Contract No: ENT10819

DS Interweave textiles

Measurement of Heat Resistance of 2 blanket types

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Introduction

Interweave Textiles commissioned manikin measurements for heat resistance for a comparison of 2 blanket types. This report presents the results for these measurements, performed in August 2023.

Methods

For the measurements a thermal manikin 'Newton' was used (Figure 1). The manikin has 32 independent zones (Figure 2) in which heat input or temperature can be controlled and measured. With the skin temperature of the manikin controlled at 34ºC, and a fixed environmental temperature the measured heat loss can be used to calculate dry heat resistance of the clothing. These measurements are described extensively in ISO15831:2004, in ISO 9920 and in ASTM 2370 and 1291. Procedures described in these standards will be followed unless specifically stated otherwise. All heat resistances were calculated using the 'parallel method' as described in the standard. Air speed was set to 0.4 m/s. All measurements were performed in triplicate.

Dry heat resistance

Dry heat resistance of the ensembles was determined in a 20ºC environment at 60% relative humidity (any variations were recorded, and results calculations accounted for these). For the complete ensembles wind speed is set at 0.4 m/s respectively.

$$Dry\ heat\ resistance = \frac{T_{skin} - T_{ambient}}{Dry\ heat\ loss} \quad \left[\frac{Kelvin}{Watt\ \ per\ square\ meter} = m^2.K.W^{-1} \right]$$

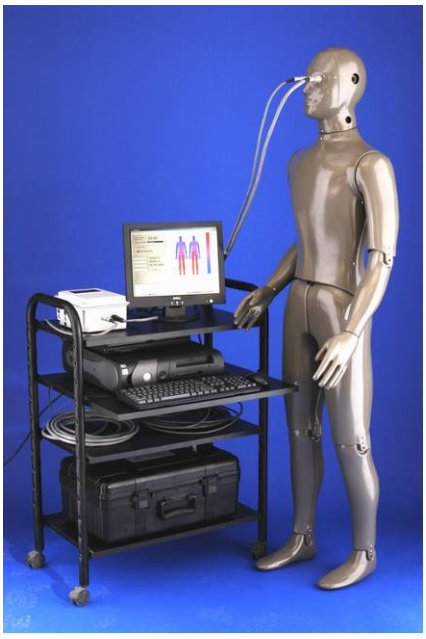

Figure 1, Thermal Manikin 'Newton'.

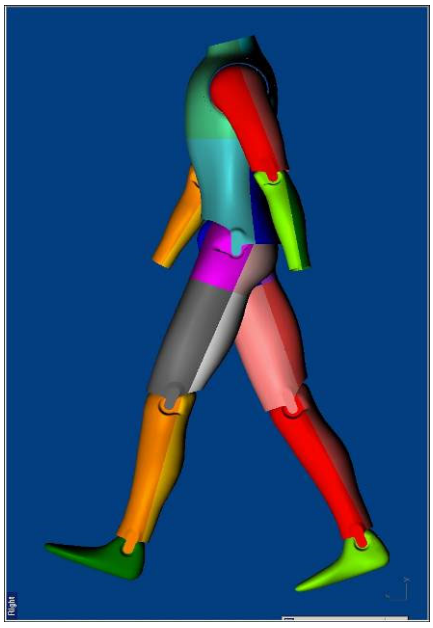

Figure 2, control zone structure of thermal manikin with each colour indicating an individual zone. Head and Face zone not shown.

Clothing description / tests to be performed

Two blanket types were tested: a standard NHS blanket ‘Blue’ and an isolating blanket ‘Thermarmour’. The manikin was for these test placed on a medical examination bench. The blankets were wrapped around the manikin with a snug fit around the neck and fully covering the body including feet. The manikin was nude underneath the blankets.

