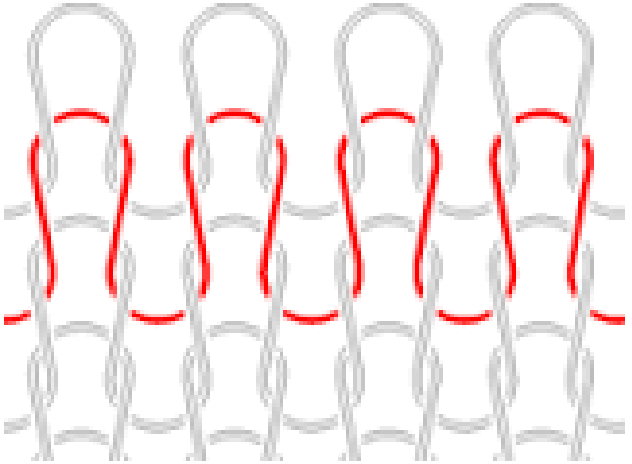
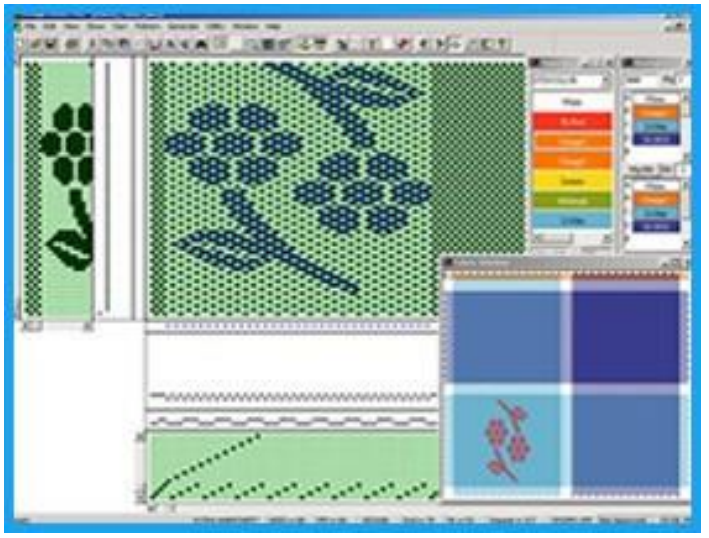
Geometry of fabrics

- Design parameters
- Specific mass of area
- Specific volume mass
- Cover factor
- Porosity





Design and structural parameters

- **Wovens**
  - Weave
  - Warp, weft density
  - Area mass
  - Volume mass
  - Porosity
  - Thickness
  - Cover factor
  - Crimp factor
- **Knitted fabric**
  - Knit weave
  - Density of wale, course
  - Stitch density
  - Stitch length
  - Area mass
  - Volume mass
  - Porosity
  - Thickness
  - Entanglement
  - Density coefficient

