resistance measurements.

### *Thickness*

The thickness of each of the fabrics was measured with a Thickness, Compression and Recovery Tester, Model CS-55. For materials other than the battings, the pressure plate diameter was 29 mm and the pressure on the fabrics was 1 kPa. For the two batting materials, a 90 mm plate was used and the pressure was 0.167 kPa. The uncompressed thickness of the battings was estimated by eye using a steel rule. For the Canadian batting (C2), the thickness was also measured when subjected to the 1 kPa pressure with the smaller plate. The precision of the measurement is estimated to be 0.008 mm which is greater than normally required for most textile applications. Several readings were made over various points in each sample and the results averaged.

### *Water Vapour Resistance*

Water vapour resistance was defined as the resistance of the materials to the mass flow rate of water vapour per unit area per unit vapour pressure difference. The apparatus used to measure this was produced in-house based on a design developed at TNO [2], referred to as the Van Beest & Wittgen (VBW) method. Most of the fabrics were tested at approximately 50% relative humidity at room temperature (21° to 23°C). However, one of the samples (UK3) was suspected of containing a hydrophilic membrane, so it was measured at several mean relative humidities (average of the relative humidities on each surface of the sample). The relative humidities at the sample were changed by adding spaces (known thickness) of air above and below the sample; between the sample and the dry and wet surfaces respectively. Since the water vapour resistance of air is known, and the sample resistance is determined by subtracting the resistance of the air layers from the total resistance measured, the relative humidity at both surfaces of the sample was calculated and averaged.

Samples of fabric were held horizontally in the apparatus between a surface saturated with water and a surface that was continuously dried by a desiccated air-stream. The intrinsic resistance of the apparatus was determined by measuring the resistance of still air layers of known thickness and comparing the results with tabulated values for air. The difference was attributed to the apparatus resistance (on the dry side of the sample) which was subtracted from each sample's measured value. As water evaporated from the wet surface, it was replenished with water from a graduated pipette. The evaporation rate was measured by timing the movement of the meniscus through the pipette. The values obtained by this measurement technique are estimated to have an uncertainty (one standard deviation) of less than 1% of the mean value.

### *Thermal Resistance*

The thermal conductivity of each material was measured using a "Heat Flow Meter Instrument" (HFMI), model FOX400 (Lasercomp Inc., Lynnfield, MA). Fabric samples were placed in this device between two isothermal plates ( $\pm 0.01^\circ\text{C}$ ), the temperature of each being specified by the user. The resulting heat flow is measured by internal thin-film heat flux transducers. The calibration of the internal heat flux transducers (performed by the manufacturer

to NIST SRM 1450b) was used, which results in a manufacturer's reported accuracy of  $\pm 2\%$  for the computed thermal resistance. For the textiles, the distance between the plates was set automatically by the apparatus which has a reported accuracy of  $\pm 0.0025$  cm. The bottom plate is moved towards the upper plate by stepper motors and the apparatus uses force transducers to determine when to stop the plate travel. The plate separation reported by this apparatus agreed with the fabric thickness measurement previously described to within the reported accuracy of either apparatus. For the battings, the plate separation was specified *a priori* and the thermal conductivity was measured at several thicknesses. The thermal conductivity of the sample was computed automatically from the measured heat flux, the temperature difference and the plate separation. Thermal resistance was computed from the thermal conductivity and the plate separation and it is expected that the uncertainty in this value is approximately  $\pm 0.001$  m<sup>2</sup>K/W.

The samples were measured at three nominal temperatures of 20°, 30° and 45°C. For the textiles, the temperatures of the plates were set to 1°C above and below the nominal temperatures. For the battings, the plates were set to 5°C above and below the nominal temperatures to increase the apparatus sensitivity.

#### *Multi-layer thermal test*

As discussed in the following section, the results of water vapour resistance and thermal resistance tests obtained with the sweating hot plate were compared with those of other tests done. Differences were noted between the two tables of results, which were not always consistent. Two additional tests were done in an attempt to better understand these differences.