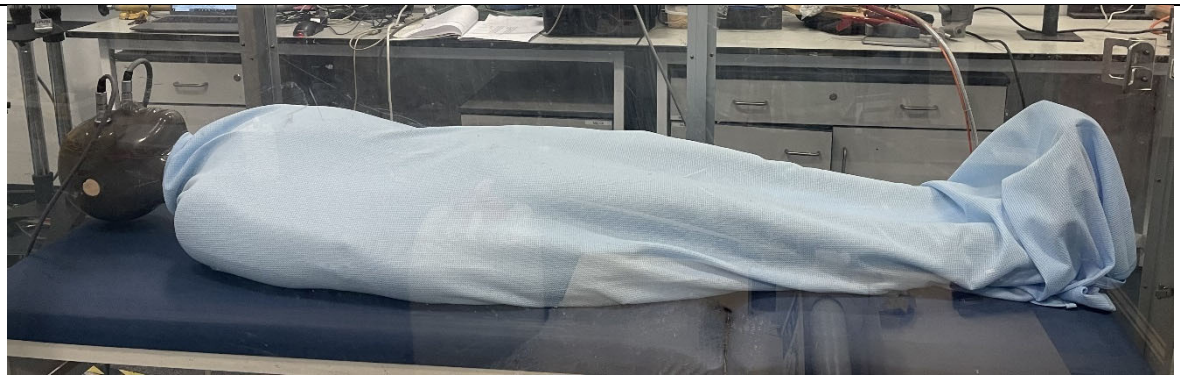

Figure 3, the ‘Blue blanket’.

Figure 4, the Thermarmour blanket, ‘

RESULTS

Manikin Calibration

The manikin was calibrated against other European manikins using two test clothing ensembles as mentioned in ISO 15831. The results are presented in Figure 6. The European average is derived from the results of project 'SUBZERO' which compared 6 European manikins to each other.

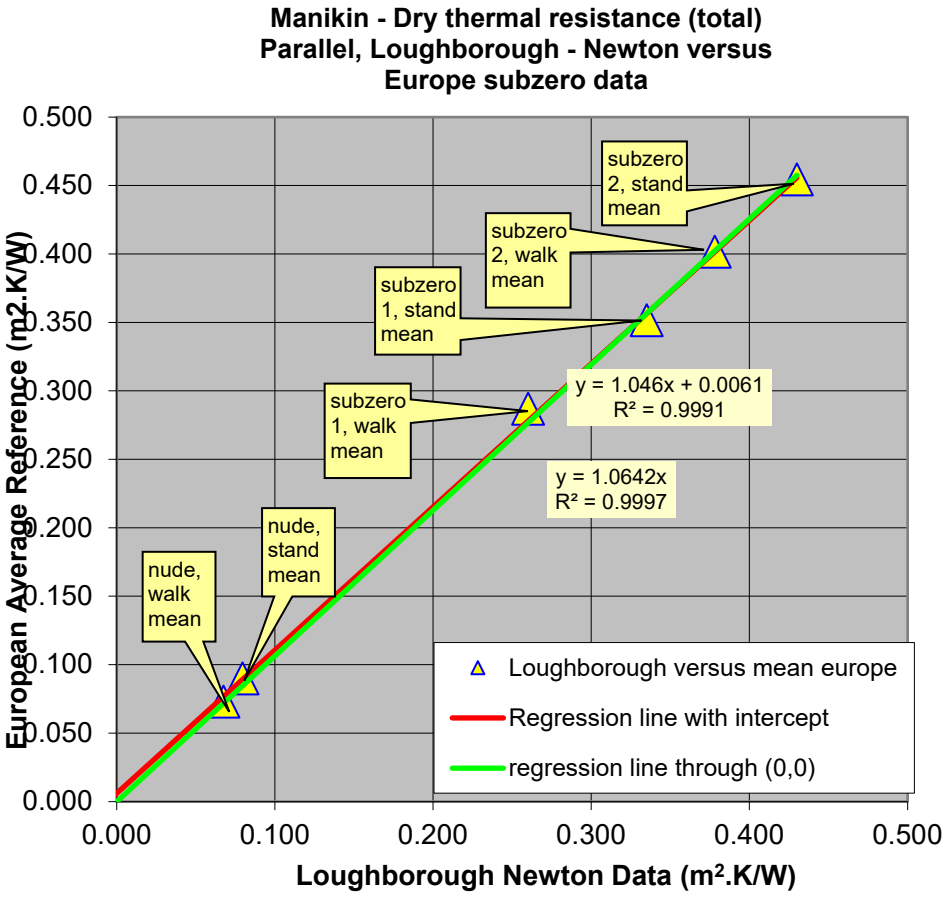

Figure 7, test results for two calibration clothing ensembles on Newton versus results of average European manikin.

