

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

CLOTHING DESIGN IN ASPECT OF ENSURING THE PHYSIOLOGICAL AND PSYCHOLOGICAL COMFORT



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I. DEFINITION OF CLOTHING:

Clothing is a product which covers the human body.

They fulfil two general functions:

1. **Protection from harmful external environment factors**, as a temperature, wind, rain, snow, harms of body.



2. **Aesthetical function** - satisfy of human needs which depend on society habits and they are manifestation of their culture:

- times (époque),
- religion,
- economical and political situation,
- level of technology.



II. DEFINITION OF CLOTHING

Clothing – it is good which is making from patterns, received on the base of anthropometric measurements of human body, cutting from textiles. Than patterns are connected by sewing or fusing (welding) to ready to wear three-dimension garment.



THE ASPECTS OF DESIGN CLOTHING

Rules of clothing industry is production of :

- fashioned clothing
- useful clothing



GOOD LOOKING AND BEST FILLING

TEXTILE GOODS

(woven, knitted, non-woven, etc.)



RAW MATERIALS

GARMENT



THE ASPECTS OF DESIGN CLOTHING

1. techniques development



2. new, very interesting and original designed fabrics



grow up the design and useful possibility of clothing

THE ASPECTS OF DESIGN CLOTHING

The forms and shapes of garment, as well as their properties depend on three mayor factors:

1. The kind of raw materials,
2. Technology of their making,
3. Their topic and destination.

1



2



3



THE WAY OF DESIGN CLOTHING

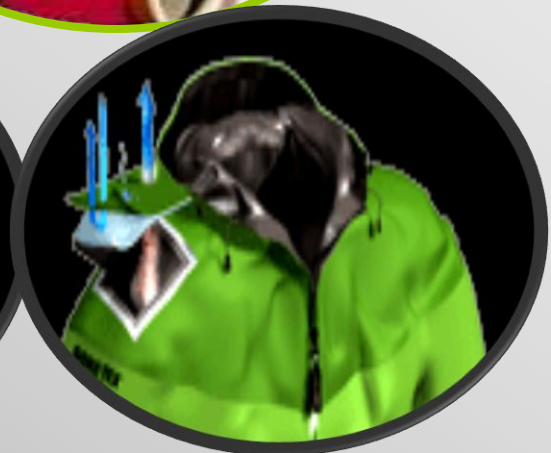
➤ The art design



➤ The materials design



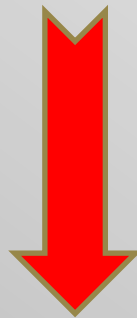
➤ The structure design



THE ASPECTS OF DESIGN CLOTHING

The clothing is characterized by a lot of different properties, which describe and decide about:

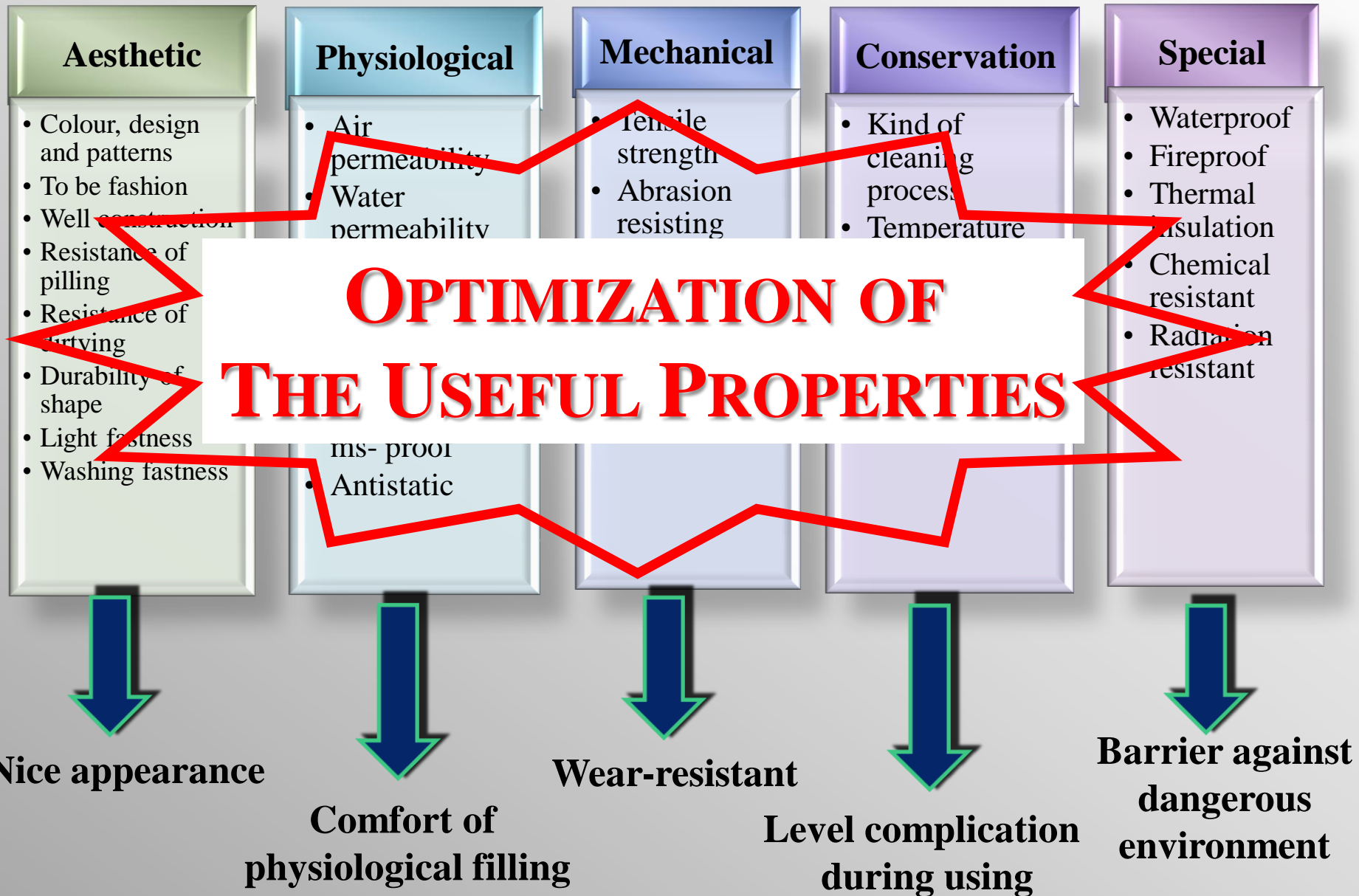
- ✓ clothing functionalism to fulfill designed function,
- ✓ as well as decide about the physiological and psychological comfort.



USEFUL PROPERTIES



MAJOR USEFUL PROPERTIES OF CLOTHING



THE PHYSIOLOGICAL COMFORT

Comfort is a state of satisfaction when we don't feel
any negative feelings



MICROCLIMATE BETWEEN HUMAN BODY AND CLOTHING

- ✓ METABOLISM,
- ✓ CONDITIONS OF HEAT Exchange
(heat comfort and discomfort),
 - ✓ THERMAL INSULATION,
 - ✓ PERMEABILITY OF AIR
(windproof, ventilation),
- ✓ PERMEABILITY OF WATER AND WATER
VAPOUR TRANSPORT.

MICROCLIMATE OF CLOTHING

One of the primary rule of clothing is insurance properly microclimate between human skin and clothing layers. This microclimate it is the cooperation between following factors:

- TEMPERATURE
- PRESSURE OF VAPOUR MOLECULES
- HUMIDITY
- AIR MOTION

Value of these factors depends on:

1. How much heat produce a human body,
2. How looks a heat exchange condition with environment.

THE PHYSIOLOGICAL COMFORT

Garment should provide maximum comfort in all weather conditions, in different terrains as well as regardless of the type of physical activity.



