

The importance of comfort in over water flight suits

Robin Foulkes

W.L.Gore & Associates

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Agenda

- Physiological Comfort measurement & prediction
- Comfort impact on performance
- Moisture Vapour transport in over water flight suits
- Summary

Methods of garment evaluation : textile properties to performance

According to:



Level Four: Controlled and limited Field test



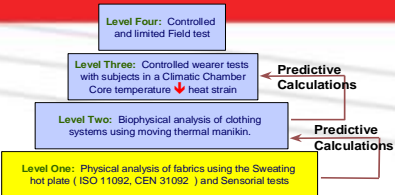
Level Three: Controlled wearer tests with subjects in a Climatic Chamber
Core temperature - heat strain

Predictive Calculations
Physiological /
empirical models

Level Two: Biophysical analysis of clothing systems using moving thermal manikin
Ventilation measurements.

Predictive Calculations
clothing models

Level One: Physical analysis of fabrics using the Sweating hot plate (ISO 11092, CEN 31092)
Total Heat Loss, Permetest, Baselayers- sensorial tests

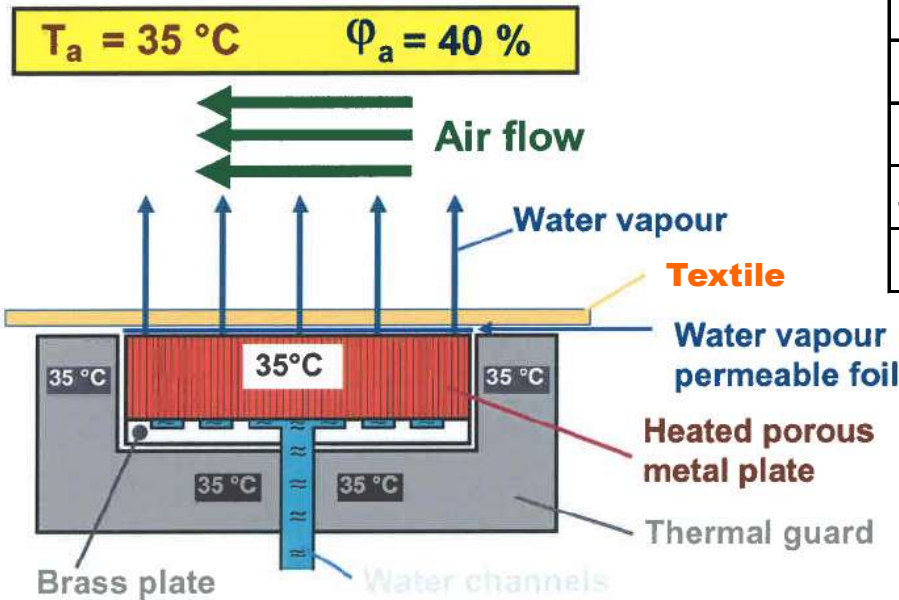


ISO 11092 (Skin Model)