In the next pages, results of the measurements will be presented for individual zones as well as for grouped zones. Finally estimates are presented for expected heat losses from individual and grouped zones for the two blankets at 20 ºC. Note that the very high SD's in the back region in Table 1 are due to the very high insulation and therefore very low heat losses of just a few watts in those areas. Small variations have a big impact there, but do not influence the overall results in a relevant way.

Table 1, Heat Resistance (Insulation, in $m^2{}^\circ C/W$) data with standard deviations (showing variations between individual tests on same blanket) for the two blanket types, shown for the whole body and for all zones excluding the head. Equivalent left and right zones are averaged. SD%= standard deviation of the three measurements in percent of the measured value.

Zone	mean heat resistance $m^2{}^\circ C/W$	mean heat resistance $m^2{}^\circ C/W$	heat resistance SD%	heat resistance SD%
	Blue	Thermarmour	Blue	Thermarmour
All	0.224	0.327	2.7	1.2
All-no head	0.255	0.422	2.2	0.8
Face	0.114	0.115	2.4	4.5
Head	0.086	0.084	5.8	1.7
Arm Upper Front	0.194	0.278	7.3	4.9
Arm Upper Back	0.191	0.317	1.9	1.8
Arm Lower Front	0.233	0.391	2.5	0.8
Arm Lower Back	0.288	0.446	4.7	13.2
Hands	0.225	0.384	3.2	2.6
Torso Upper Front	0.158	0.263	2.4	4.5
Torso Upper Back	0.425	0.582	15.0	29.0
Torso Mid Front	0.232	0.375	2.4	6.0
Torso Mid Back	5.585	4.056	26.4	34.0
Torso Lower Front	0.266	0.466	1.4	3.6
Torso Lower Back	1.273	1.499	1.8	20.0
Hip Front	0.164	0.318	2.0	8.4
Hip Back	2.971	3.300	26.3	13.9
Leg Upper Front	0.247	0.520	0.3	4.2
Leg Upper Back	0.487	0.743	6.8	10.9
Leg Lower Front	0.204	0.348	8.3	0.1
Leg Lower Back	0.342	0.492	10.9	9.8
Feet	0.201	0.290	9.4	2.0