MICROCLIMATE OF CLOTHING

The parameters of properly microclimate between human skin and clothing layers:

- ✓ **the average temperature of skin - 32 to 34⁰C**
- ✓ **the low humidity (about 30 - 40%)**
- ✓ **to keep a minimum air motion (0,1m/s)**
- ✓ **the level of carbon dioxide (CO₂) below 0,03% - similarly as the atmospheric air, which we breath.**

The formula of heat balance for human organism is:

$$\Delta Q = M - L - Q_P \pm Q_R \pm Q_{CV} \pm Q_C \pm Q_B$$

where:

M- heat of metabolism

L – loss of heat into mechanical work

Q_p – heat loss due to evaporation of sweat (perspiration)

Q_R – heat received or lost by radiation

Q_{CV} – heat received or lost by convection

Q_C – heat received or lost through conduction

Q_B - heat received or lost by respiration (breathing)

ΔQ – **Index of Required Clothing Insulation – IREQ**

- compensating volume of thermal imbalance of the human body

$$\mathbf{L = R}$$

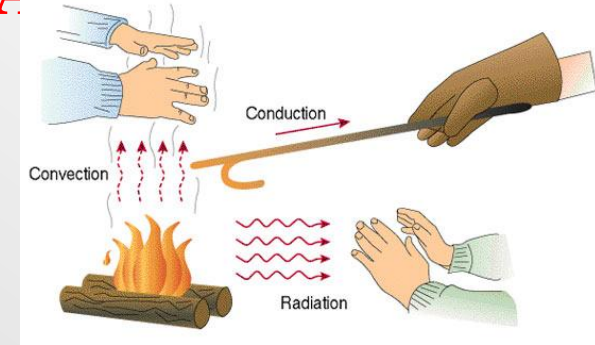
THE HUMAN BODY LOST THE HEAT•

❑ by passive way:

- ✓ radiation - approximately 60%
- ✓ conduction (contact) - about 3%
- ✓ convection (cooling by the wind) -15%

❑ through active way:

- ✓ evaporation of water from the sweat excreted on the surface of the skin - about 22%



Heat loss from the body occurs mainly through **the skin**.

In normal operation, the person loses about **50-70%** of heat by radiation to the surrounding surfaces and objects.

In a cool environment with low temperature it may be even **80%** or more.

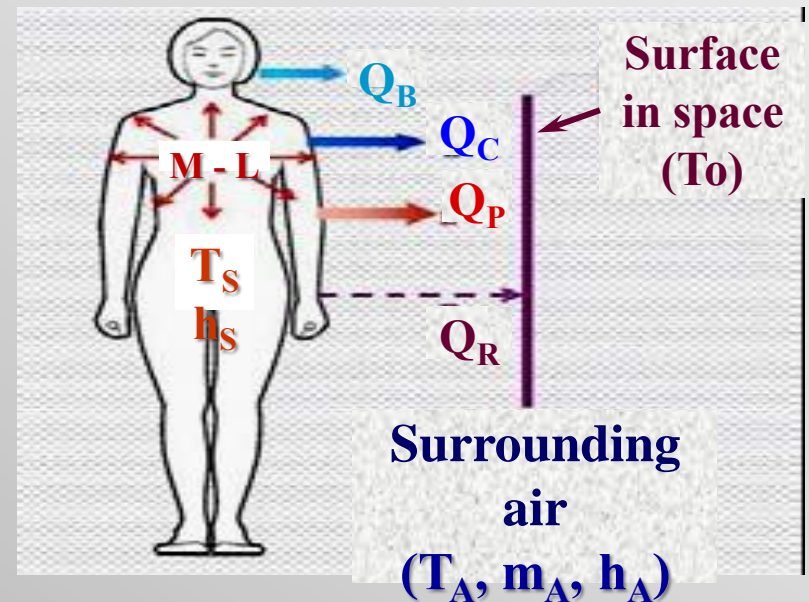
Meaning of Index of Required Clothing Insulation

① $M - L > Q_P \pm Q_R \pm Q_K \pm Q_C \pm Q_O$

- increase in body temperature - a human feels warmth and undresses

② $M - L < Q_P \pm Q_R \pm Q_K \pm Q_C \pm Q_O$

- decrease in body temperature - a human feels cold and dressed in warm clothing



METABOLISM

Metabolism is defined as all changes taking place in the human body which result in production of energy necessary for the functioning of the body.

I Reactions of synthesis (anabolism)

II Reactions of decomposition (catabolism)

The units describing the amount of metabolic heat is
[W/m²] or [met].

1met is equal to the amount of heat produced during rest

$$1 \text{ met} = 58,15 \text{ [W/m}^2\text{]} = 50 \text{ [kcal/m}^2\text{h]}$$

METABOLISM

Quantity of heat generated depends on the **intensity of activity:**

- during sleeping - the amount of heat generated is about 40W/m^2
- during the physical work - the amount of heat generated - up to 500 W/m^2

Metabolic rate also depends on **the state of our organism:**

- ✓ disease,
- ✓ frame of mind,
- ✓ mood.

METABOLISM

Examples of metabolic rate:

- **0,8met** - rest in a half-lying position;
- **1,0met** – rest in the sitting position;
- **1,2met** - rest in standing position;
- **1,6met** - light activity in the sitting or standing position (clothing industry);
- **2,0met** - middle activity in the standing position (housework);
- **3,0met** - walking at a speed of 5km/h;
- **3,4met** - hard work in standing position;
- **9,5met** - running at a speed of 15 km/h..



HEAT COMFORT AND DISCOMFORT

HEAT COMFORT

It's a state which insurance properly microclimate between body and garment during physical activity in various climatic conditions with full physical and mental efficiency - (**HOMEOSTASIS**)

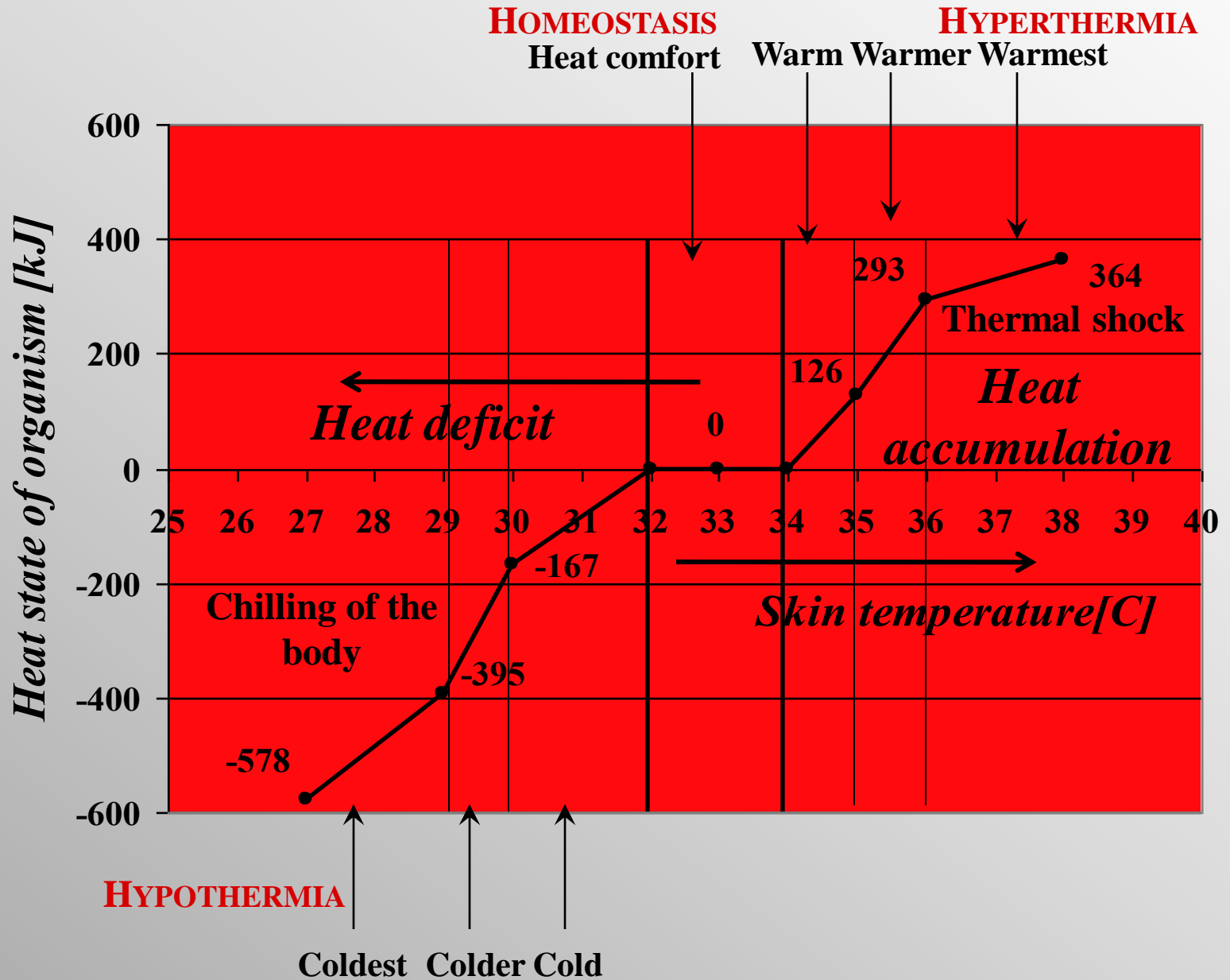
HEAT DISCOMFORT - unbalance condition of heat

