



# Thermoregulation and Physiological Performance of Protective Apparel

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I.T.S. 116<sup>th</sup> Scientific Session  
April 3, 2017



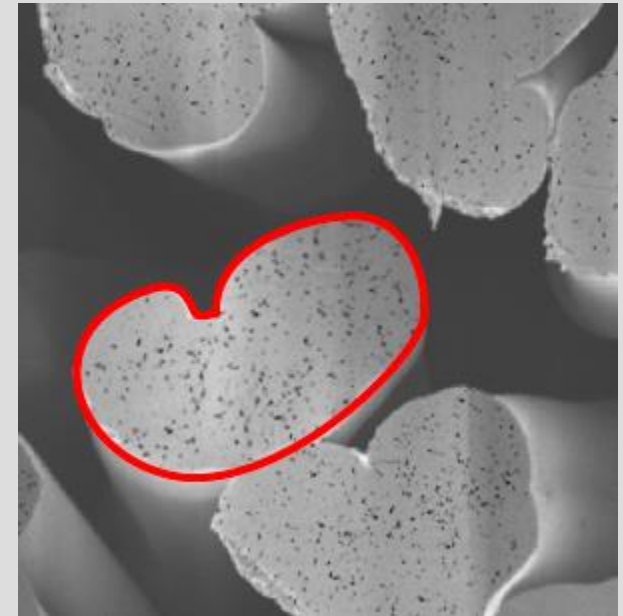
# THE HEAT PROTECTION FIBER



# What is Lenzing FR<sup>®</sup>?



Lenzing FR<sup>®</sup> is a  
Modal based  
inherently flame resistant  
cellulosic fibre.



Lenzing FR<sup>®</sup> Fiber Cross - Section

# Applications



Fire Service



Military\*/Police



Motor Sports

# Applications



Metal Industry



Oil/Gas Industry

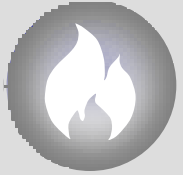


Electrical Utilities

# Key Attributes



Greenest High Performance Fiber



Higher TPP properties



Better Physiological Performance

# Physiological Performance



A study was conducted to assess and quantify the influence of protective clothing on physiological performance and thermoregulation (heat stress) during physical exertion.

# Methods of the study



- 18 fit volunteers
- 4 Test materials: long underwear + coverall
- Constant climate conditions in a climatic chamber (35°C)
- Same Workload Protocol on stationary bicycle

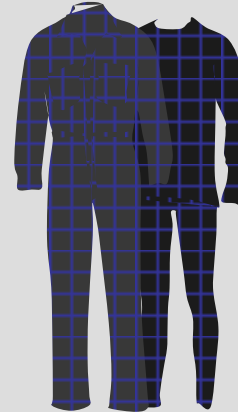
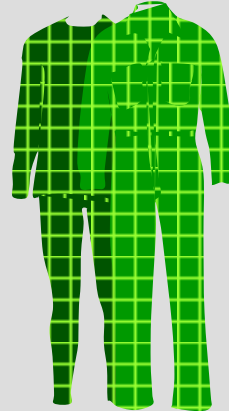


# 4 Test Materials



## Lenzing FR® Blend

**Woven: 250g/m<sup>2</sup>**  
**Finishing Fluorocarbon**  
**Knit: 240g/m<sup>2</sup>**  
**TOTAL WEIGHT: 490g/m<sup>2</sup>**

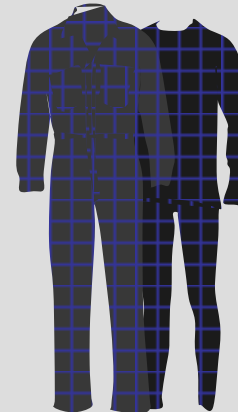
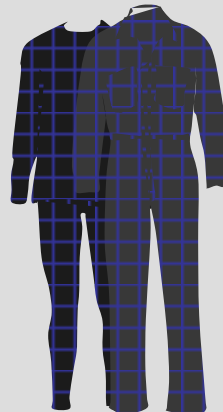