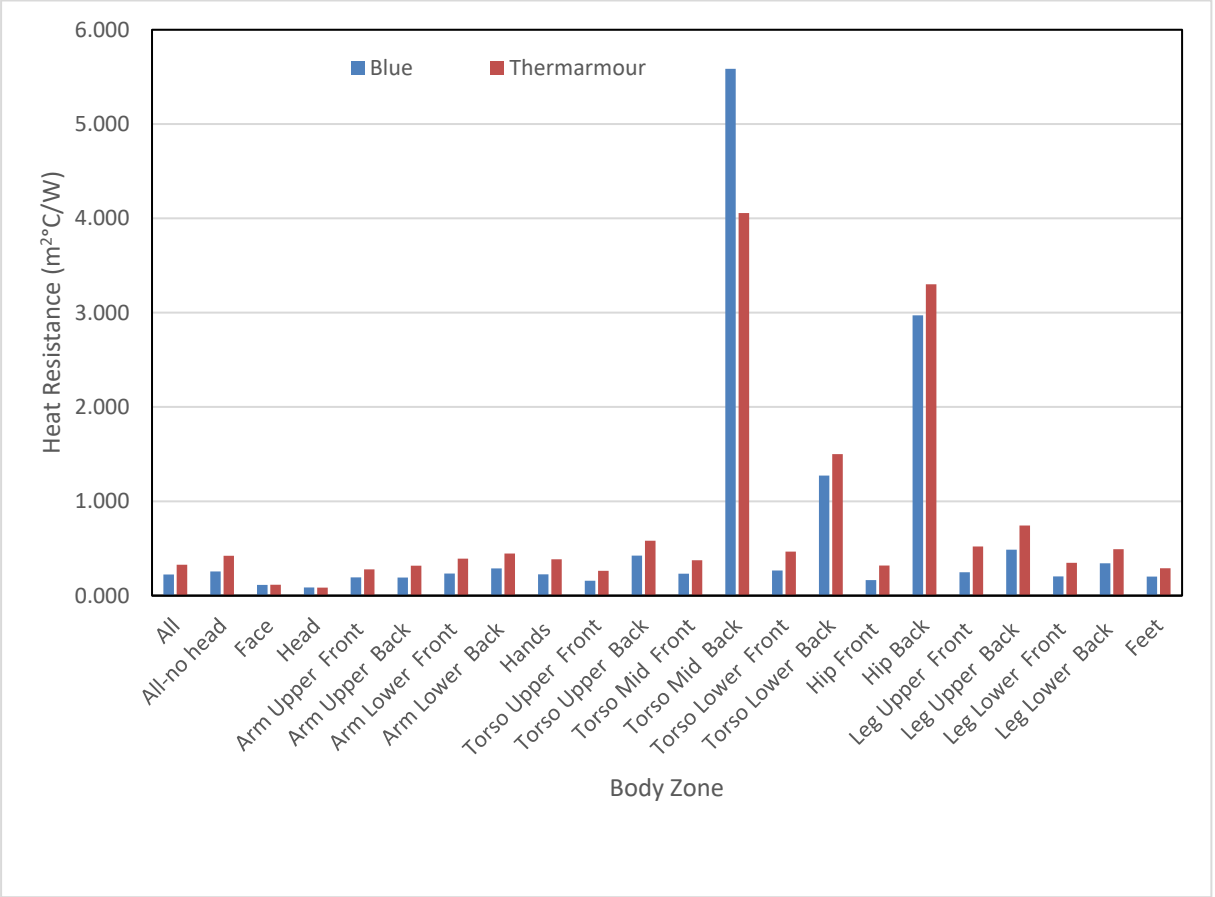

Figure 5, Heat Resistance (Insulation) data for the two blanket types, shown for the whole body and for all zones excluding the head. Equivalent left and right zones are averaged.

Table 2, Heat Resistance (Insulation) data with standard deviations for the two blanket types, shown for the whole body and for all zones excluding the head. Equivalent left and right zones are averaged. SD%= standard deviation of the three measurements in percent of the measured value. Compared to Table 1 and Fig 5, zones are grouped more together.

Zone	mean heat resistance $m^2{}^oC/W$	mean heat resistance $m^2{}^oC/W$	heat resistance SD%	heat resistance SD%
	Blue	Thermarmour	Blue	Thermarmour
All	0.223	0.327	2.7	1.2
All-no head	0.255	0.421	2.2	0.8
Face	0.114	0.115	2.4	4.5
Head	0.086	0.084	5.8	1.7
Hands	0.225	0.384	3.2	2.6
Upper arms	0.193	0.292	5.0	2.8
Lower Arms	0.253	0.410	1.4	5.4
Front Torso	0.201	0.333	2.2	1.5
Back Torso	0.799	1.030	10.4	27.4
Hips	0.256	0.486	1.0	8.0
Upper Leg	0.293	0.576	1.2	5.6
Lower Leg	0.241	0.393	2.7	3.2
Feet	0.201	0.290	9.4	2.0

