

Not all Waterproof, Windproof Breathable Membranes Are The Same

Technical information

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Agenda

- Uses & Needs
- High Breathability is Important
- Membrane Chemistry Structures
- Lamination
- ePTFE Laboratory & Field Trial Result
- Durability & Cost implications

Uses & Needs of Waterproof Breathable Garments (Membranes)

- Over water flight suits, OWFS
- Immersion suits
- Waterproof jackets and trousers
- Bivy bags (used in survival packs)
- Gloves
- Boots
- Waterproof
- Windproof
- Highly Breathable
- Durable



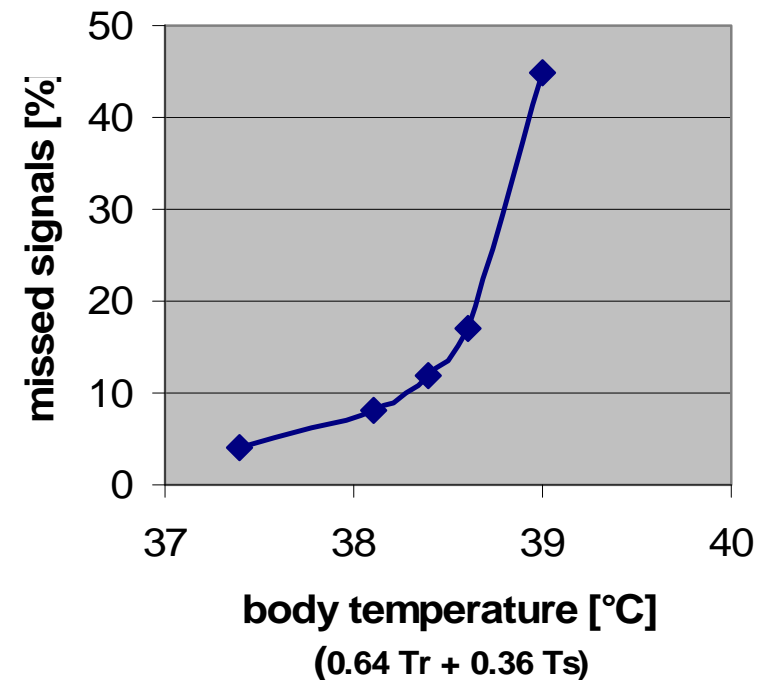
Moisture Vapour Transport (Breathability) is Important

- The body thermo regulates
 - Vasoconstriction in cold
 - Vasodilation and sweating when hot
- High moisture vapour transport supports sweating to cool body
- When cooling is not enough, core body temperature rises leading to **heat stress**
- **Evaporating** 1 litre sweat per hour = 670 W heat loss
 - Clothing hinders sweat evaporation
 - more moisture vapour transport in clothing more cooling by sweating
- Measured as evaporative resistance of a textile (Ret)

Heat stress diminishes vigilance

- Analysis of Literature on vigilance and thermal stress
 - goal: understand the influence of thermal stress on vigilance
 - auditory signal detection while walking on a treadmill in different temperature conditions
 - increasing body temperature impairs attention and vigilance
 - Source: Hancock, Sustained Attention under Thermal Stress, Psych. Bul. 1986, Vol. 99, No 2, p 263ff, data from Benor and Shvartz, 1971

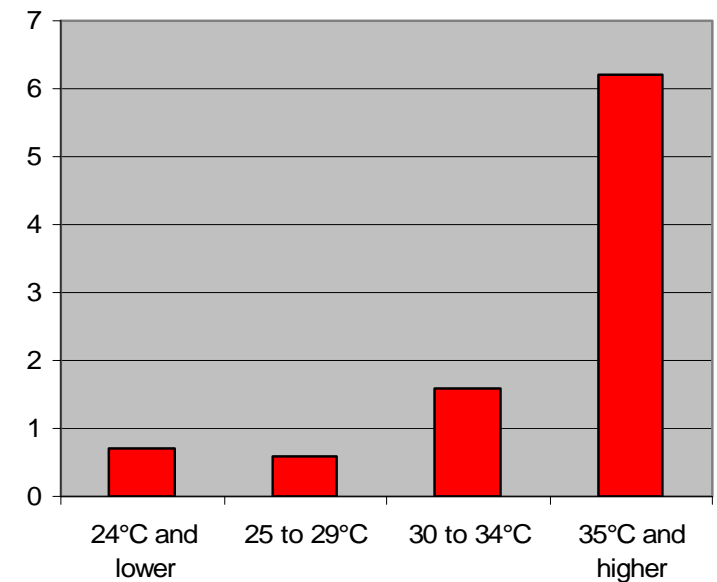
Missed signals per minute of exposure



Heat stressed helicopter pilots more likely to crash

- Study of severe 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
 - higher heat stress on hot days increases significantly the chance of severe pilot errors
 - source
Froom et al, J. o. Occ. Med., Vol. 35, No 7, 1993, p 271 ff

odds for a day with severe pilot errors depending on ambient temperature



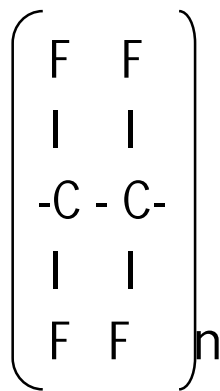
Heat stress Summary

- “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”
 - Source: USAF Flight surgeons guide chapter 5
- Higher breathability reduces heat stress