Evaporative, (Ret), and thermal resistance, (Rct), measurement

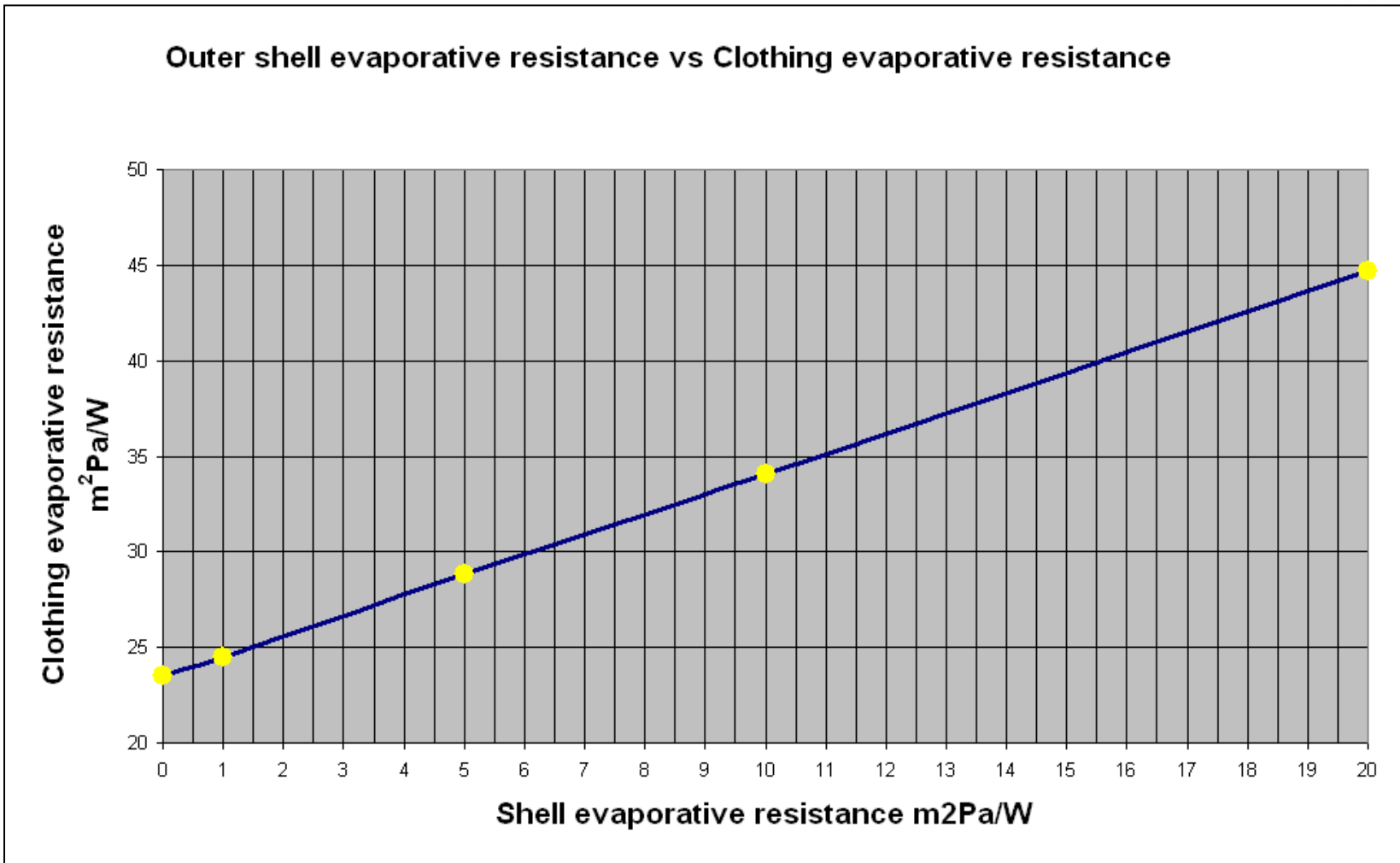


• **Ret:**
Resistance to evaporative heat transfer- the smaller the value, the more water vapour permeable the fabric.



Rating	Ret [m ² ·Pa / W]
Extremely Breathable	<6
Highly Breathable	6 to 13
Satisfactory	13 to 20
Unsatisfactory	>20

Can estimate:
Clothing evaporative resistance from the outer textile
Ret



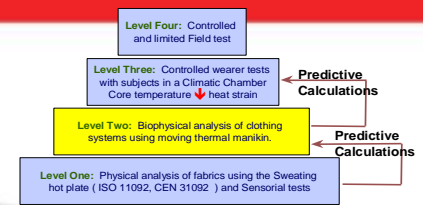
Level 2 Manikin testing



- Life size manikin
- Heated
- Articulated
- Measurement of thermal insulation
- Measurement of evaporative resistance on sweating manikins.



Instead of a complete manikin, body parts can be used, in this case a torso.



Level 3 Human subject testing in climatic chambers



- Measurement of physiological effect of clothing
 - thermal strain
 - core body temperature
 - work rate
 - tolerance time etc.



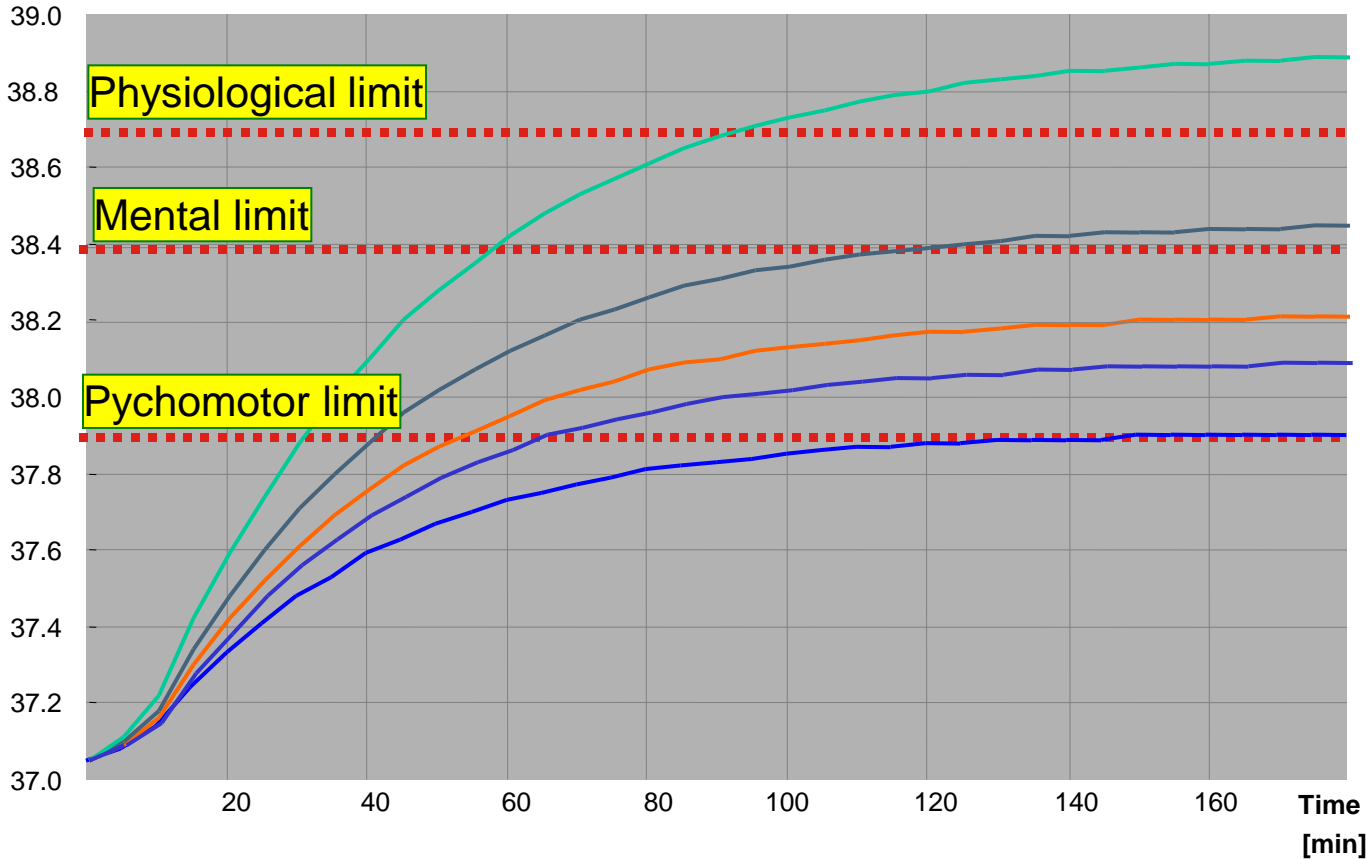
Influence of shell Ret only on heat strain