A thermal conductivity experiment was repeated using a somewhat different procedure. The purpose of the test was to determine the effects, if any, of airflow over air permeable materials. A thin material, A1, was chosen as the sample. Five separate samples of A1 were stacked and secured on the SHP test surface. The total thermal resistance was measured and divided by the number of layers to obtain a mean layer value. One layer was then removed and the above procedure was repeated. This was done until there were no layers left. Similar tests were performed on the Heat Flow Meter Instrument (HFMI).

### *Zero air flow test*

To further investigate the effect of wind speed on the water vapour resistance of materials, material C1 was tested again with no air flow over the sample. The wind tunnel was placed over the sample, but the fans were turned off (zero airflow).

## **4.0 Results and Discussion**

Results of the measured airflow speed in the wind tunnel are shown in Figure 2. The error bars shown are standard deviations, and the averages and standard deviations were derived from approximately 180 readings. The average air speed values in the wind tunnel indicate that air speeds at the bottom levels of the tunnel are lower and vary more than those at the upper levels. This is predictable, because there are gaps where the tunnel rests on the SHP which would explain the lower values. It was also anticipated that the uneven surface of the test surface protruding into the tunnel would cause more turbulence in the air flow and this would seem to be supported by the higher variability. Once steady state was reached, however, the air speeds at each monitoring point exhibited drifts within the  $\pm 0.05$  m/s required by ISO 11092.

The SHP water vapour resistance results are shown in Table 1, and the thermal resistance results are shown in Table 2. The water vapour resistance and thermal resistance of the same materials determined by more traditional means are shown in Table 3.

When comparing values for water vapour resistance, the general trend indicates that measurements made on the Australian and Canadian samples with the SHP are approximately half those made by the VBW method. The results of the British samples seem to indicate a less consistent difference. For example, the batting (UK2) result is approximately the same while the UK3 results are difficult to compare. The difficulty arises from the fact that waterproof, water vapour permeable materials with a hydrophilic coating, like UK3, have a resistance which is humidity dependent. Since the relative humidity at the vapour permeable barrier of UK3 is not known for the SHP test, it is not known which of the three results of the VBM test method is appropriate for comparison. The result on the SHP for UK1 is approximately twice that of the VBM test method.



Small variances in the water vapour resistance test results were expected because of differences in the temperature and humidity in the two test methods, but were estimated to be less than 5%. The SHP water vapour resistance tests were done at 35°C and 40% relative humidity whereas the VBW tests were done at room temperature (21°C to 23°C) and various relative humidities ranging from 45% to 93% (most being approximately 50%). This would imply that SHP results should be lower than standard methods.

The major influence on the difference in results is believed to be the presence or absence of air movement over the samples. In the SHP experiments, for both water vapour resistance and thermal resistance tests, the sample was exposed to a constant air flow of 1 m/s while in the VBW method there was no air flow over the sample. It is believed, as was also suggested by Gibson et al. [3], that air penetration of the sample, because of the presence of air flow, would cause the test surface to exhibit non uniform temperature distributions. This would give rise to a higher heat flux at the test surface due to an additional component of heat flow along the test surface between areas of temperature differences. A lower than expected water vapour resistance and thermal resistance would then be the result.

The more wind resistant sample material, UK3, showed results that were much closer when comparing the SHP and VBW test method. The sample on the SHP does not make contact with the water nor is there an air gap between the test surface and the sample. Test results for the VBW method are reported for mean relative humidities of 93% (water contact), 60% (smaller air gap) and 52% (larger air gap). The SHP WVR result was expected to be between those obtained by standard methods, and the thermal resistance result is expected to be more similar. This seems to be true. The WVR result for another sample, UK2, may be approximately the same between the two test methods because this material is composed of a thick batting which may resist air penetration more than the thinner materials, causing the effect to be a smaller fraction of the overall value.

The results of the water vapour resistance test repeated on C1, without an air flow over the sample, showed that the values acquired on the SHP were the same as those obtained on the standard method; i.e. 6.3 m<sup>2</sup>Pa/W on the sweating hot plate versus 6.5 m<sup>2</sup>Pa/W on the VBW device. This supports the hypothesis that using an air flow over the sample can reduce the water vapour resistance.