Design parameter

Yarn interlacing point

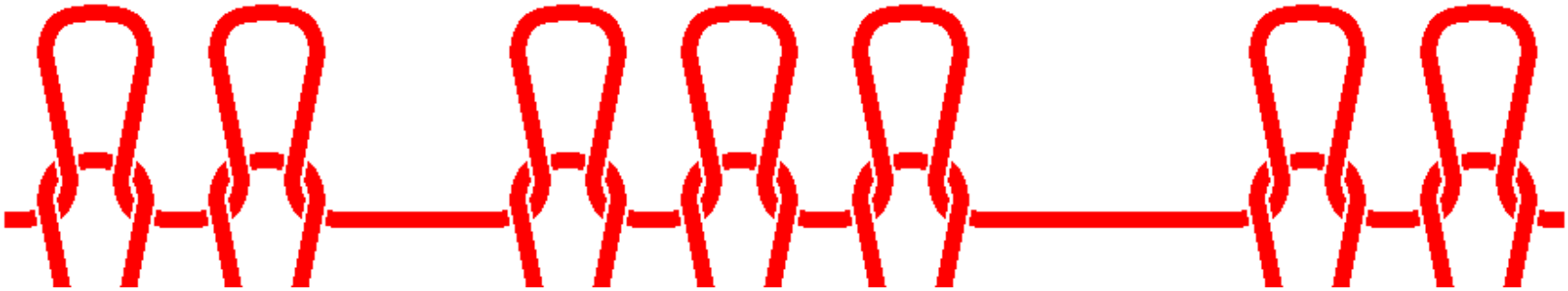
basic fabric unit

Influence on fabric parameters

used technology

interaction of interlacing points

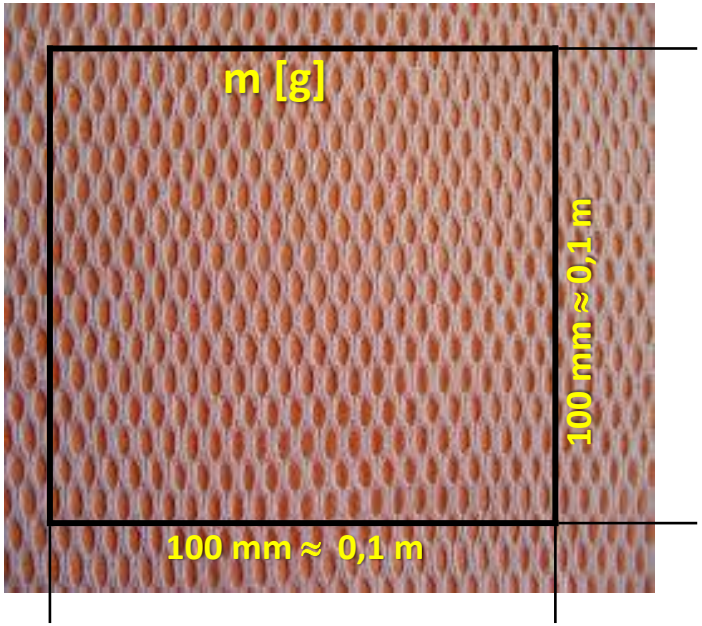
density of interlacing points



Mass per unit area

ρ_S [g/m²], [kg/m²]

$$\rho_s = \frac{m}{S} = \frac{m}{l \cdot b} \; [kg \cdot m^{-2}]$$



ISO 3801:1977 - Textiles - Woven fabrics - Determination of mass per unit length and mass per unit area

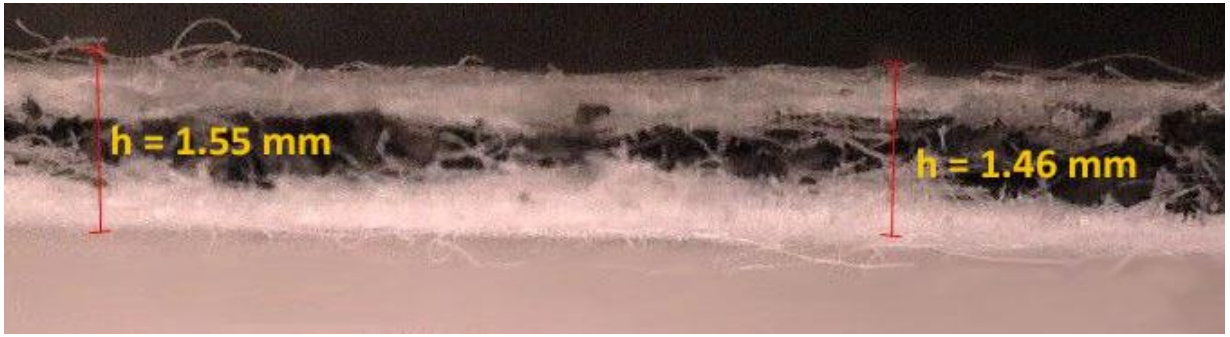
- **Gravimetric method**
  - Weighing of exactly cutted fabric specimen and recalculation to [kg.m^{-2}]
  - Standardized specimen is 100 x 100 mm
  - Mass of common meter - mass of 1 m of fabric in whole width

Mass per unit volume

$$\rho_V = \frac{m}{V} = \frac{m}{S \cdot h} = \frac{m}{l \cdot b \cdot h} = \frac{\rho_S}{h} \quad [kg \cdot m^{-3}]$$

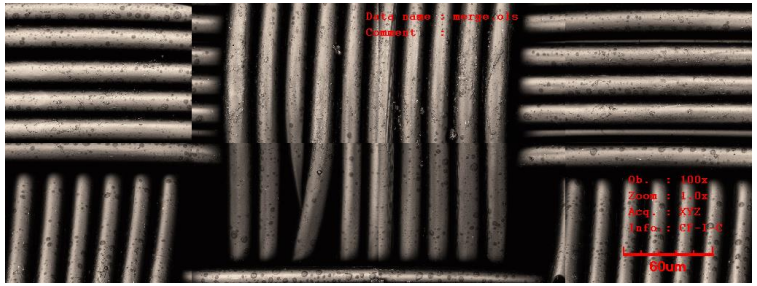
ρ_V [kg.m^{-3}]