Garments with lower shell Ret (higher MVP) reduce heat strain



Predicted Core Temperatures for different Shell Fabric Ret for same activity

Body temperature [Tr in °C]



- varying fabric Ret
- Long Underwear + Rain suit
- Ambient 10°C / 80%
- Activity level 450 W

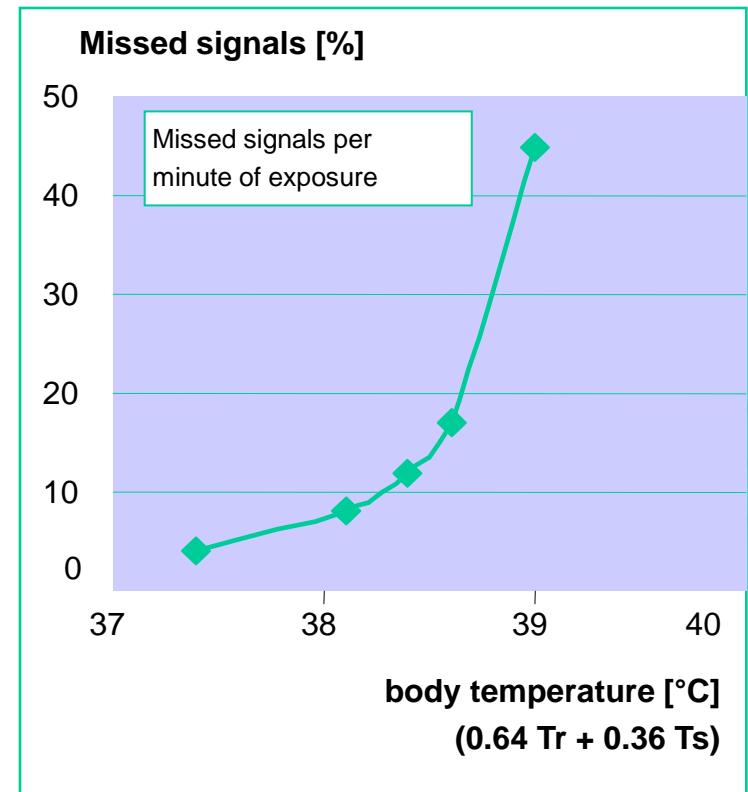
Source: GORE simulation based on Hohenstein physiology model

Ret 5 Ret 10 Ret 13 Ret 20 Ret 40

Heat Stress Attenuates Vigilance

• Analysis of literature on vigilance and thermal strain

- » **Goal:**
understand the influence of thermal stress on vigilance
- » auditory signal detection while walking on a treadmill in different temperature conditions
- » **Finding within this study**
Increasing body temperature impairs attention and vigilance



Even Slight Discomfort Reduces Mental Performance

• Performance influence of sleeves with different comfort

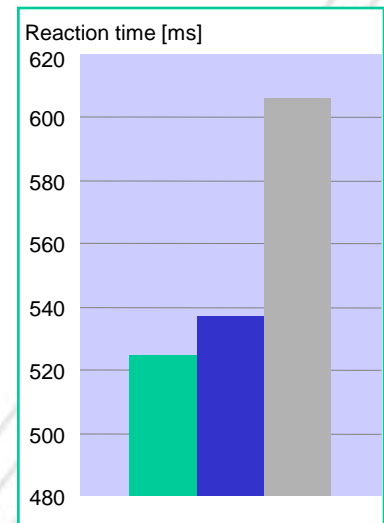
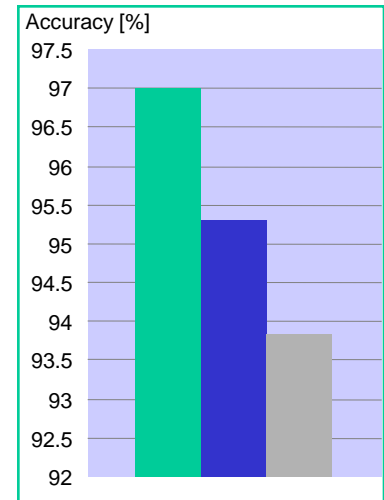
–» **Goal:**




investigate the influence of slight discomfort on cognitive ability

–» computer tasks designed to relate to military tasks

–» **Finding within this study**

Less comfortable sleeves showed negative influence on reaction time and accuracy



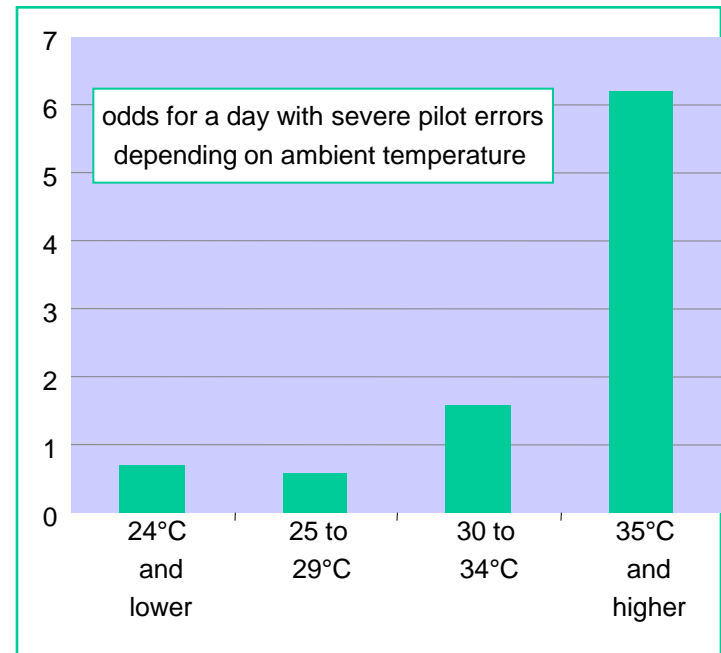
-  naked arms
-  cotton sleeves
-  woollen sleeves