- become cooled (**HYPOTHERMIA**)

- overheated (**HYPERTHERMIA**)

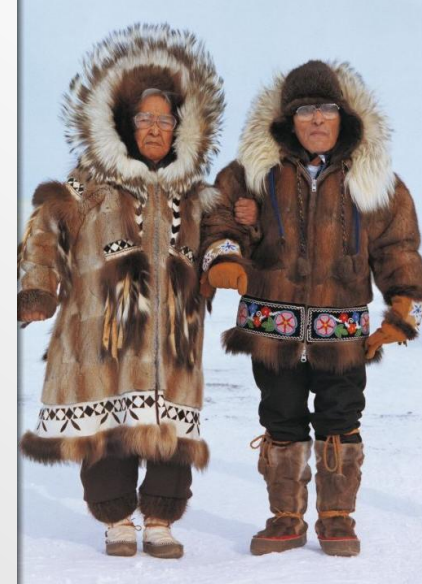
Both of these state are unprofitable!

HEAT COMFORT AND DISCOMFORTS



THERMAL INSULATION

Thermal insulation determines the amount of heat flow in the unit of time through 1m^2 of the material, with the 1K temperature difference on both sides of the garment.



Clothing with adequate thermal insulation prevents excessive heat loss to the environment.

The major thermal insulation unit is [$\text{m}^2\text{K}/\text{W}$].

With regard to clothing also force unit:

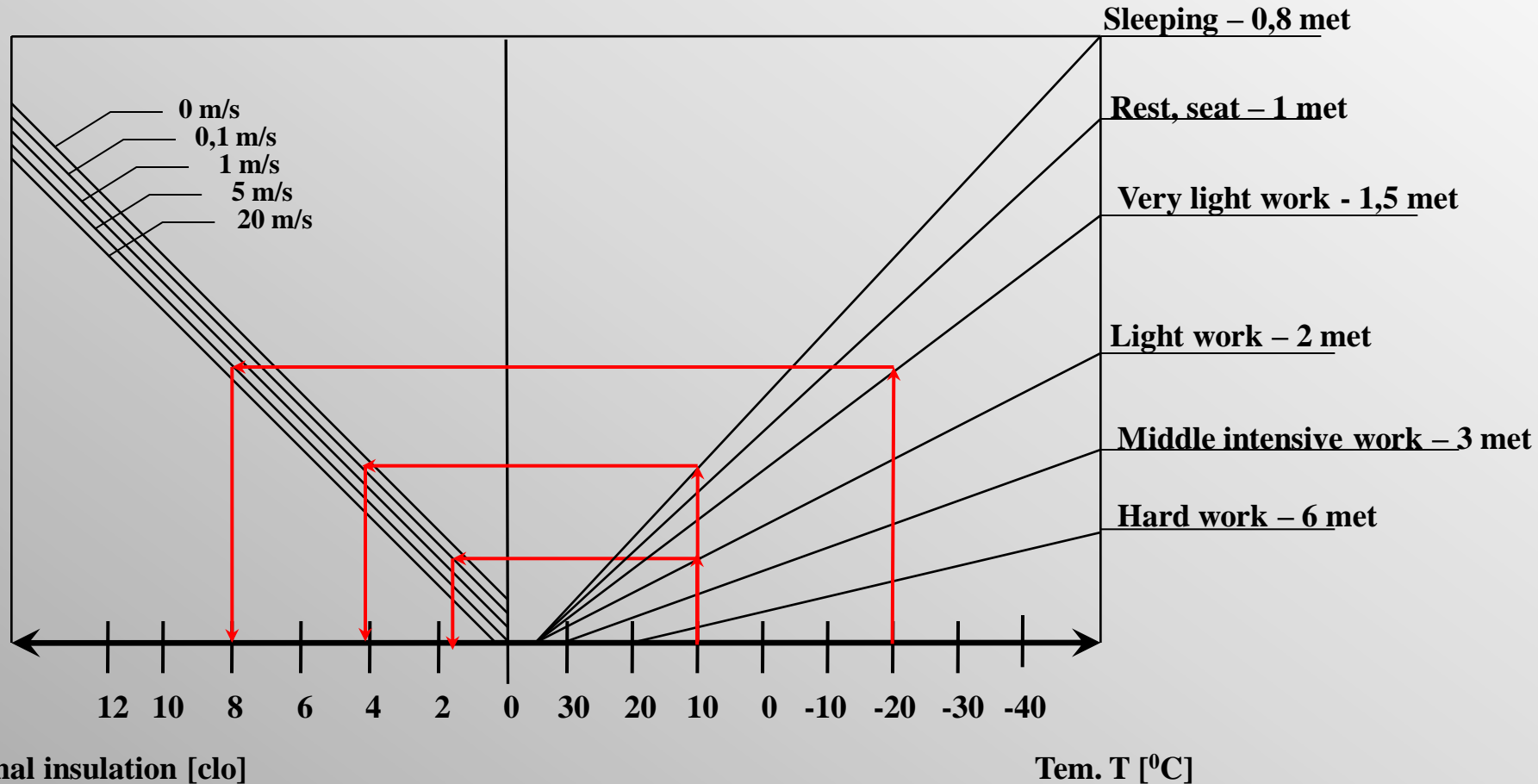
✓ 1 clo – U.S. unit (**1 clo = 0,155 $\text{m}^2\text{K}/\text{W}$**)

✓ 1 tog – British unit (**1tog = 0,1 $\text{m}^2\text{K}/\text{W}$**)

1 clo = 1,55 togs

NOMOGRAM OF BEHMANN

gives possibility to define thermal insulation of garments depending on climate's factors and the kind of work



FACTORS INFLUENCING ON THE THERMAL INSULATION OF CLOTHING:

1. The kind, properties and structure of textile fabrics which make up clothing:

- ✓ porosity,
- ✓ number of layers,
- ✓ square mass,
- ✓ thickness of the fabric (there is a limit about 17 -23 mm - larger thickness of the layer does not significantly affect on the thermal insulation).

2. The construction of clothing and its level of fitting to the body.

The garment closely fitting to body have a smaller thermal resistance than loose clothing (with the same kind of fabric), the optimum layer of air gap arounds the body is 5 mm - further increase is the causes of heat lost.

3. Thermal indicators:

- ✓ coefficient of heat transfer
- ✓ resistance of heat transfer
- ✓ specific heat of materials
- ✓ density of heat flux.

The normal clothing – 1-4 clo

The body skin – 0,15 - 0,18 clo

The arctic clothing – 11-14 clo

PERMEABILITY OF AIR

The measure of air permeability is the speed of air passing perpendicularly through the material in terms of its surface area, pressure drop and the time

R [mm/s].

The air permeability greatly influences on:

✓ **the thermal insulation**

✓ **ventilation.**

To obtain good thermal insulation properties, the fabric should be characterized by a **low air permeability**.

Too-tight clothing makes impossible of proper skin breathing. This provides to disturbances in the body's heat and an increase in carbon dioxide concentration around human skin -

good ventilation - high air permeability.

PERMEABILITY OF AIR

Depending on the value of this parameter can distinguish three groups of materials under a pressure differential of 100Pa:

- 1.fabric with high air permeability - **in excess of 600 mm/s**,
- 2.fabric with medium air permeability - **200 ÷ 600 mm/s**
- 3.fabric with low air permeability - **less than 200 mm/s**

The increase in wind speed from 0m/s to 2m/s could be cause of decrease in clothing insulation by up to **70%**.