This does not, however, explain the fact that the SHP WVR result for UK1 is twice that of the standard method. It has, however, been noticed in other SHP tests that the wicking material covering the test surface (used to spread the “sweat” evenly over the test surface) can become wrinkled if not carefully prepared for a test. This wrinkling causes air pockets to occur randomly over the test surface, causing lower heat flux and higher resistance. If the sample itself develops wrinkles i.e. not flattened properly on the test surface, this could again result in air pockets, lower heat flux, and higher water vapour resistance. This may have offset the expected lower water vapour resistance values (the result of air penetration) expected for the water vapour resistance values for UK1 and C1.

When comparing values for thermal resistance, the SHP results for the Australian samples and UK3 are approximately twice those of the HFMI test method. The results for UK1 and C1 are approximately the same, and the SHP results for UK2 and C2 are approximately half of those for the HFMI method.

As explained in the previous section, the Australian material, A1, was tested again with one to five layers per test, on both the SHP and HFMI. The total thermal resistance was measured and a mean layer value calculated by dividing by the number of layers. As can be seen in Figure 3, the SHP results are greater than the HFMI test by about 50%. Both sets of data formed a linear relationship with a common intercept of  $0.008 \text{ m}^2\text{K/W}$ . The average thermal resistance (slope) of the SHP results, however, was  $0.0083 \text{ m}^2\text{K/W}$ , which was approximately twice that of the HFMI,  $0.0046 \text{ m}^2\text{K/W}$ . It is believed that the thermal resistance values of very thin samples is so low compared to the sensitivity of the SHP apparatus that even very small errors in sample set up on the test surface can cause large errors in results. In any event, the thermal resistance of most textiles is only a small component of typical garments and this error in thermal resistance for thin fabrics is of little consequence.

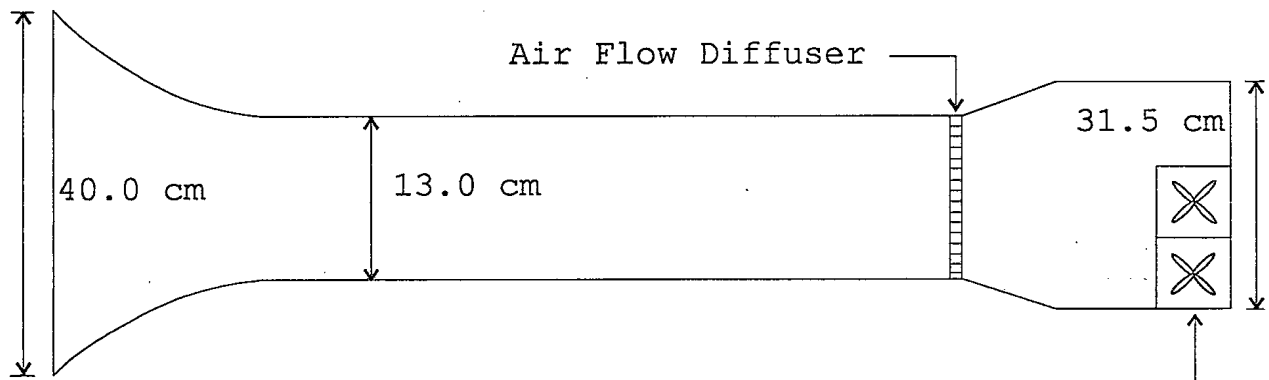
## 5. Conclusions

The water vapour resistance and thermal resistance of eight sample materials was determined using a sweating hot plate, and the results were compared to those obtained by other standard methods. The method used on the sweating hot plate, ISO 11092, included a uniform air flow over the test sample. Differences in results were noted and attributed to air penetration of the samples in the presence of this air flow. Because of the effect air flows have on the determination of water vapour resistance and thermal resistance, sweating hot plate results cannot be directly compared to other standard test methods not using air flows over samples. It was also concluded that the sweating hot plate was not suited to determining the thermal resistance of thin materials.