–Source: R. Bell, Relationship Between Clothing Comfort And Performance: Implications For The Future Warfighter, Natick Soldier Center

Helicopter Pilots with heat strain more likely to crash

• Study of helicopter pilot errors in Israel

- » **Goal:**
show relevance of laboratory heat stress tests for the field
- » temperature distribution of days with and without accidents and near miss occurrences
- » **Finding within this study**
Higher heat strain on hot days increases significantly the chance of severe pilot errors



Heat Strain degrades Decision Making

•Heat effects on mental performance

» “Performance changes ... in highly motivated heat stressed subjects include:

» **higher error rate**

» **narrowed attention with neglect of secondary tasks**

» **diminished capacity for learning or response to unusual events**

» **shorter simple reaction time”***



Stress Levels and Adaptability

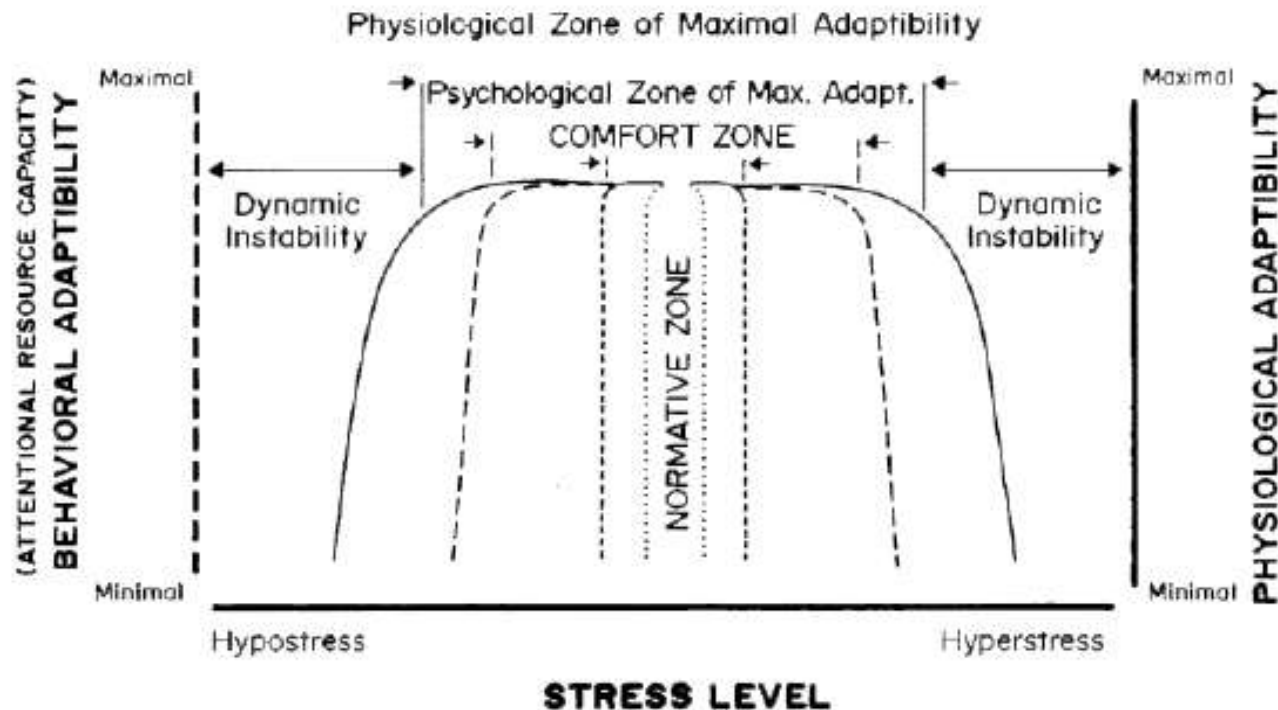


Figure 8: *The Hancock and Warm Model for Maximal Adaptability. From Hancock, P.A., & Warm, J.S. (1989). A dynamic model of stress and sustained attention. Human Factors, 31, 519-537.*