- V – Volume of fabric [m^3]
- h – Thickness of fabric [m]

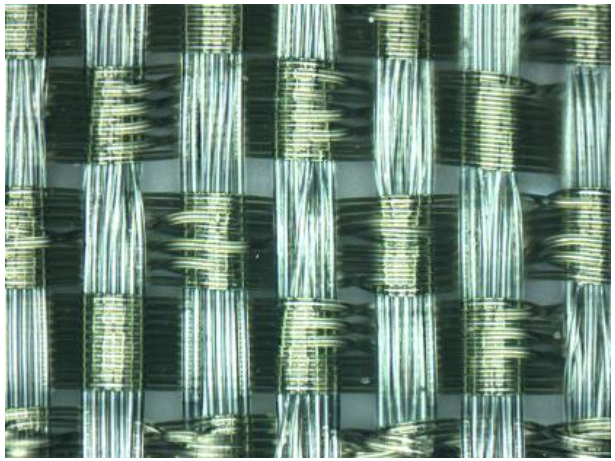


Porosity of fabric

$$p = \frac{\rho_{vlK} - \rho_V}{\rho_{vlK}} \cdot 10^2 \ [\%]$$



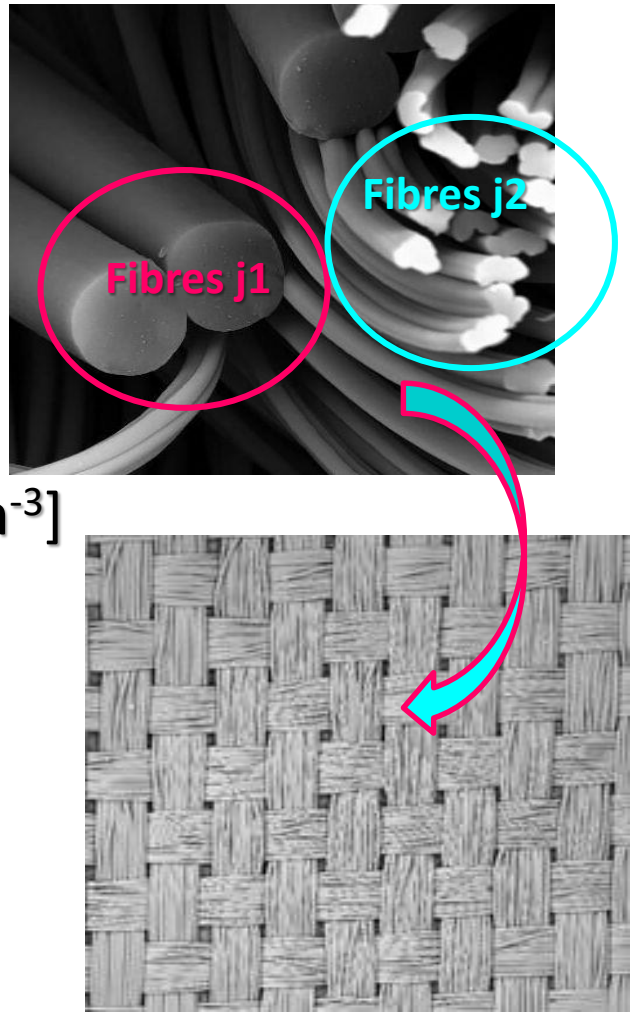
- p – porosity of fabric [%]
- ρ_{vl} – volume density of climatized fibres [kg.m^{-3}] (virgin fibre material without pores)
- ρ_V – fabric volume mass density [kg.m^{-3}]
  - one component fabric