WIND CHILL TEMPERATURE

T = temperature of air [°C]

V₁₀ = wind speed [km/h]

V ₁₀ \ T	5	0	-5	-10	-15	-20	-25	-30	-35	-40
5	4	-2	-7	-13	-19	-24	-30	-36	-41	-47
10	3	-3	-9	-15	-21	-27	-33	-39	-45	-51
15	2	-4	-11	-17	-23	-29	-35	-41	-48	-54
20	1	-5	-12	-18	-24	-30	-37	-43	-49	-56
25	1	-6	-12	-19	-25	-32	-38	-44	-51	-57
30	0	-6	-13	-20	-26	-33	-39	-46	-52	-59
35	0	-7	-14	-20	-27	-33	-40	-47	-53	-60
40	-1	-7	-14	-21	-27	-34	-41	-48	-54	-61
45	-1	-8	-15	-21	-28	-35	-42	-48	-55	-62
50	-1	-8	-15	-22	-29	-35	-42	-49	-56	-63
55	-2	-8	-15	-22	-29	-36	-43	-50	-57	-63
60	-2	-9	-16	-23	-30	-36	-43	-50	-57	-64
65	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65
70	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65
75	-3	-10	-17	-24	-31	-38	-45	-52	-59	-66
80	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67

RISK OF FROSTBITE

Lower or without any risk

Lower of frostbite for people

Little dangerous frostbite for people after 10-30 minutes

Increased dangerous frostbite for people after 5-10 minutes

Increased dangerous frostbite for people after 2-5 minutes

Great dangerous frostbite for people below 2 minutes

VENTILATION

Permissible content of carbon dioxide (CO₂) in the air around the human skin should be at the level of 0,03-0,04%. The increase in CO₂ levels above 0,08% may cause of discomfort or even deterioration the state of health.

The factors which decide on clothing's ventilation:

- ✓ the structure of fabrics (filling, pattern);
 - ✓ thickness;
 - ✓ number of fabrics layers;
 - ✓ humidity of fabrics;
- ✓ thickness of air layer around the body;
 - ✓ the kind of fabrics finishing;
 - ✓ the parameters of ambient air.

PRODUCTION OF CARBON DIOXIDE BY HUMAN BODY

□ during seating in temperature $T=25^{\circ}\text{C}$

the production of carbon dioxide (CO_2) is **250** [$\text{mg/h}\cdot\text{m}^2$]

□ during seating in temperature $T=40^{\circ}\text{C}$

the production of carbon dioxide (CO_2) is **350** [$\text{mg/h}\cdot\text{m}^2$]

□ during work in temperature $T=25^{\circ}\text{C}$

the production of carbon dioxide (CO_2) is **600 –
900** [$\text{mg/h}\cdot\text{m}^2$]

WATER VAPOUR TRANSPORT

The ability to transport water vapour depends on:

- ✓ hygroscopic properties of fibres,
- ✓ external conditions.

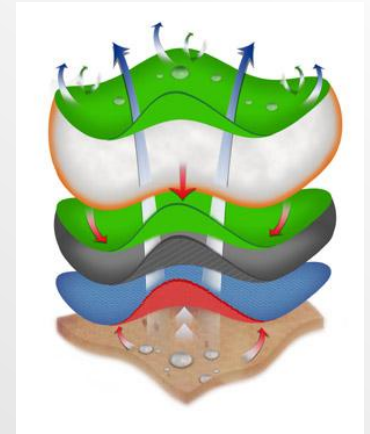
Transport of water vapour is characterized mostly by three indicators:

1. Water vapour transmission resistance (R_{et}), expressed in $[m^2Pa/W]$;
2. Water vapour permeability (MVT), expressed in $[g/m^2*24]$;
3. Flow of water vapour, expressed in $[g/24h]$.

WATER VAPOUR TRANSPORT

Sweat is discharged by:

- ✓ diffusion,
- ✓ absorption,
- ✓ desorption,
- ✓ fibres wetting,
- ✓ capillary condensation,
- ✓ air exchange rate of the layers around body skin.



Wet skin could significantly increase the effect of chilling body and decrease the time for frostbite.

The moisture content of the level **10-20%** could causes of drop in thermal insulation **up to 30%** compared to the dry fabric.

In **50%** water and the insulation value is only **8%!**

This is because, the water conducts heat **24 times** more than dry air!

THE FACTORS WHICH DECIDE ON WATER VAPOUR PERMEABILITY:

- ✓ thickness,
- ✓ volumetric mass,
- ✓ filling,
- ✓ kind of fibres,
- ✓ temperature difference on both sides of the garment,
- ✓ relative humidity on both sides of the garment,
- ✓ speed of the air motion.

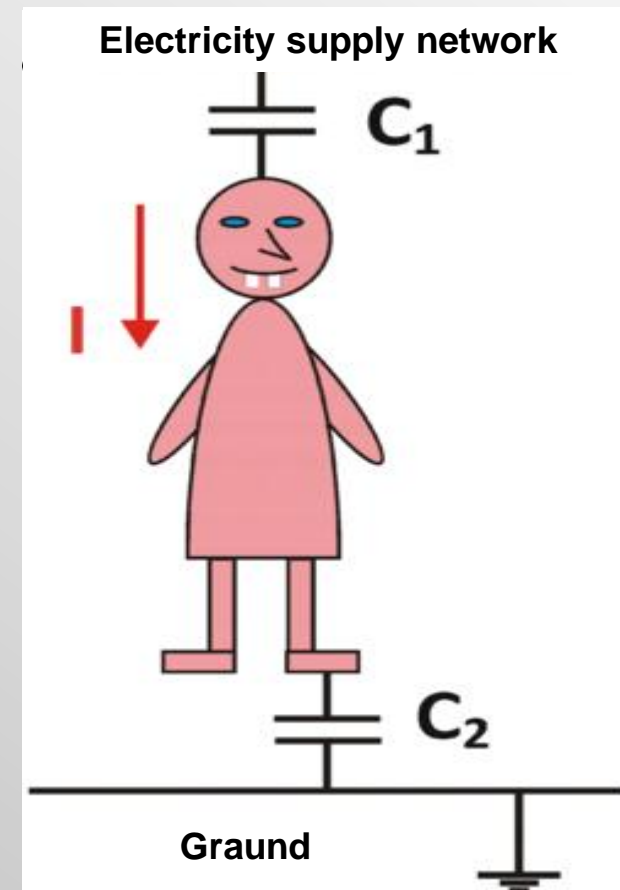
THE ABILITY TO ELECTRIFICATION

The ability to collect on the product surface static electricity (negative or positive), as a result of friction or air movement.

Static electricity may be generated on the human body by the contact way during walking, remove clothing, performing home or professional actions.

The human body can accumulate electrical charges, if it is insulated from the earth, for example, by non-conductive footwear or floor.

Maximum voltage electricity which usually found in humans can reach a value of several kV.



THE ABILITY TO ELECTRIFICATION

Positive electric charges have a negative impact on humans.

Synthetic fibers - a high electric potential, reaching up to **400-500 V/cm** - can lead to imbalances or changes in the bioelectrical structure of protein molecules in the blood.

Negative electric charges have a positive impact on human health. It is believed that their appearance may help to treat pain of muscle and joint, especially related to rheumatology.