Thermal Discomfort Is Sign of Heat Strain

• Core temperature and warm sensation

» Goal

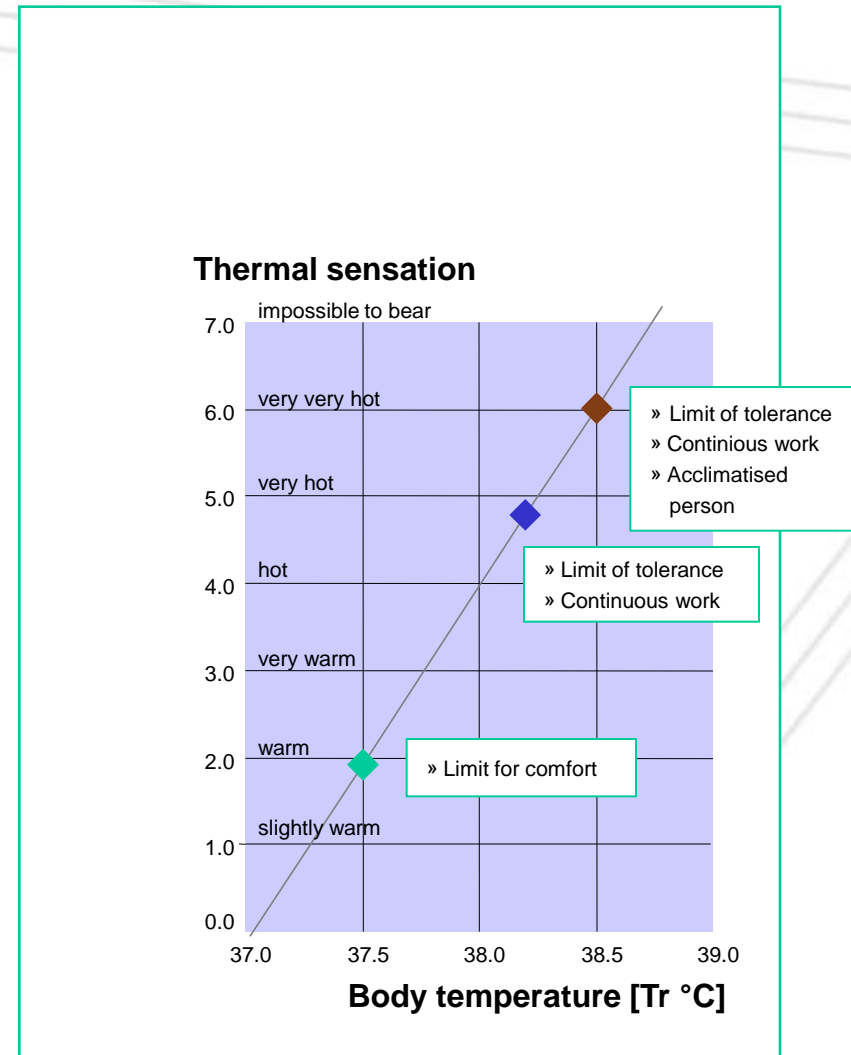
build a clothing evaluation system for wear comfort

- » extensive skin model testing
- » manikin testing and
- » climatic chamber trials with a wide variation

– of textiles and clothing

–» Finding within this study

Thermal discomfort sensation is directly correlated with heat strain and body temperature