Porosity – fibre blend

- Volume density of fibrous mixture ρ_{sm} [kg/m³]

$$\rho_{sm} = \frac{1}{10^2} \sum_{j=1}^{k} \rho_{vlj} \cdot v_j$$

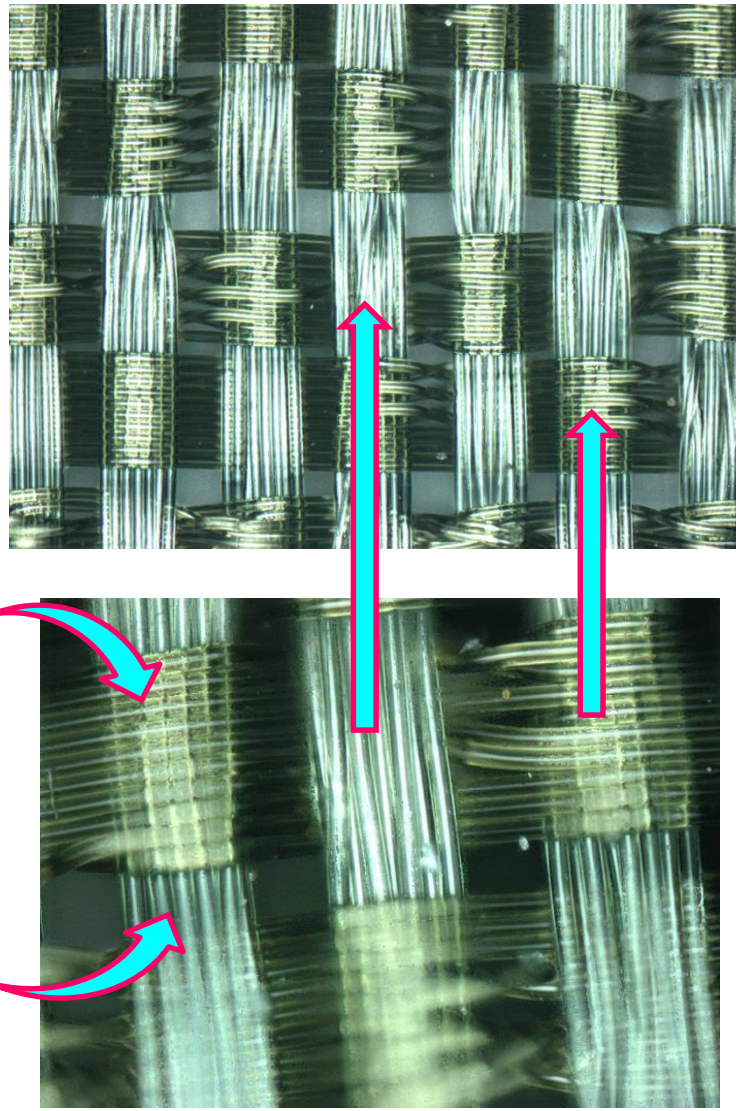


- ρ_{sm} – blend volume density [kg.m^{-3}]
- ρ_{vlj} – volume density of j-part of climatized fibres [kg.m^{-3}]
- v_j – volume fraction of j-part in fibrous blend [%]

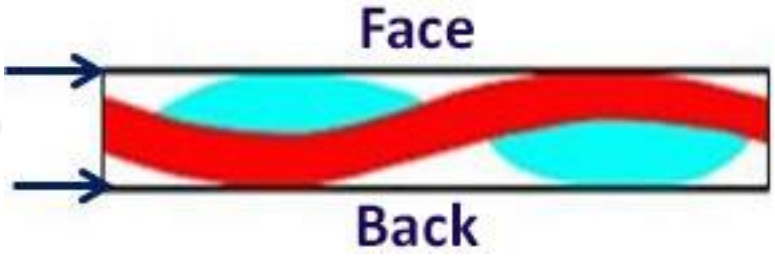
$$p = \frac{\rho_{vlK} - \rho_V}{\rho_{vlK}} \cdot 10^2 \ [\%]$$