Polytetrafluoroethylene (PTFE)

- Uses in everyday materials- plumbers tape to non-stick frying pans



Molecular Structure

Long chain polymer



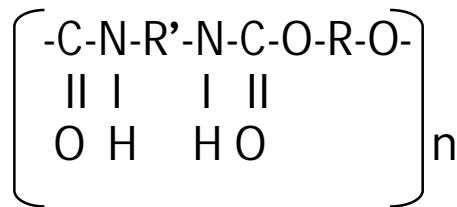
Unique attributes – PTFE

- Chemically resistant, inert
 - Naturally non-reactive with other chemicals
- Temperature stable -200 to +260 °C
- Very low surface energy
 - water beads on surface
- Expanded ePTFE very open structure
 - Highly breathable

Polyurethane (PU)

- Uses in everyday materials - Paints to packaging foams

Molecular Structure



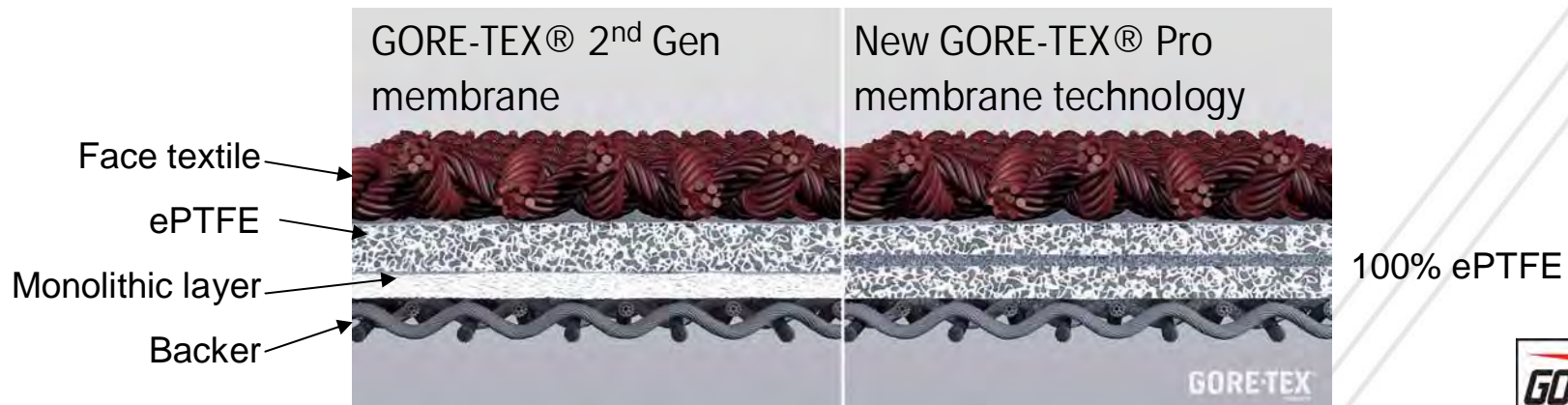
Long chain polymer

Typical Attributes – Polyurethane

- Temperature stable to ~120°C
- Properties dictated by raw material
- Thin membrane –
 - highly breathable
 - waterproofness low - leaks early
- Thicker membrane,
 - waterproofness Good
 - Breathability low
- Trade off
 - durability or breathability

Not All ePTFE Membranes the Same

- 1st generation ePTFE membranes
 - Initially waterproof, leak with little use
 - basis of WINDSTOPPER® membranes
- 2nd generation ePTFE
 - Large differences in performance for breathability and durability
 - Gore has a wide range of 2nd generation ePTFE
 - Covers different uses and needs
 - Resistance to contamination e.g. Oils, fuels, insect repellent (DEET).