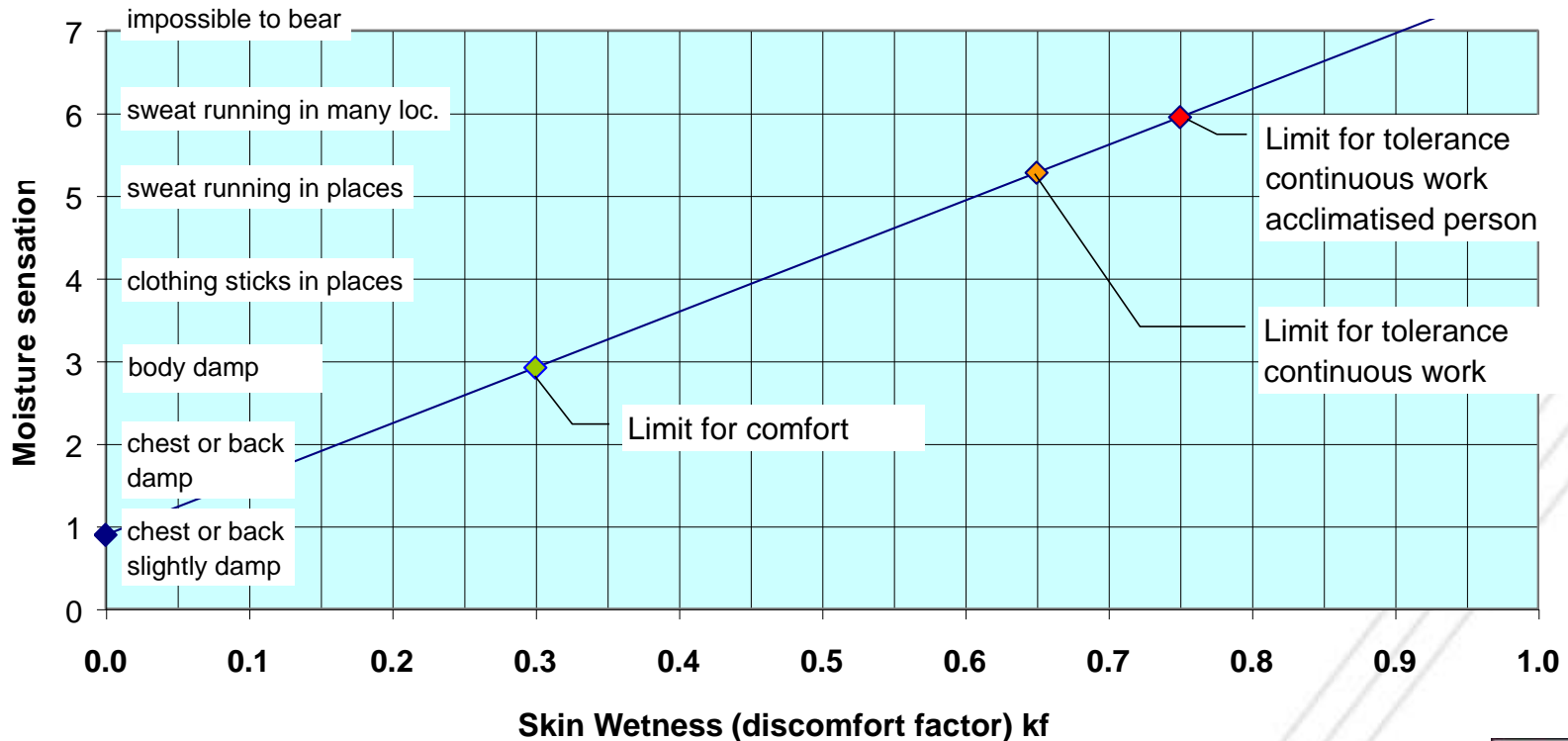


Skin Wetness and Moisture Sensation

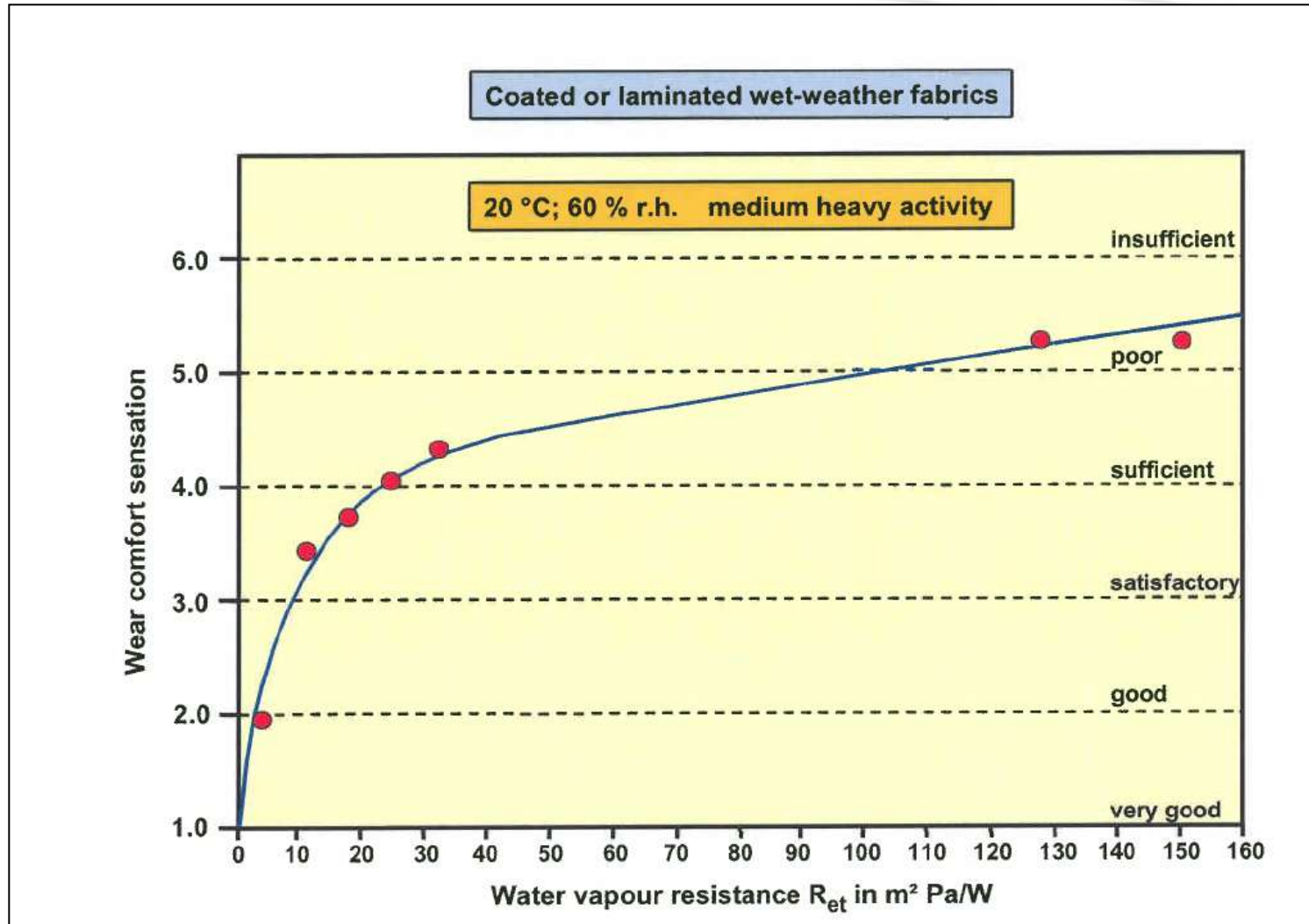
Skin Wetness and Moisture Sensation

In situation of heat strain

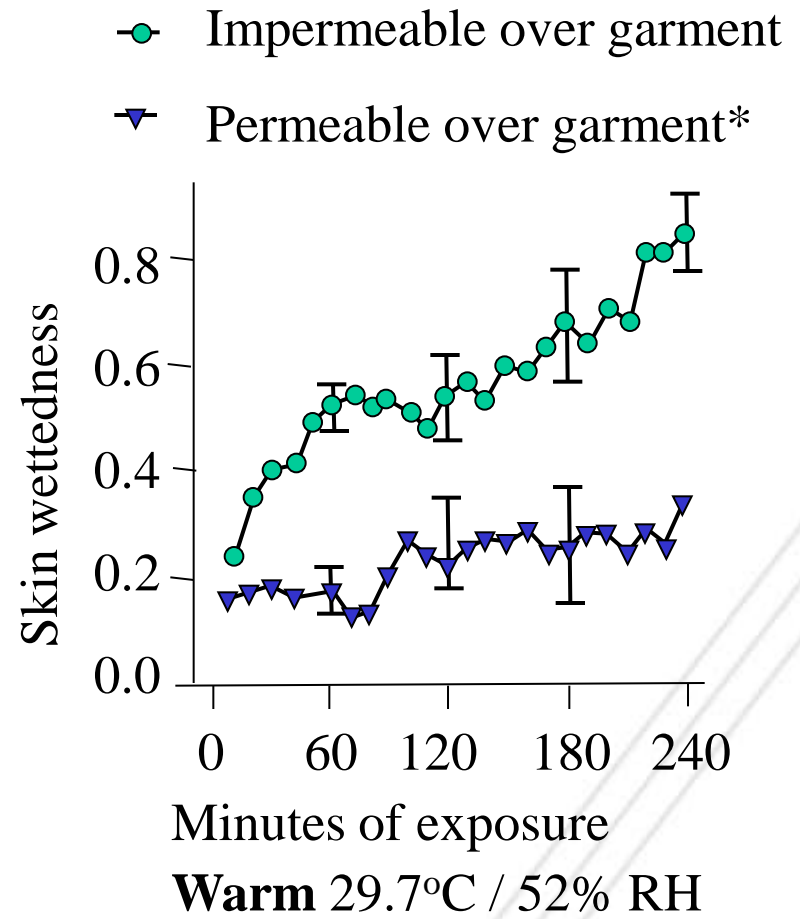
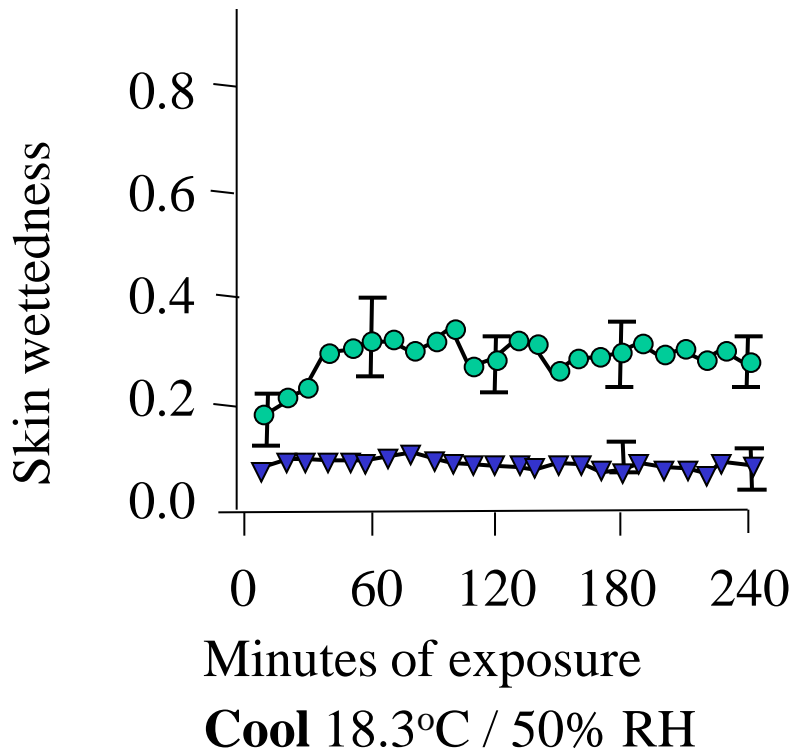