THE ABILITY TO ELECTRIFICATION

Electrostatic discharge causes:

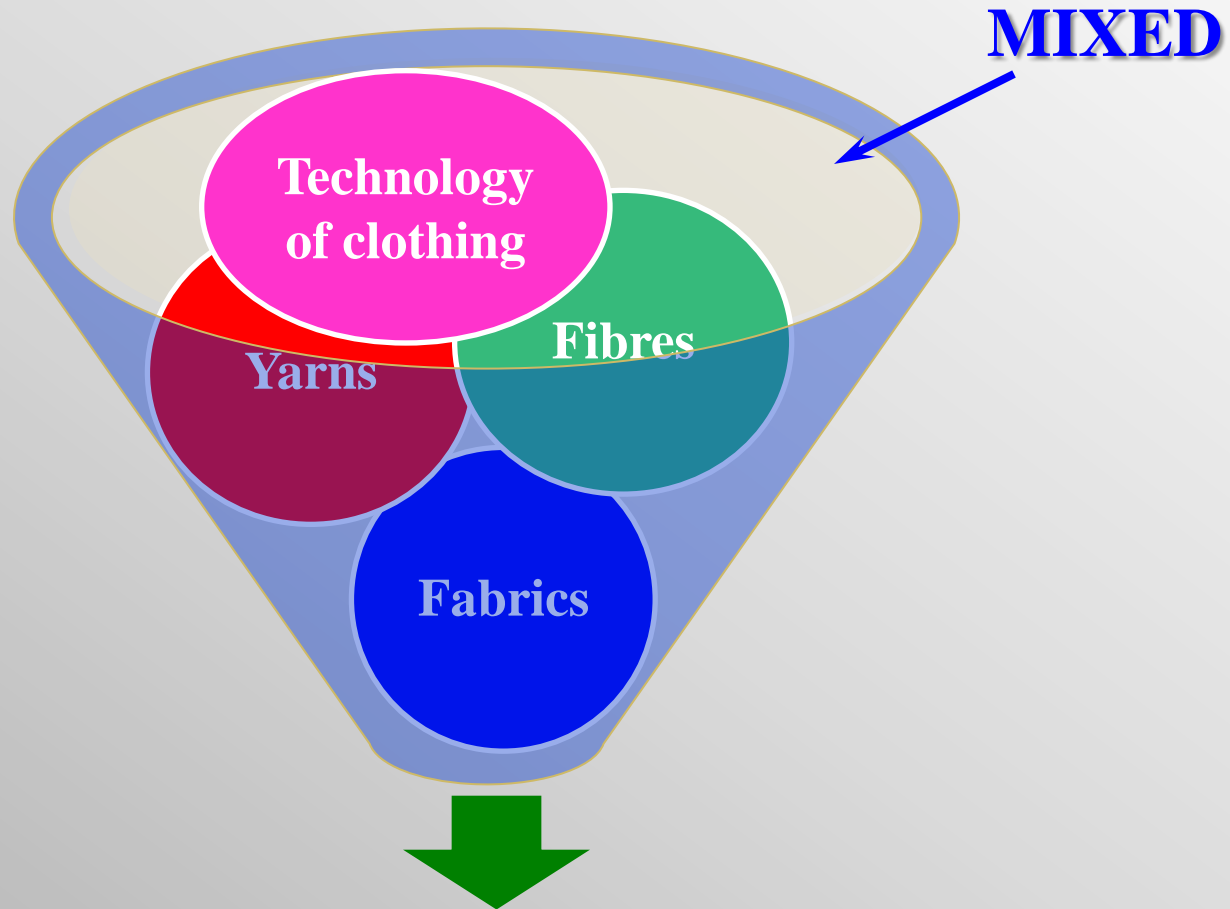
- ✓ feeling of discomfort by the person wearing the garment,
- ✓ reduction of hygienic comfort associated with adhesion clothing (especially underwear) to the skin and making difficult for breathe,
- ✓ increased ability of the garment to become a dirty

ANTISTATIC ACTION:

- **silver** is the best electrical conductor - X-Static fibres used in clothing dissipate electrical charges generated by friction.
- **carbon fibre** - coal is an extremely durable material electrically conductive. Carbon fibre is used to discharge static electricity in special clothing.
- **flax** - not electrifies - even with small addition of flax fibres blended in the material greatly reduces the ability of electrostatic charging.

Design the Physiological Comfort of Clothing from fibres to ready clothing

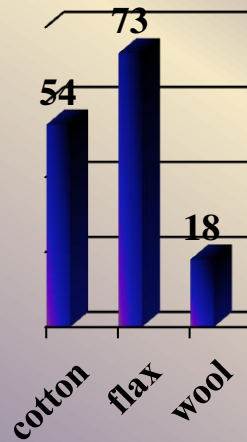




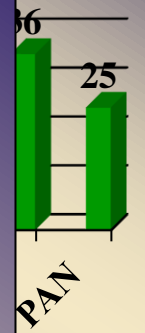
**THOUSANDS OF POSSIBILITY
AND MULTIPLY COMBINATIONS**

FIBRES - COMPARISON SOME PROPERTIES

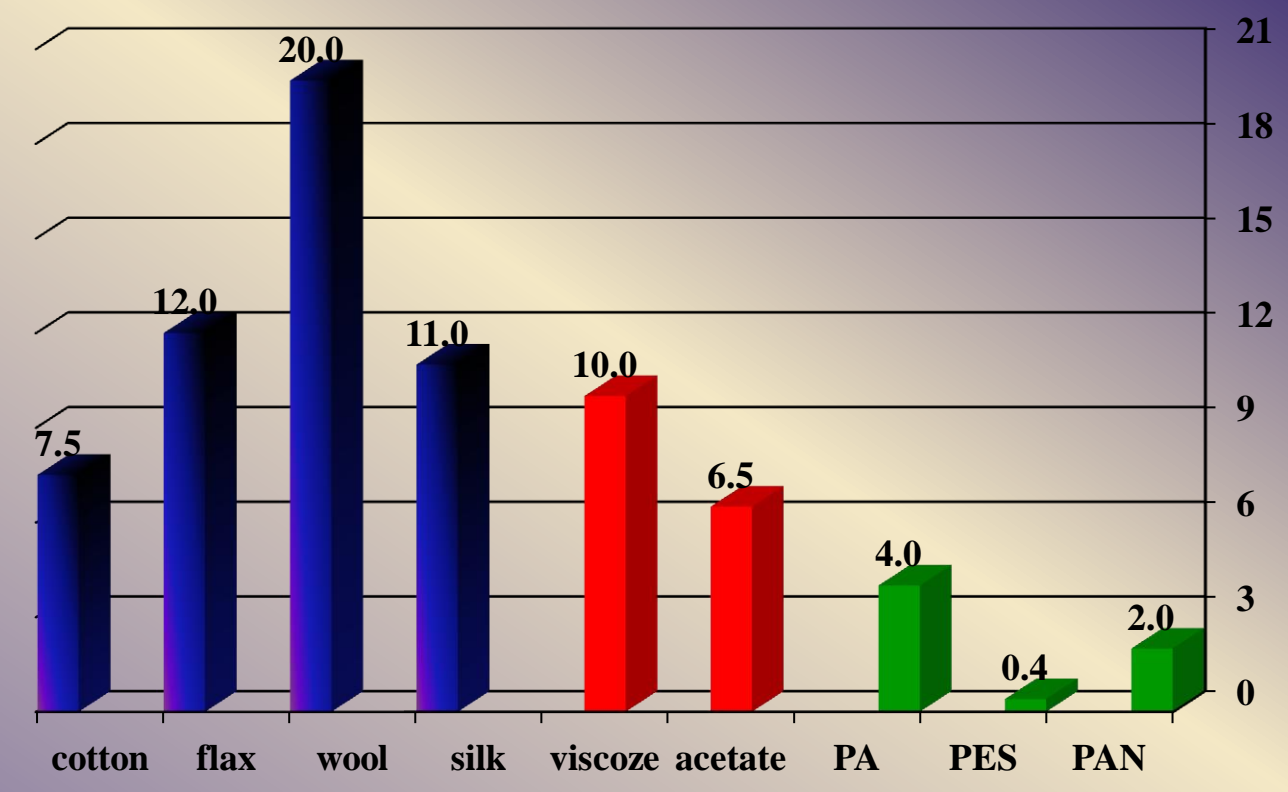
Strenght [cN/tex]



Elongation [%]



Hygroscopicity [%]