$$\rho_{sm} = \frac{1}{10^2} \sum_{j=1}^{k} \rho_{vlKj} \cdot v_j$$

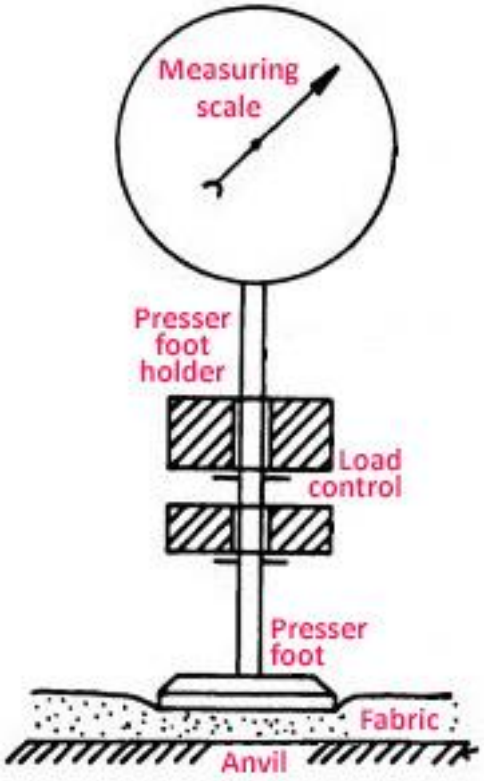
$$[kg \cdot m^{-3}]$$

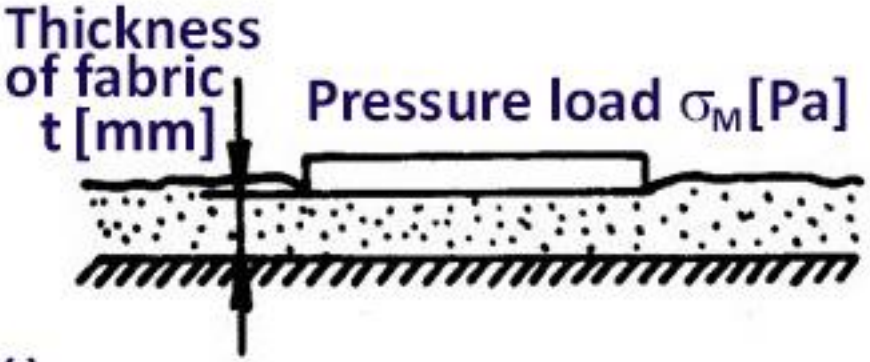


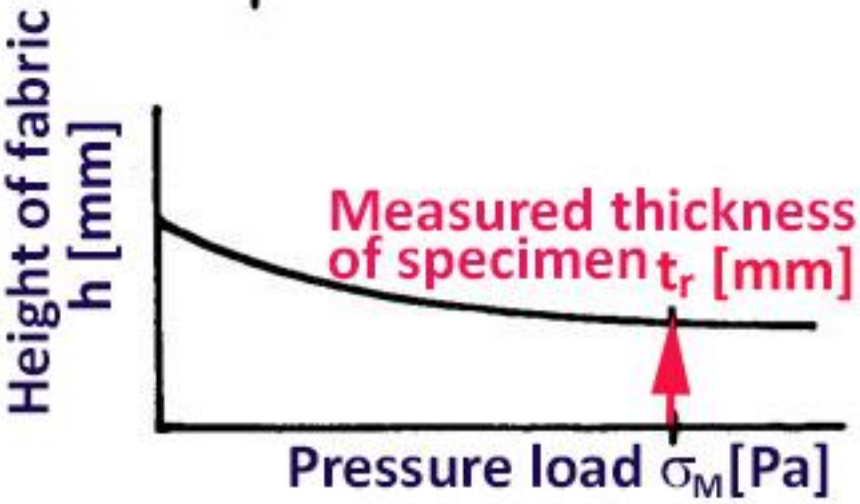
Fabric thickness



$$\rho_m = \frac{F}{S} \ [Pa]$$





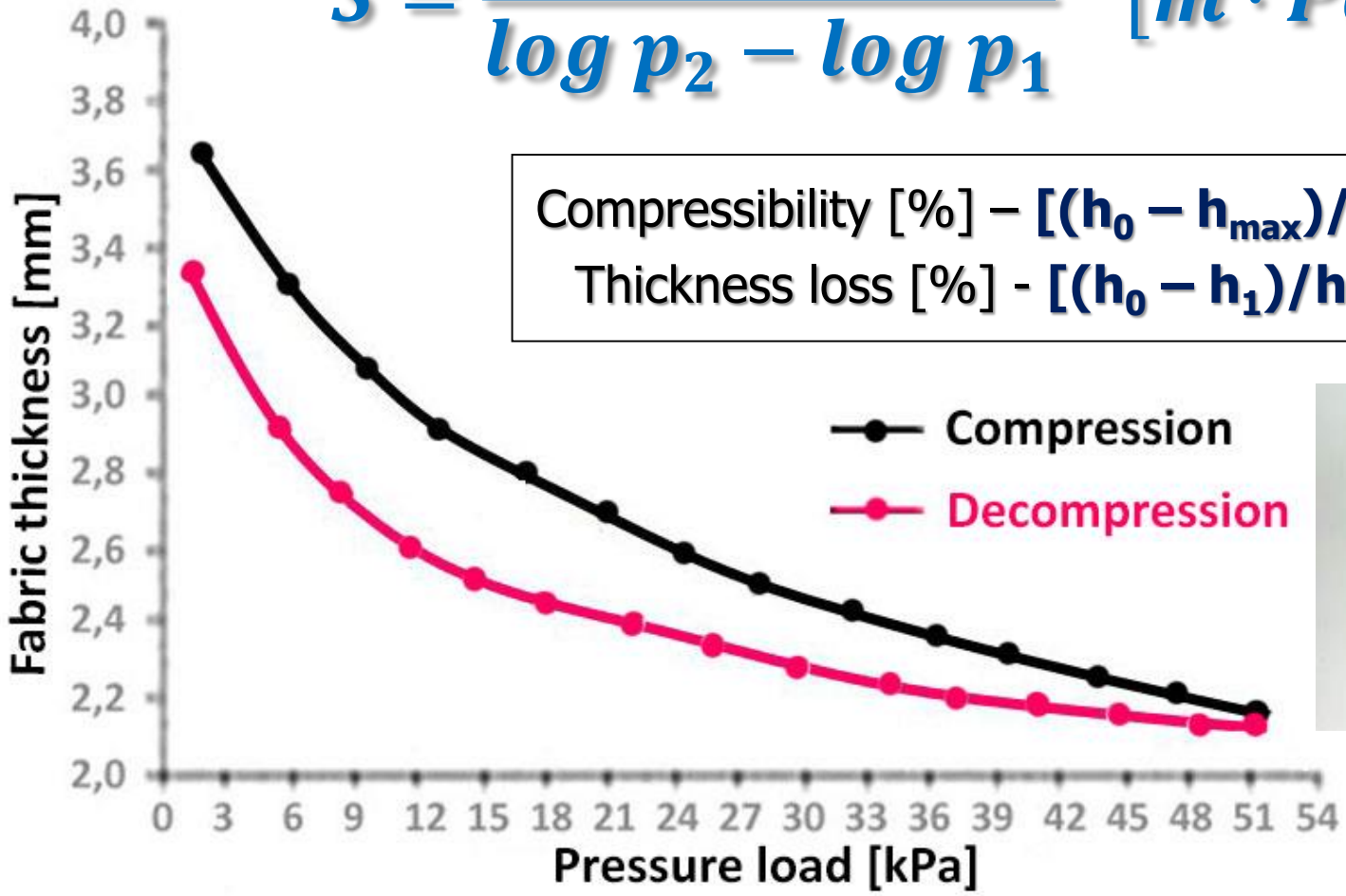


Compressibility