## References

1. International Organization for Standardization, International Standard ISO 11092, 1993. "Textiles - Physiological Effects, Part 1: Measurement of Thermal and Water Vapour Resistance under Steady-State Conditions (Sweating Guarded-Hotplate Test)", prepared by ISO Technical Committee ISO TC 38.
2. van Beest, C.A. and Wittgen, P.P.M.M., "A Simple Apparatus to Measure Water Vapour Resistance of Textiles", *Textile Research Journal*, , V56(9), 566-568, September 1986.
3. Gibson, P., Auerbach M., Gibla J., Teal W., and Endrusick T., "Interlaboratory Evaluation of a New Sweating Guarded Hot Plate Test Method (ISO 11092)" *Journal of Thermal Insulation and Building Envelopes*, Volume 18, 182-200, October 1994.

# Side View



# Top View

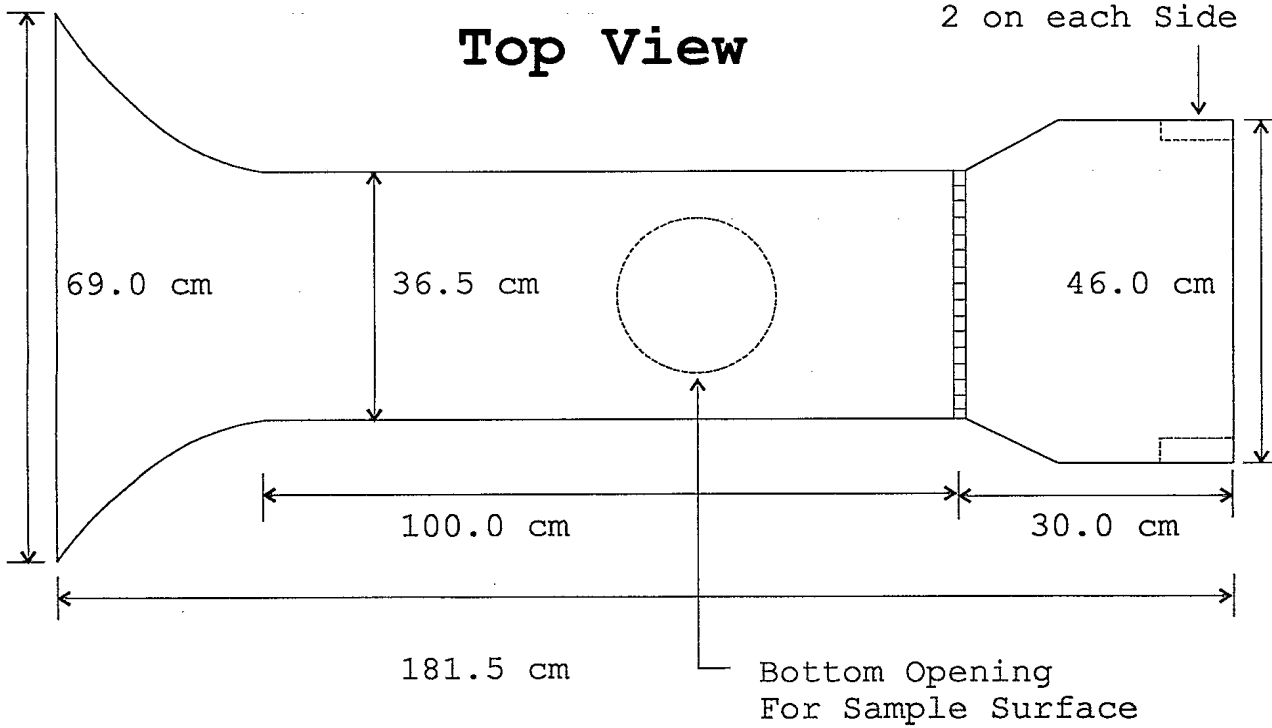


Figure 1: Diagram of the Wind Tunnel

**Figure 2: Air speeds at various positions in the SHP wind tunnel. The error bars are standard deviations.**

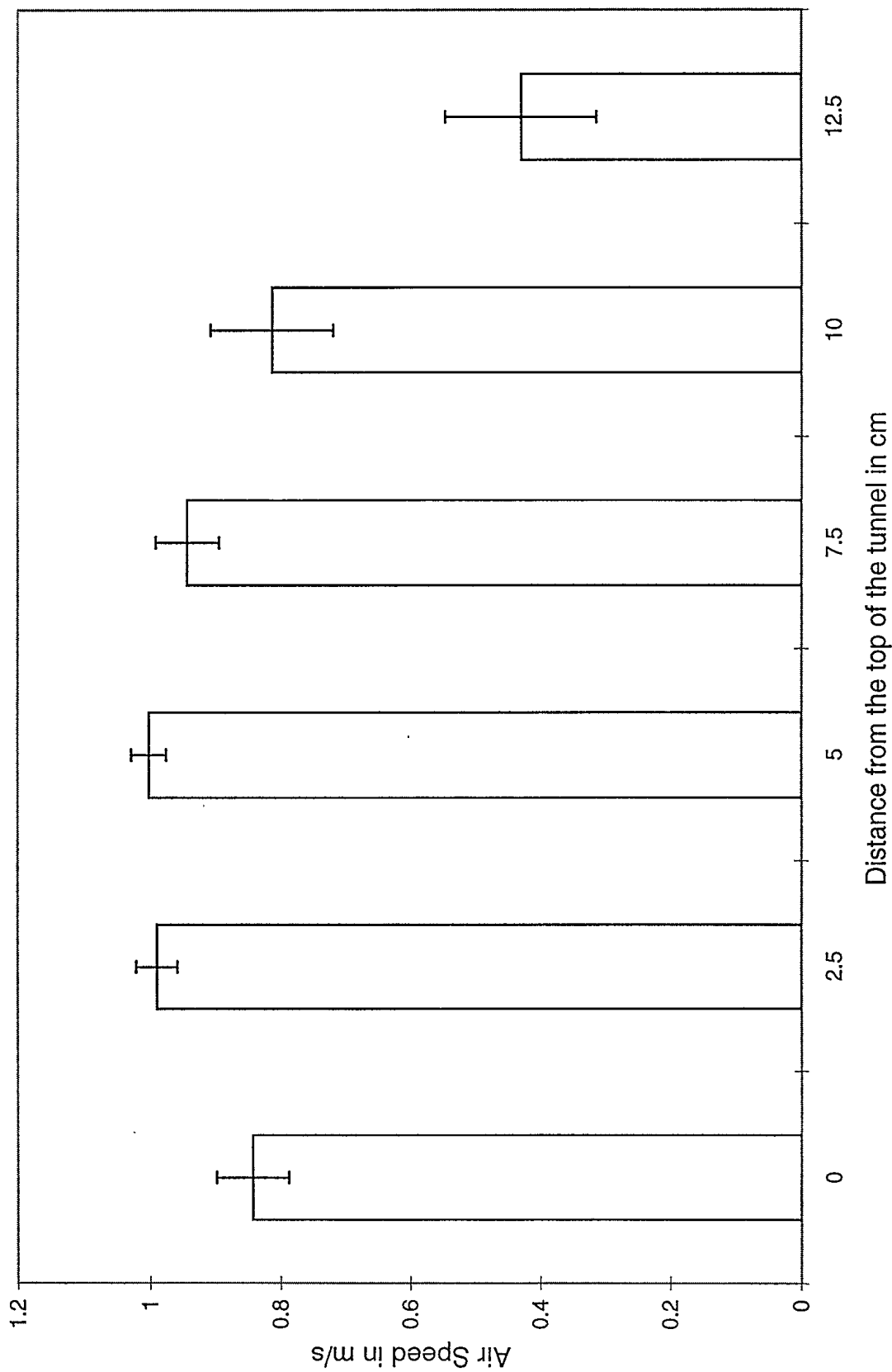
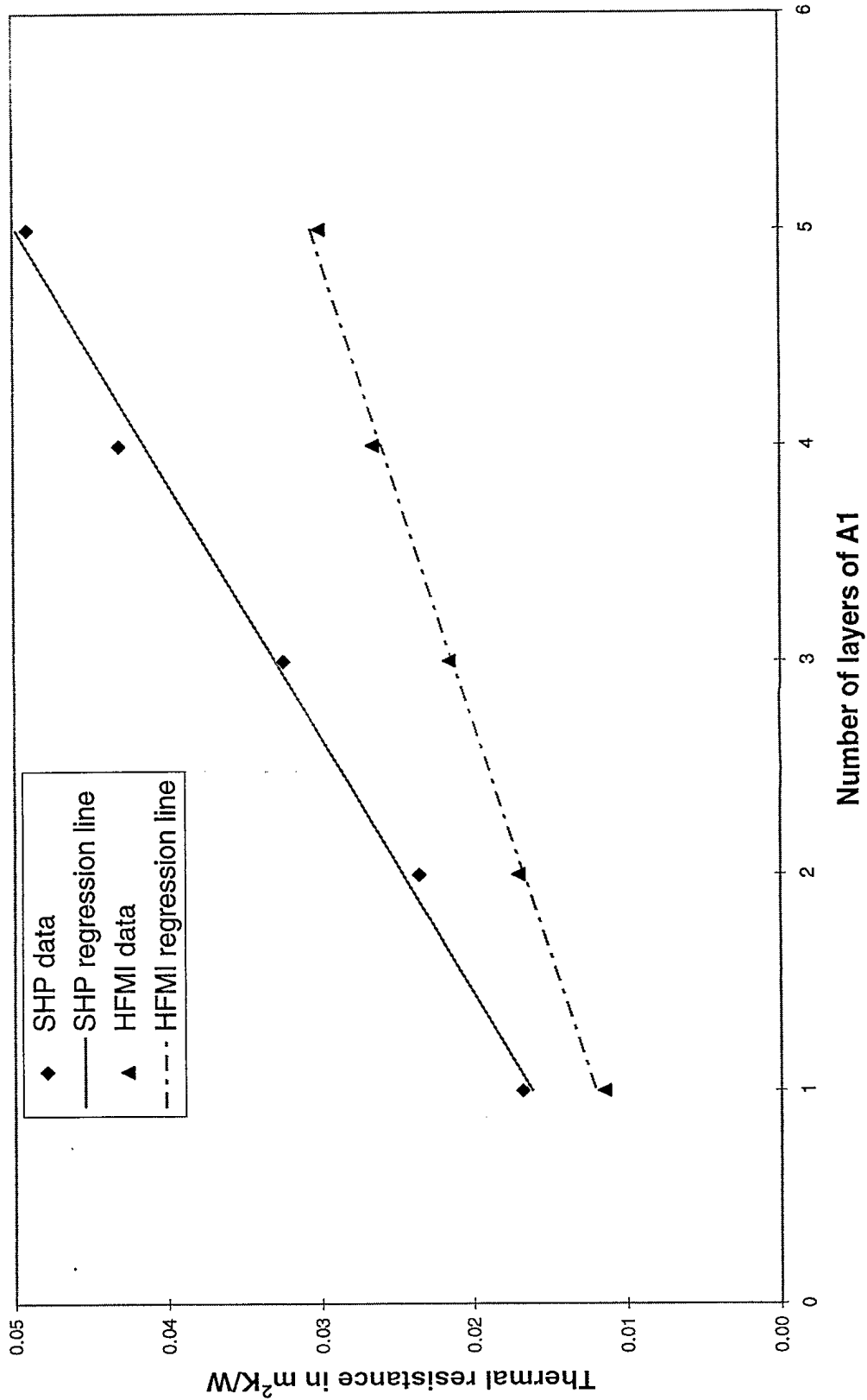