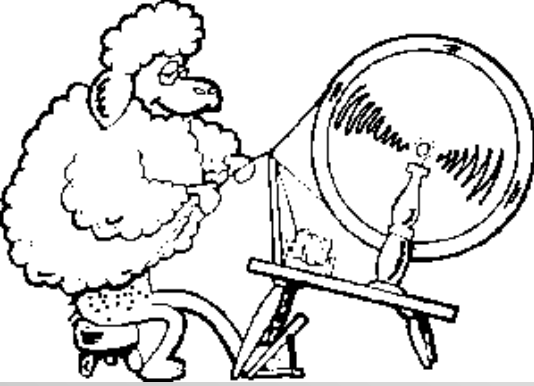
very

lower

above 60%

cotton flax wool silk viscoze acetate PA PES PAN

cotton flax viscoze silk rayon wool PES



II STEP: YARN

technological
spinning
process

number of
yarn

kind of twist

with/
without core

destination

lower twist of yarns → **soft fabric with good thermal insulation but with lower strength and lower wrinkle resistance**

multiply twisted yarn → **fabric with high level of tensile strength and very well resistance of friction, but stiff and with lower thermal insulation**

high twist of yarns → **the grain, folded surface of fabrics.**

III STEP: FABRICS FOR CLOTHING

MATERIALS FOR CLOTHING

Woven fabrics

Knitted fabrics

Plaited fabrics

Bonded fabrics

Non-woven fabrics

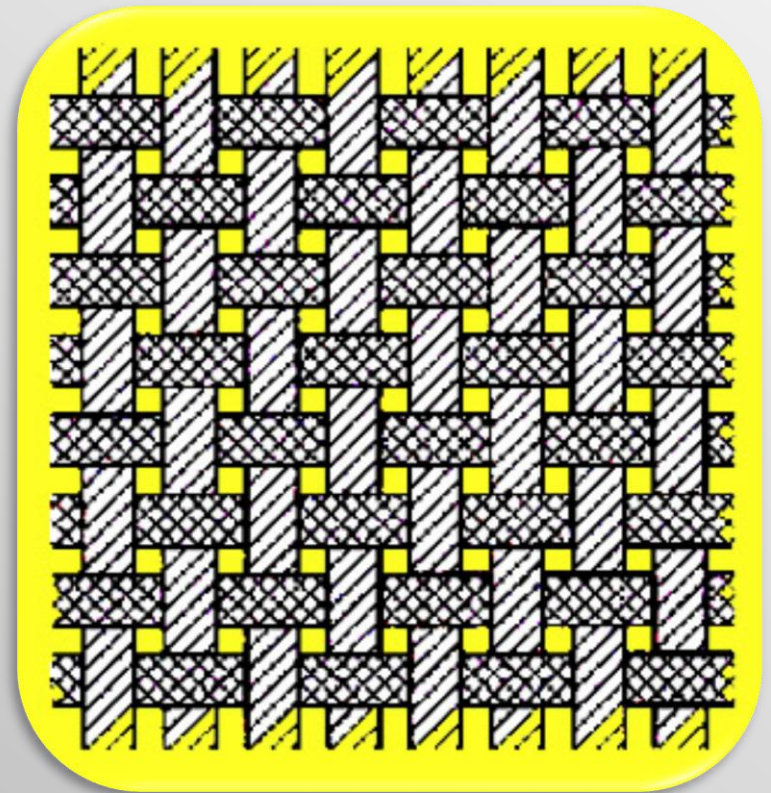
Laminates

Animals skins

WOVEN FABRICS

The parameters determinate structure of woven fabric important for clothing:

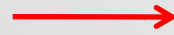
- ✓ kind of pattern;
- ✓ density of yearns;
- ✓ thickness;
- ✓ square mass.



Pattern

➤ tensile strength of fabric

the more points of interlacing
weft with warp



the fabric is more strength but
least abrasion resistance

plain fabric the most strength than satin

➤ appearance of surface

the longer loose section
between interlacing



the surface of fabric
is smoothly and polish

satin fabric

➤ kind of laying and fitting on the body

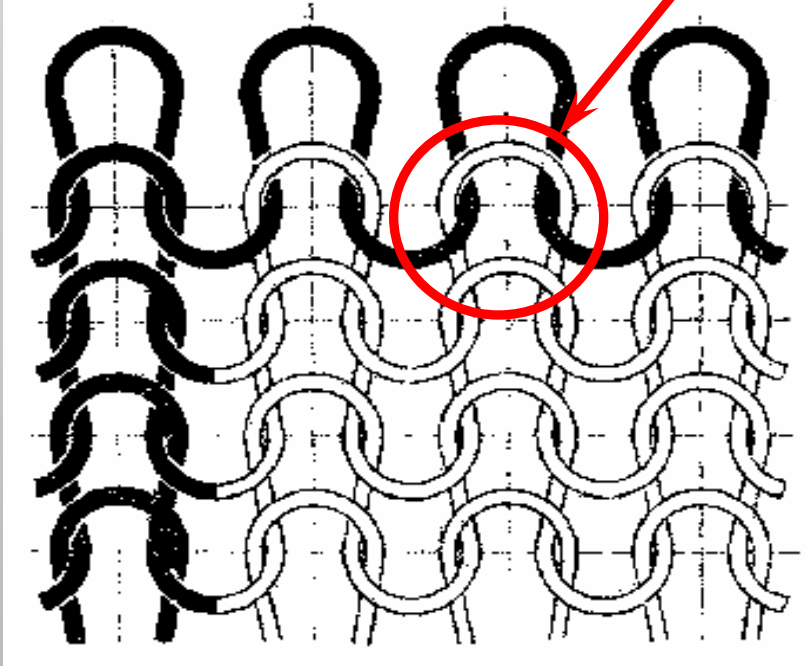
the least points of interlace
weft with warp



the fabrics has better hand
(catch) and is better laying
and fitting.

KNITTED FABRICS

LOOP



The parameters determinate structure of knitted fabric important for clothing:

- ✓ kind of pattern;
- ✓ density of wales and courses;
- ✓ filling;
- ✓ thickness;
- ✓ square mass;

FILLING OF FABRIC AREA

Almost 70% capacity of textile fabric is occupied by air, which is the best heat insulator:

- **inside smoothing woven fabric the capacity of air amount about 50%;**
- **inside the knitted fabrics – 80%,**
- **inside fluffing fabrics (flannel, polar, fleece fabric) – about 90%.**

COMPARISON KNITTED WITH WOVEN FABRIC

Advantages:

1. more elasticity and resilience;
2. more stretching;
3. more softer;
4. more cold protection;
5. better ventilation;
6. better fitting and setting.



Defects:

1. tendency to pilling;
2. unravel - easily unstitch;
3. roller edges;
4. difficult for sewing process – need the different methods and special equipments.

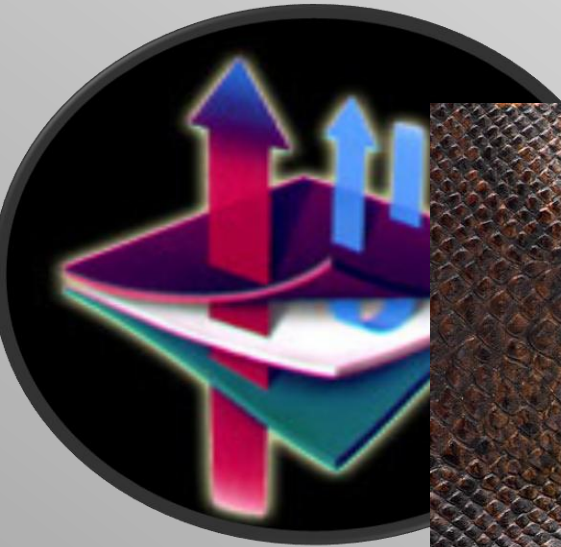


LAMINATES

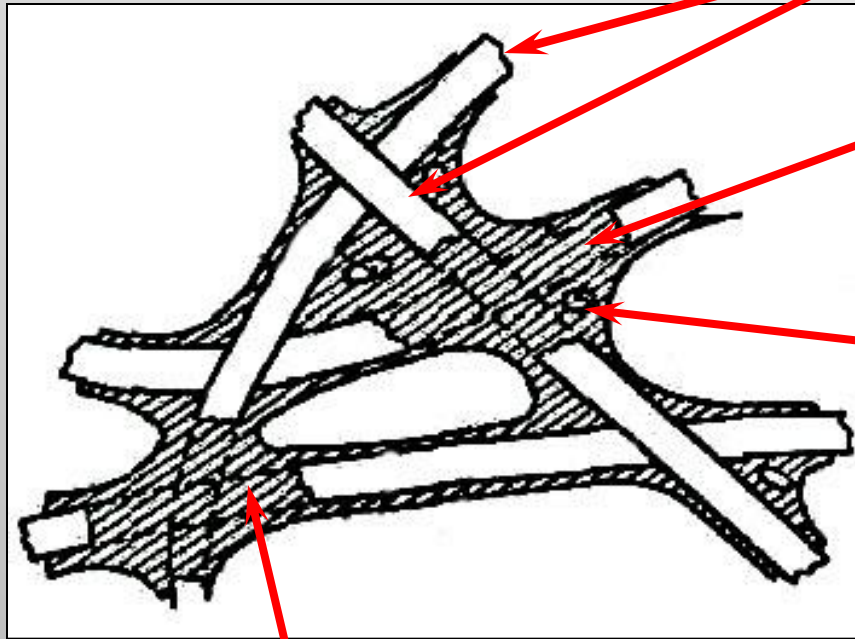
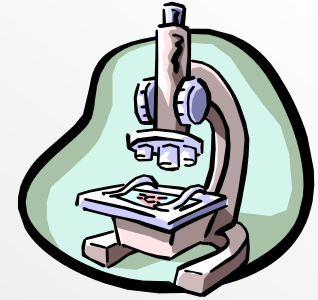
The two, three or more layers are built the laminates fabrics.