Source: Hohenstein report AIF 4827 - 1984



The water vapour resistance as measured on the skin model is directly related to wearer comfort.



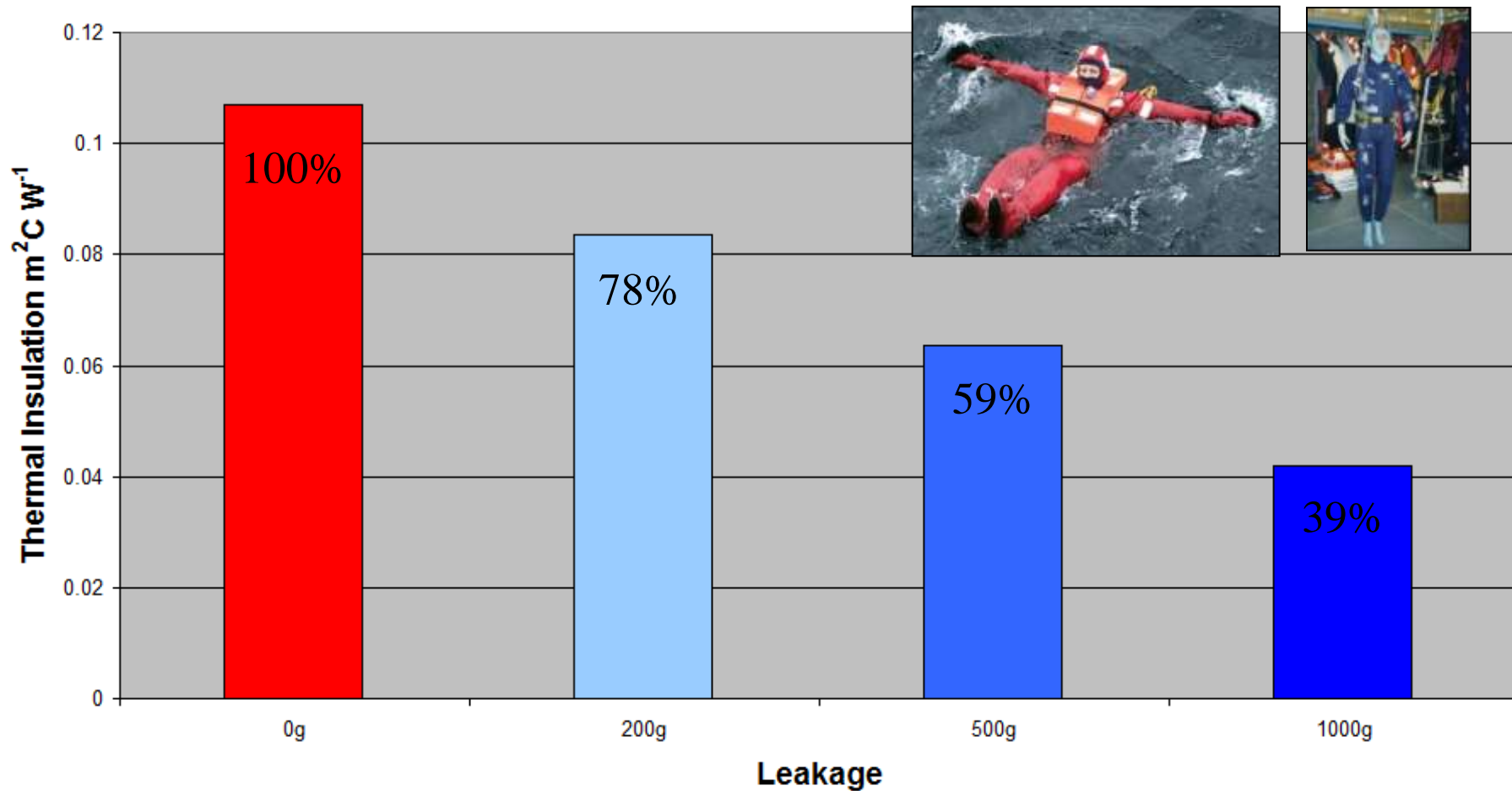
Effects of Wearing Impermeable and Permeable Protective Clothing on Thermoregulatory Responses While Sedentary