Lamination

- Membranes laminated to textiles with adhesives
 - Too much glue –
 - low breathability
 - Too little glue
 - likely to delaminate
 - Different textiles and membranes laminate differently
- Typically membrane suppliers don't laminate

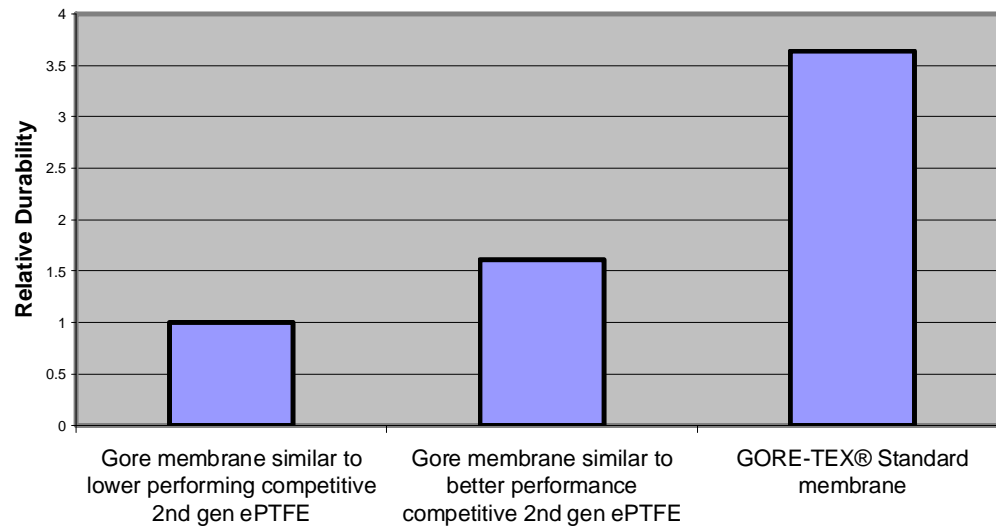
Seam Sealing

- Seam sealing weak point in garments
- Gore only company to make membrane, laminate seam tape, seam sealing machines & provide production settings
- Gore product support ensures garments correctly manufactured



GORE-TEX® membranes are More Durable

Indication of Relative Membrane Durability

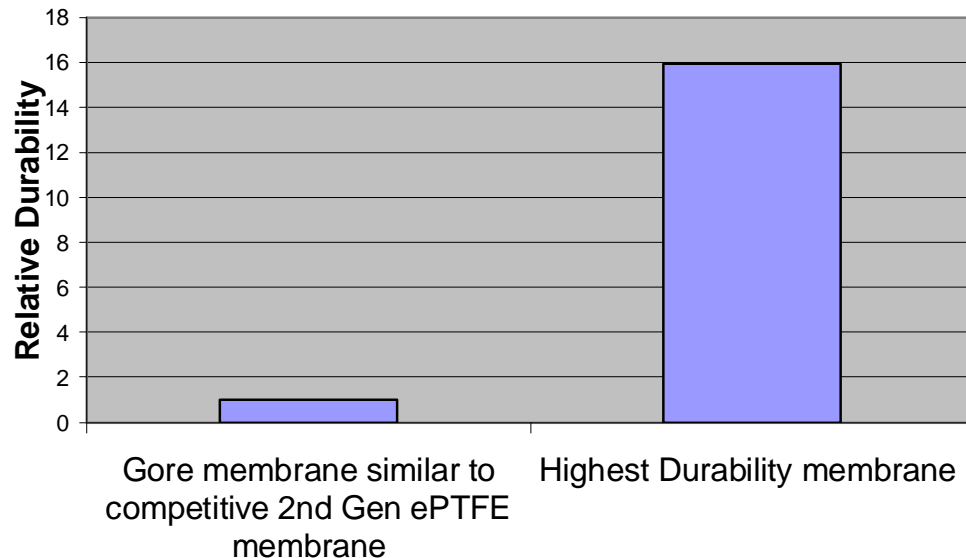


Gore uses specialist membranes in Aircrew products due to high performance requirements

- Results for 2nd generation ePTFE membrane
 - ePTFE with monolithic layer
 - Based on several internal Gore lab tests
 - Representative of different membranes seen in the market
 - Based on laboratory tests linked to field use
- GORE-TEX® membranes are different to competitive membranes
- Durability has a big impact on whole life costs

Real Field Test Data

Field trial Comparison



- Based on a field test looking at leakage
- High durability membranes are used in GORE-TEX® Aircrew products,
 - including highest durability membrane shown
- Gore understands failure modes
 - Hence can design durability & breathability of membranes

Durability & Cost implications

- Last slide showed field test with 16 times longer life for GORE-TEX® garment
 - Same membrane as used in some air crew garments
 - Assume a GORE-TEX® OWFS costs **€800**
 - Suit made from competitive membrane
 - Theoretically to equal life cycle cost price = **€50** (50 x 16 = 800)
- From lab tests results shown a GORE-TEX® suit will last over twice as long a competitive garment
 - Suit made from competitive membrane
 - Theoretically to equal life cycle cost price = **€220 – 355**
- Does not account for
 - Transport, storage, extra planning , buying cost
 - Assumes seam sealing is durable
 - Does not account for damaged garments not repairable

Summary

- Durable garment breathability, waterproofness combination of membrane & seam sealing
- Data shows significant durability differences in membrane performance
- GORE-TEX® membranes optimised for Breathability, Durability & Whole life costs
= End User Performance



“Our products will do what we say they will do!”

Bob Gore