The example of these materials are:

- laminate with membrane;
- covered materials by synthetic resin - artificial skins;
- laminate with polyurethane foam - home footwear.



NONWOVEN



FIBRES

FILM OF THERMOPLASTIC
POLYMERS

HOLES

THERMOPLASTIC POLYMERS
[GLUE]

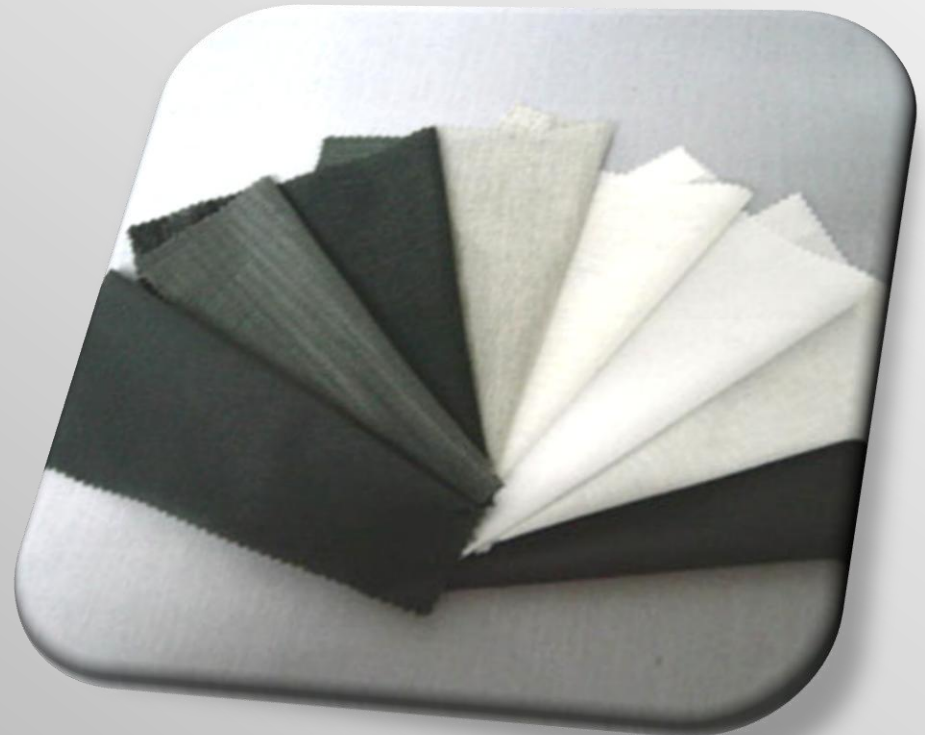


Non-woven can be used as outer fabrics - disposable (single-used) clothing, but almost in clothing technology is used as interlining.

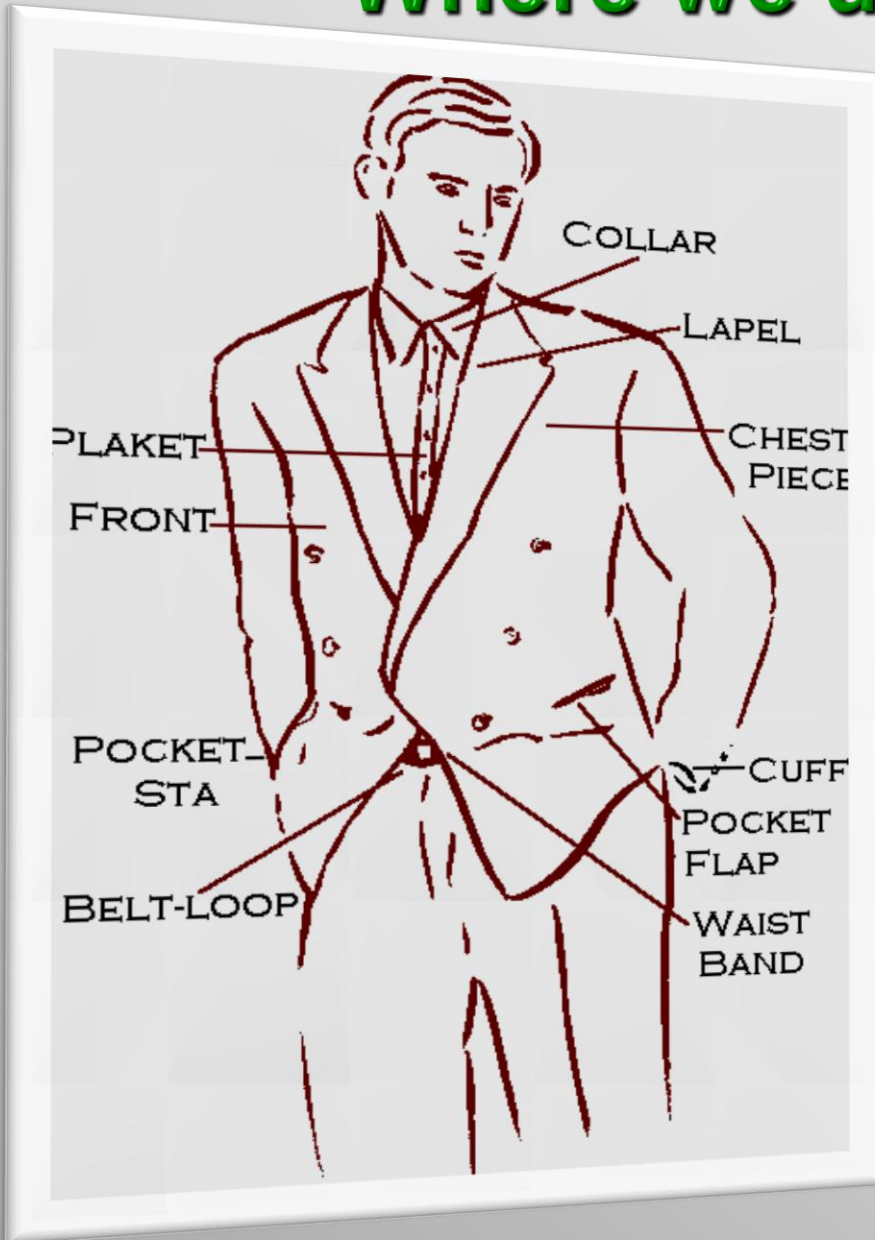
Interlinings - materials attached to the bottom side of the fabric.

They primary purposes are ensure in clothing:

- ✓ maintains shape,
- ✓ suitable stiffness,
- ✓ good stretching,
- ✓ good relaxation,
- ✓ better strength.

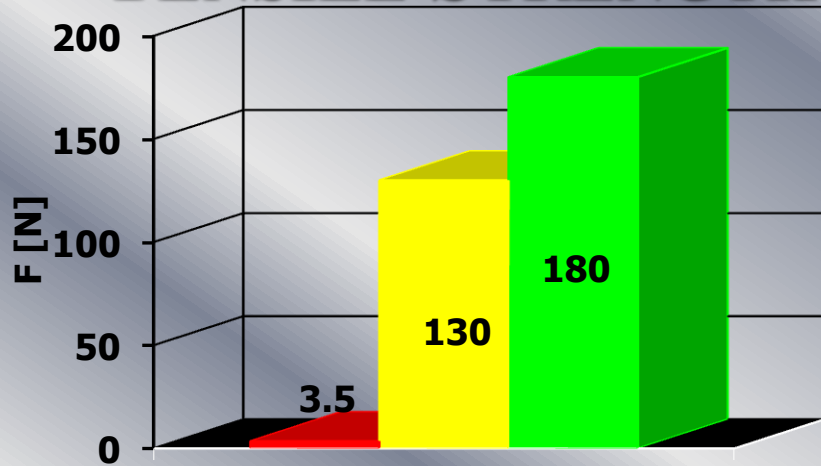


Where we use interlining?