Tipton : The effect of leakage in Survival suits

Insulation of Immersion suits with leakage

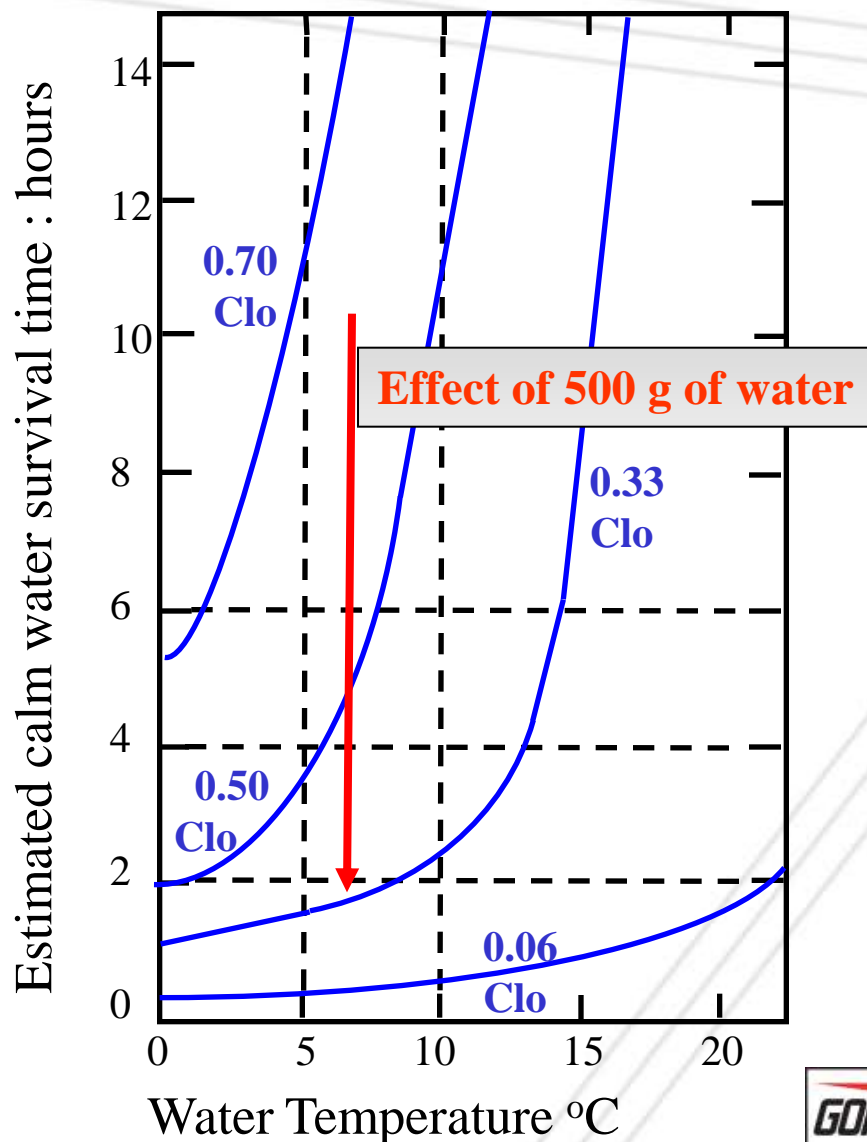
Tipton 1997 The effect of water leakage on the protection provided by immersion protective clothing worn by man HSE



The consequence of that reduction in insulation – survival time after immersion.

Model estimates time to cool deep body temperature (arterial) of 34°C for 10th percentile thin individuals plotted against water temperature

If an immersion suit is partially open then risk of death is significant increased



Summary

- Higher moisture vapour permeability in immersion suits
 - increases performance
 - lowers sweat rates
 - Wet/Damp insulation reduces survival time in cold water
 - Causes leakage or sweat
- Important features in over water flight suits
 - High moisture vapour permeability
 - High Durability