## Modacrylic/Cotton

**Woven: 250g/m<sup>2</sup>**  
**Finishing Fluorocarbon**  
**Knit: 210g/m<sup>2</sup>**  
**TOTAL WEIGHT: 460g/m<sup>2</sup>**

## Aramid

**Woven: 260g/m<sup>2</sup>**  
**Finishing Fluorocarbon**  
**Knit: 200g/m<sup>2</sup>**  
**TOTAL WEIGHT: 460g/m<sup>2</sup>**



## FRT Cotton

**Woven: 280g/m<sup>2</sup>**  
**Finishing Fluorocarbon**  
**Knit: 200g/m<sup>2</sup>**  
**TOTAL WEIGHT: 480g/m<sup>2</sup>**

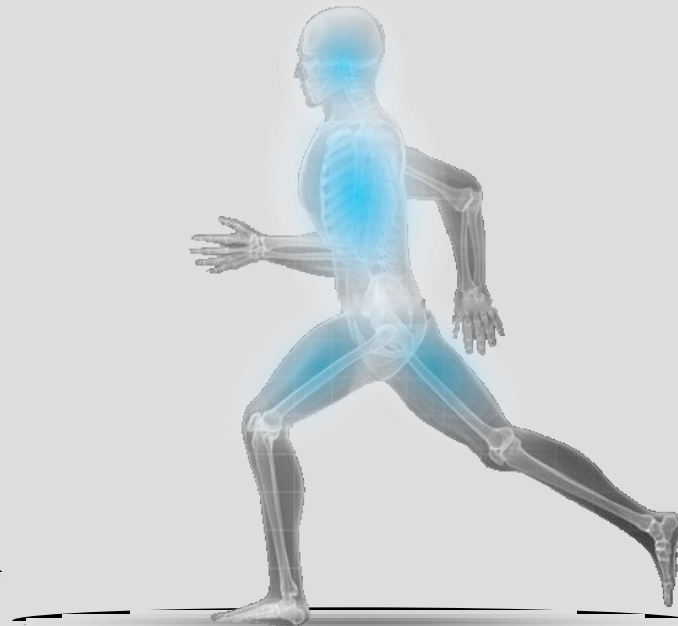
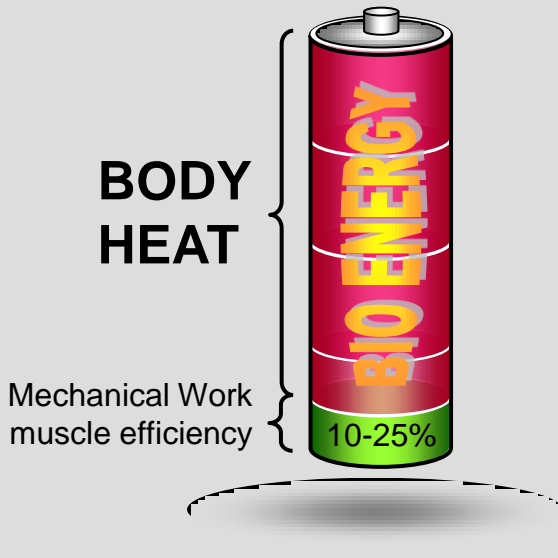
# 3 Physiological Facts