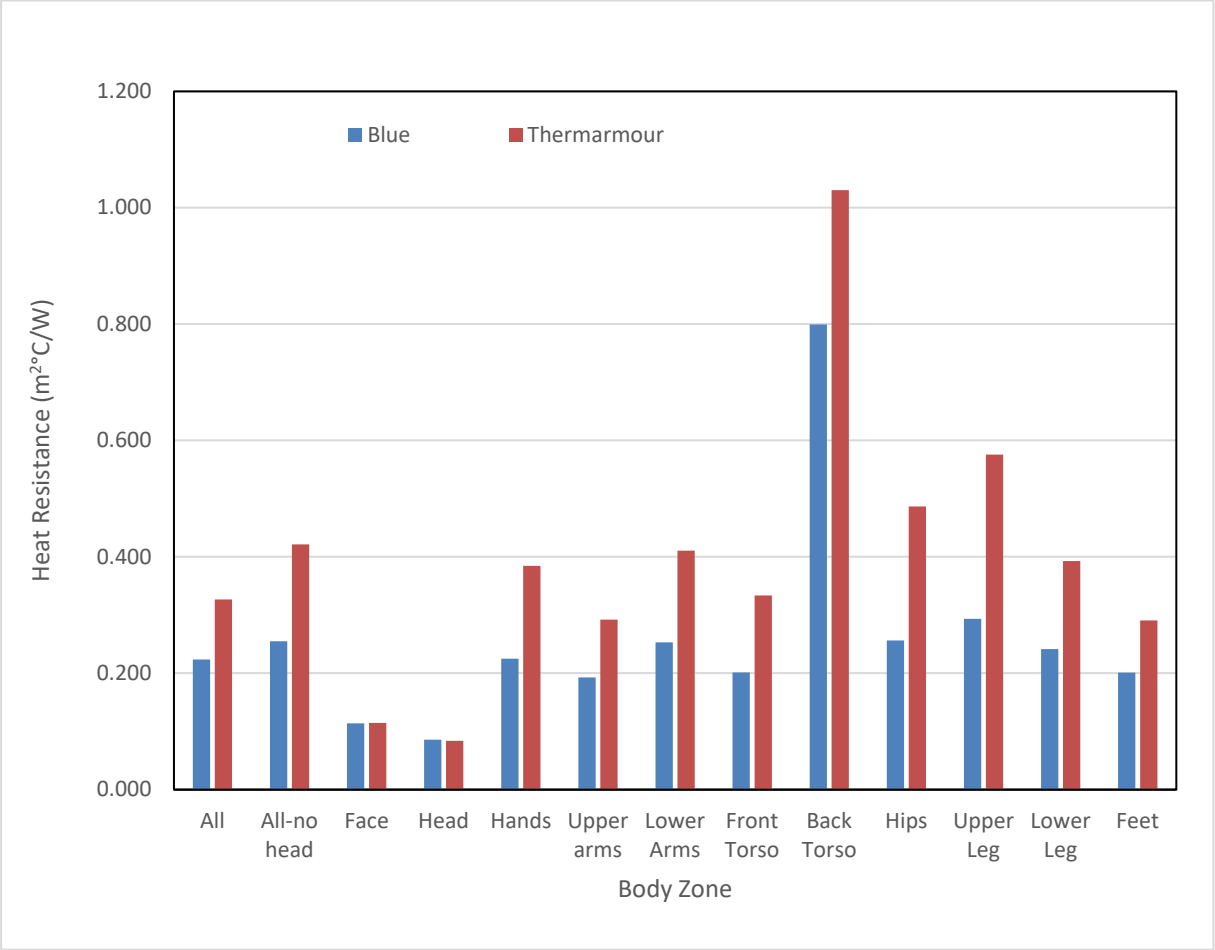

Figure 6, Heat Resistance (Insulation) data for the two blanket types, shown for the whole body and for all zones excluding the head. Equivalent left and right zones are averaged. compared to Table 1 and Fig 5, zones are grouped further together.

Table 3, Heat Resistance (Insulation) data with standard deviations for the two blanket types, shown for the whole body and for all zones excluding the head. Equivalent left and right zones are averaged. SD%= standard deviation of the three measurements in percent of the measured value. Compared to Table 2 and Fig 6, zones are grouped further together.

Zone	skin area (m2)	estimated heat loss (Watt) at 20 degrees C	estimated heat loss (Watt) at 20 degrees C
		Blue	Thermarmour
All	1.81	114	78
All-no head	1.66	91	55
Face	0.049	6	6
Head	0.098	16	16
Hands	0.088	5	3
arms	0.293	19	12
Torso	0.433	20	13
hips+legs	0.731	39	21
feet	0.119	8	6
arms+torso	0.726	39	25