Figure 3: Graph showing the total thermal resistance of from 1 to 5 layers of sample A1, measured by a sweating hot plate (SHP) and a heat flux measuring instrument (HFMI).



**Table 1: WATER VAPOUR PERMEABILITY RESULTS**

*(TST & AT = 35C, RH = 40%, Air Speed = 1 m/s, Sweat Rate = 0.2 g/m<sup>2</sup>/sec)*

<i>Material</i>	<i>Heat Flux (W/m<sup>2</sup>)</i>	<i>Ret total (m<sup>2</sup>Pa/W)</i>	<i>Ret sample (m<sup>2</sup>Pa/W)</i>
No Sample (Ret 0)	336.22	10.02	10.02
Australian Samples			
A1 (Light Wt)	299.82	11.24	1.22
A2 (Medium Wt)	295.49	11.40	1.38
A3 (Heavy Wt)	269.93	12.48	2.46
British Samples			
UK 1 (Fleece)	170.05	19.82	9.80
UK 2 (Thick Insulation)	83.52	40.35	30.33
UK 3 (GoreTex)	203.02	16.60	6.58
Canadian Samples			
Cdn - 1 (Wool)	243.36	13.85	3.83
Cdn - 2 (Batting)	121.00	27.85	17.83

**Table 2: SHP Thermal Resistance Results**

*Test Surface Temperature = 35C, Ambient Temperature = 20C,  
Relative Humidity = 65%, Air Speed = 1 m/s*

	<i>Heat Flux (W/m<sup>2</sup>)</i>	<i>Total Resistance (m<sup>2</sup>K/W)</i>	<i>Sample Resistance (m<sup>2</sup>K/W)</i>
No Sample	241.5	0.062	0.000
<b>Australian Samples</b>			
A1 (Light Wt)	170.2	0.088	0.026
A2 (Medium Wt)	168.9	0.089	0.027
A3 (Heavy Wt)	168.9	0.089	0.027
<b>British Samples</b>			
UK 1 (Fleece)	84.9	0.177	0.115
UK 2 (Thick Insulation)	47.9	0.313	0.251
UK 3 (GoreTex)	176.5	0.085	0.023
<b>Canadian Samples</b>			
C1 (Wool)	131.2	0.114	0.052
C2 (Batting)	71.8	0.210	0.148



**Table 3: Thermal Resistance & Water Vapour Resistance  
Of Samples Determined By Other Methods**

Material	Sample Thickness (mm)	Plate Separation (mm)	HFMI Device		Water Vapour Resistance ( $m^2 Pa/W$ )	VBW Device Sample RH (%)
			@ 20C	Thermal Resistance @ 30C ( $m^2 K/W$ )		
Australia						
A1	0.41	0.3	0.0128	0.0126	2.4	48%
A2	0.48	0.4	0.0128	0.0126	3.7	47%
A3	0.61	0.6	0.0161	0.0159	4.9	47%
British						
UK 1	4.65	4.7	0.132	0.127	5.6	45%
UK 2	35.00	35.0	0.636	0.594	37.4	62%
"		25.0	0.518	0.485	27.6	64%
"		15.0	0.378	0.358	19.4	67%
UK 3	0.48	0.5	0.0169	0.0168	3.1	93%
"					14.6	60%
"					17.4	52%
Canadian						
C1	1.49	1.3	0.0413	0.0404	6.5	54%
C2	12.00	11.9	0.296	0.280	37.5	62%
"		7.5	0.208	0.198	34.2	63%
"		5.0	0.149	0.143	22.3	66%



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A round-robin determination of certain textile properties has been proposed as part of a TTCP PTP3 effort to facilitate the exchange of data between countries using different apparatuses. The objective of the study, Operating Assignment 9, is to see if the measured values of thermal and water vapour resistance of various fabrics are comparable between the SEA Sweating Hot Plate (used by Australia and Canada) and the Hohenstein Sweating Hot Plate (used by the United Kingdom and the United States). Several fabric samples were submitted for testing by each nation taking part in the round-robin tests. All nations tested the samples independently using their own equipment and test methods. The work presented here is a detailed description of the test method used by Canada and the results achieved.

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round-robin test  
water vapour resistance  
thermal resistance  
TTCP  
sweating hot plate



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