**1** Physical exercise leads to **heat stress** because of the low efficiency of muscular work

**2** Optimizing of physiological performance = Optimizing of body cooling

**3** No moisture-management, no effective body cooling



# Functionality of Lenzing FR® Blends

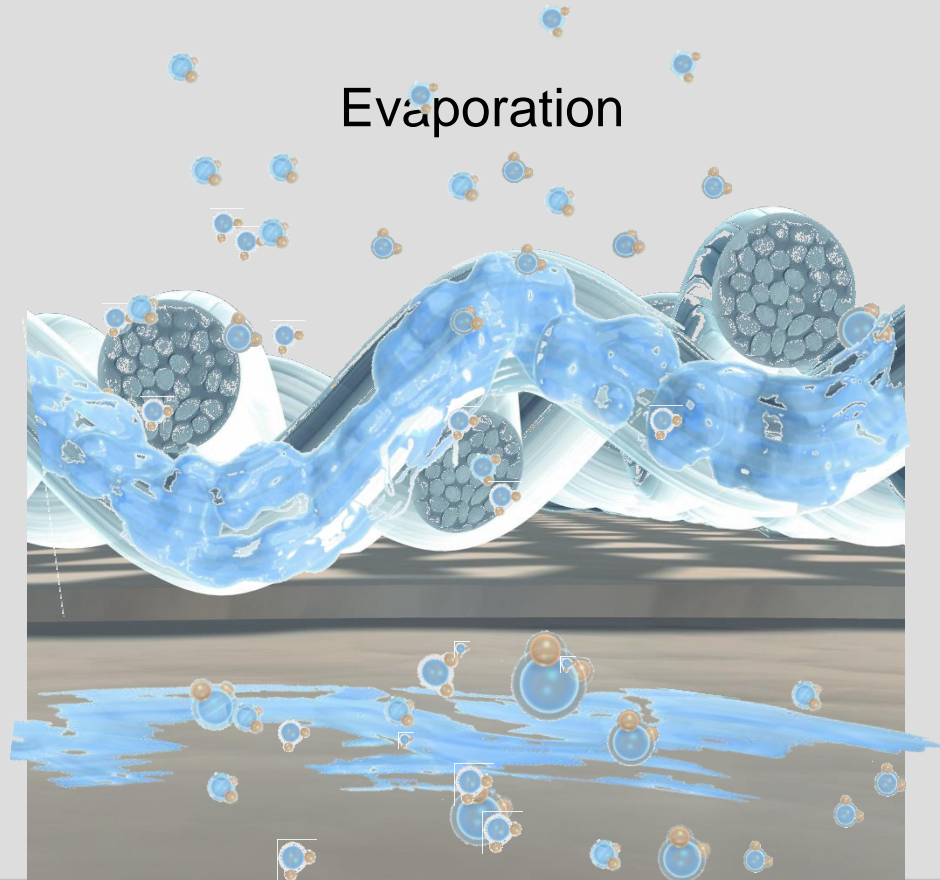


Garment

Cooling

Sweat

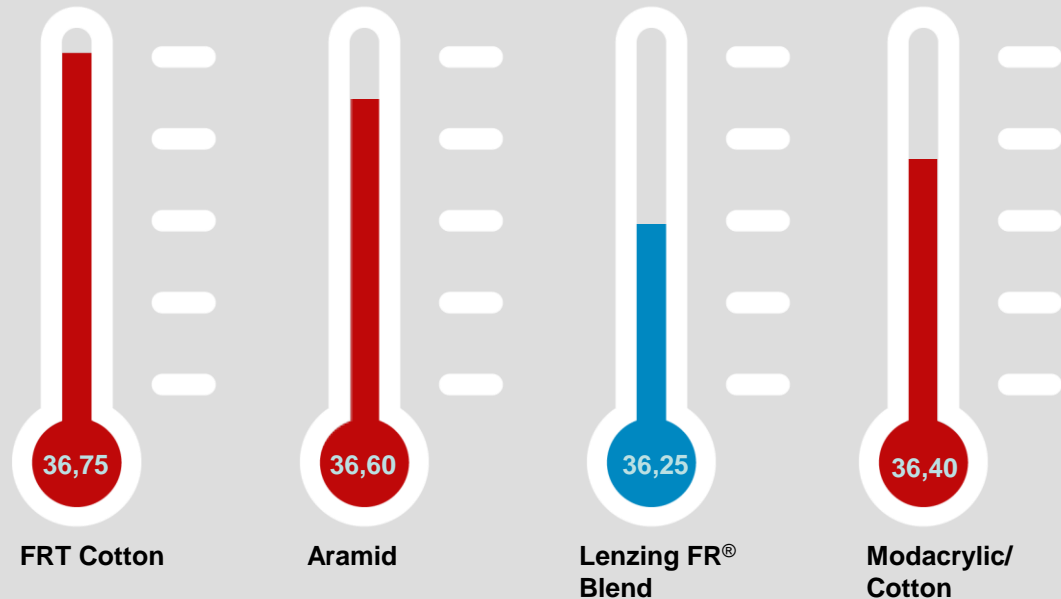
Skin



# Maximum Skin Temperature



Skin Temperature [°C]