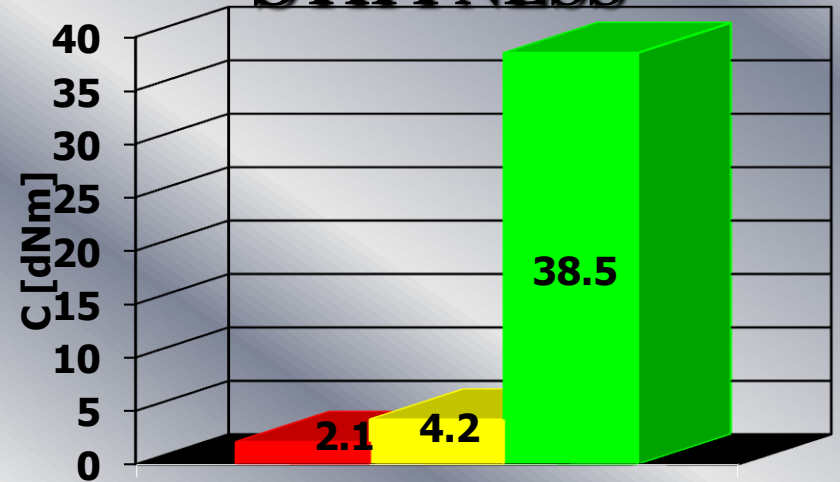


TENSILE STRENGTH



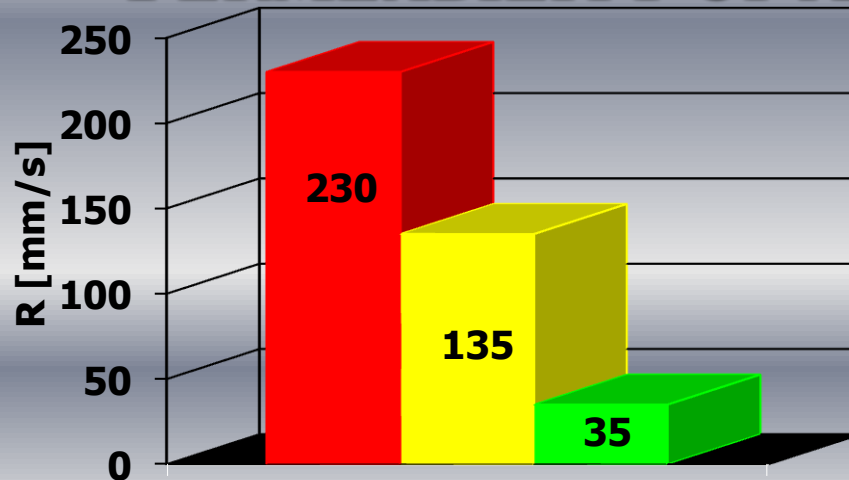
■ nonwoven ■ woven ■ laminate

STIFFNESS



■ nonwoven ■ woven ■ laminate

PERMEABILITY OF AIR



■ nonwovens ■ wovens ■ laminates

IV STEP: CLOTHING CONSTRUCTION

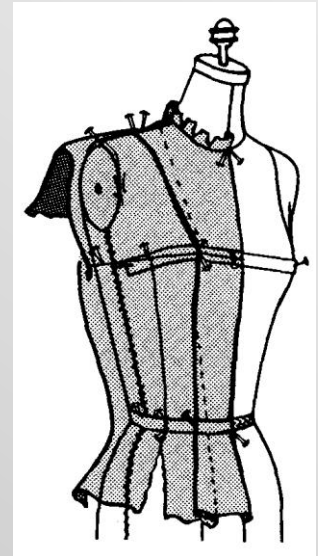
The construction of clothing and its level of fitting to the body.

The garment closely fitting to body have a smaller thermal resistance than loose clothing.

Minimum functional freedom - the amount added to the measurement of the body, that yields a minimum of freedom of movement.

Minimum added providing free suspension of the garment on the body - clothing should be freely cover the surface of the body – to form the "second" skin – in the circumference of the chest - about 3.0 cm.

Minimum added providing freedom of physical movements (without dynamic movements) - results from the average amplitude of inhalation and exhalation, which is about 4.0 cm in circumference of the chest.



IV STEP: CLOTHING

SEWING

The clothing become from pattern, which are joined by sewing or by special other technique (fusing or welding).

Almost 85 -90% of clothing is made by sewing, but these connection are permeability for air, water or other factors – this technique is recommended only for traditional garment.

The technology of fusing or welding seam give possibility to make a connection which is impenetrable for above factors as well as it is resistant to pollution, clogging dirt, dust and oily substances – it is designed for barrier clothing.

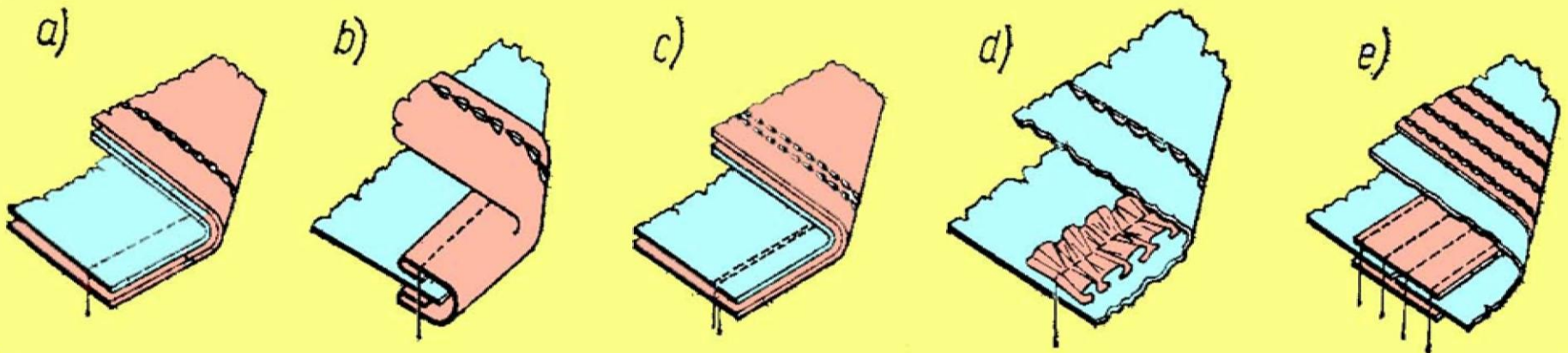


SEWING SEAM it is the smallest elements of clothing structure. It become from at least of one textile fabric, which has special laying and is joined by threads during sewing.

The threads make a special systems of interlacing and interlooping – **STITCH**

THE KIND OF SEAMS:

- Joining seams** – joined minimum two textile elements,
- Hem seams** – finishing or decorating hem of textile elements



SHORT CHARACTERISTIC OF PRIMARY STITCHES

LOCKSTITCH

**THE SAME
APPEARANCE**

**NO
STRETCHING**

CHAINSTITCH

**DIFFRENT
APEARANCE**

**STRONGER,
EXTENSIBLE**

OVERAGE STITCH (OVERLOCK)

**FINISHING AND
OVERADGE
HEM**

**STRONGER
EXTENSIBLE**

The clothing Design Step by Step

FIBRES

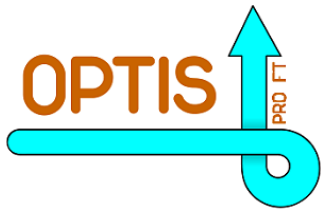
YARNS

FABRICS

TECHNOLOGY
OF CLOTHING

CLOTHING

In every of these stages undertakes the decisions which define usefull proprieties including the physiological comfort of garment!



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

CLOTHING DESIGN IN ASPECT OF ENSURING THE PHYSIOLOGICAL AND PSYCHOLOGICAL COMFORT

Thank you very much for attention!



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