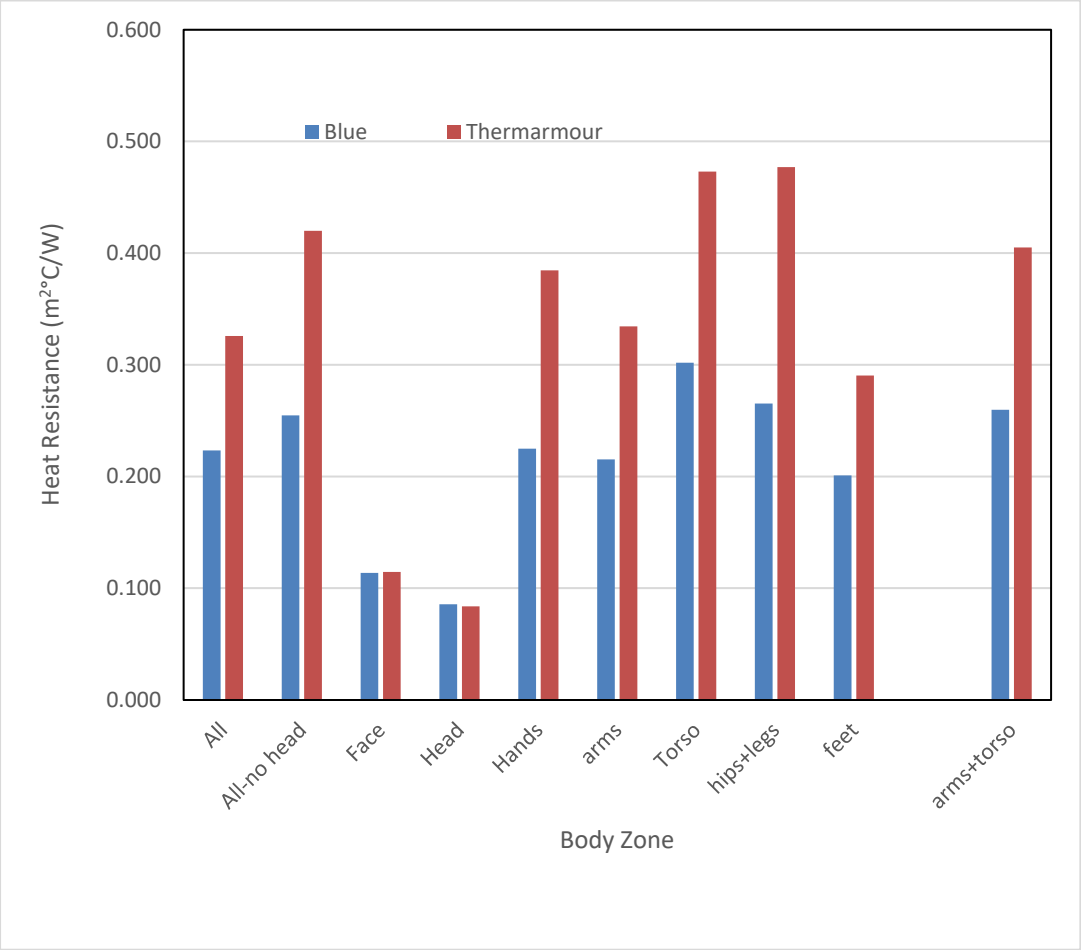

Figure 7, Heat Resistance (Insulation) data for the two blanket types, shown for the whole body and for all zones excluding the head. Equivalent left and right zones are averaged. Compared to Table 2 and Fig 6, zones are grouped further together.

Table 4, Body heat loss values (in Watts) for the whole body, for the body excluding the head, and for different body parts at a temperature of 20 °C.

Zone	skin area (m2)	estimated heat loss (Watt) at 20 degrees C	estimated heat loss (Watt) at 20 degrees C
		Blue	Thermarmour
All	1.81	114	78
All-no head	1.66	91	55
Face	0.049	6	6
Head	0.098	16	16
Hands	0.088	5	3
arms	0.293	19	12
Torso	0.433	20	13
hips+legs	0.731	39	21
feet	0.119	8	6
arms+torso	0.726	39	25

Conclusion

As can be seen in tables 1-3 and figures 5-7, the Thermarmour blanket provided substantially more insulation than the standard blanket This is linked to a substantial lower heat loss from the body as calculated in Table 4: for Thermarmour. With an approximated heat production of a resting person (1.8 meters stature) of around 100 watts, in the Blue, the person will cool down, while in the Thermarmour the person will warm up.

References

1) BS EN ISO 15831:2004 Clothing. Physiological effects. Measurement of thermal insulation by means of a thermal manikin

2) BS EN ISO 9920:2003 Ergonomics of the thermal environment. Estimation of the thermal insulation and evaporative resistance of a clothing ensemble

3) ASTM F1291-16 Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin

4) ASTM F2370 – 16 Standard Test Method for Measuring the Evaporative Resistance of Clothing Using a Sweating Manikin1