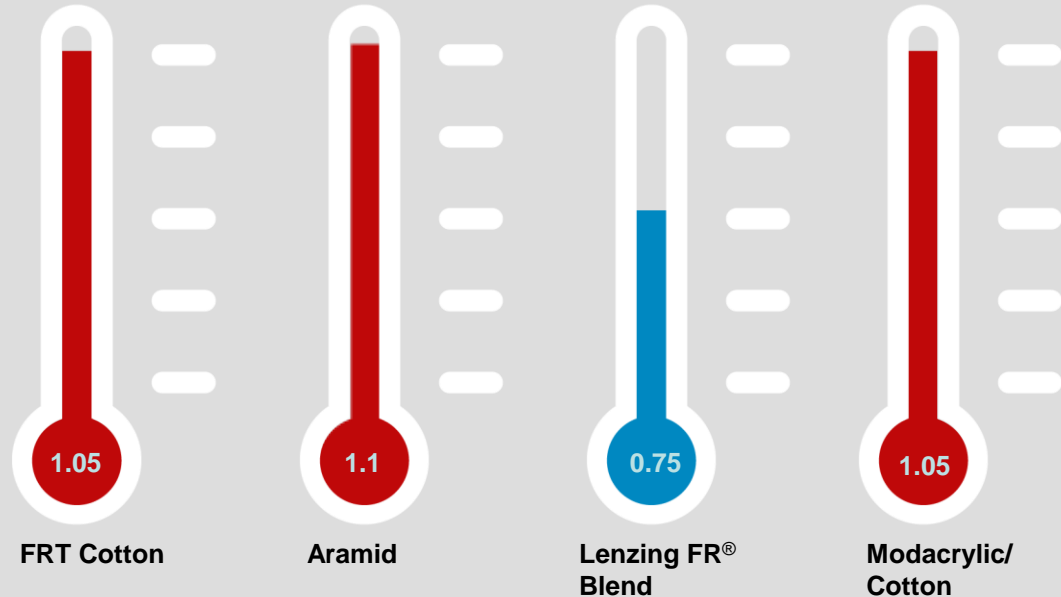


Due to evaporation of sweat, temperature on the skin is coolest with Lenzing FR®

# Difference in Body Core Temp.

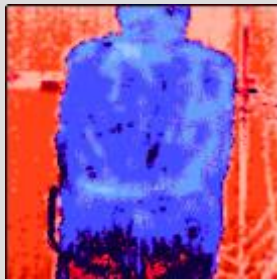


Body Core  
End Temperature –  
Start Temperature [°C]



As a consequence of efficient moisture management, overall body cooling is supported

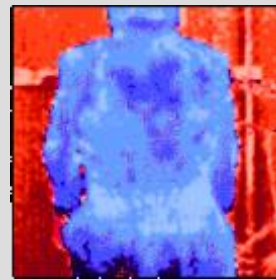
# Thermographic Pictures



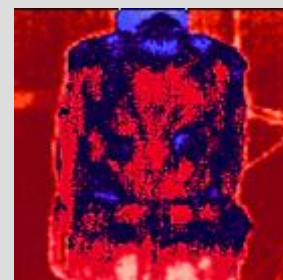
FRT Cotton




Aramid




Lenzing FR®  
Blend



Modacrylic/  
Cotton

 Heat Stress

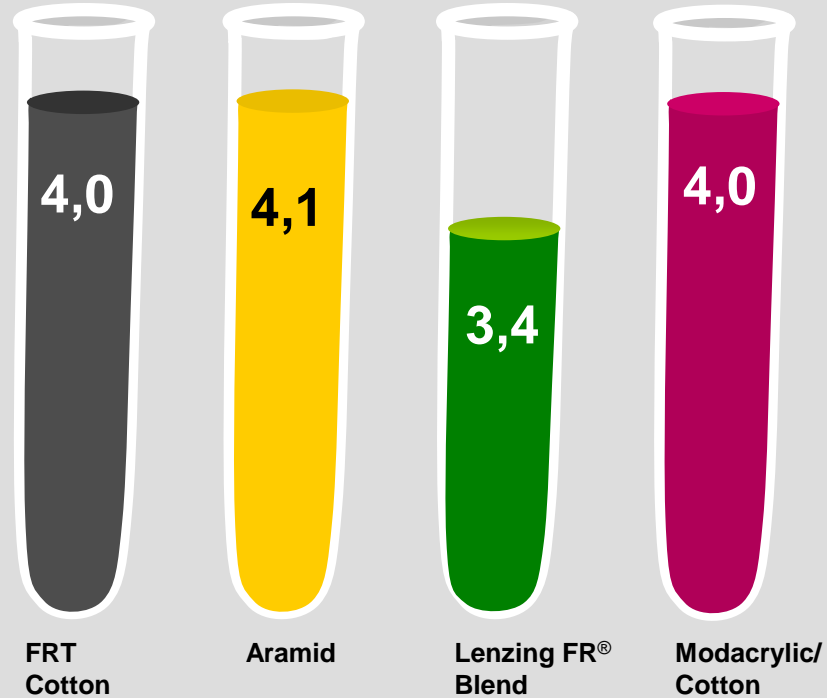
 Efficient Cooling

# Lactate Concentration



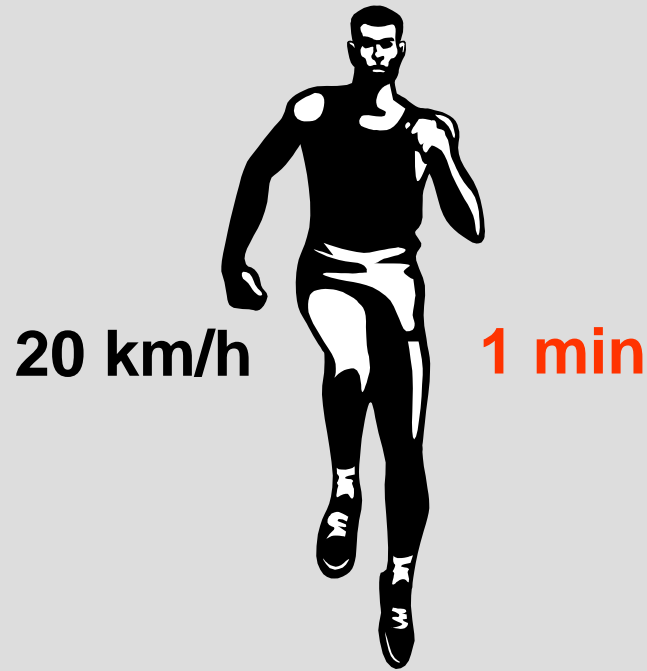
Lactate [mmol/l]

$\geq 4$  mmol/l = Anaerobic



Volunteers wearing Lenzing FR<sup>®</sup> are still in the aerobic metabolism

# Workload @ Anaerobic Threshold



Thanks to the body climate control properties of Lenzing FR® volunteers were able to perform 16 Watts additional work.  
This is the equivalent of running 1 minute at 20 km/h.






*PHYSIOLOGICAL PERFORMANCE  
OF PROTECTIVE CLOTHING*

*MEDICAL UNIVERSITY GRAZ/AUSTRIA*

# Conclusion



Flame resistant fabrics that incorporate a cellulosic fiber increase:

-  Heat Protection
-  Comfort
-  Physiological Performance





# Thank you!

## DISCLAIMER

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