h_1 – thickness [m] in pressure p_1 [Pa]
h_2 – thickness [m] in pressure p_2 [Pa]

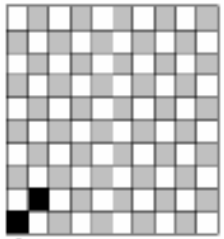
$$S = \frac{h_1 - h_2}{\log p_2 - \log p_1} \quad [m \cdot Pa^{-1}]$$

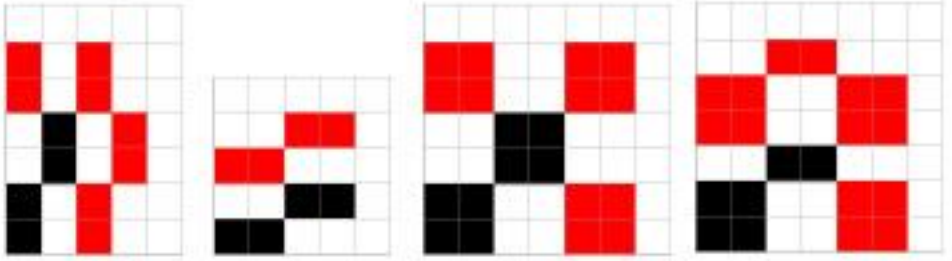
Compressibility [%] – $[(h_0 - h_{max})/h_0]*100$
Thickness loss [%] - $[(h_0 - h_1)/h_0]*100$



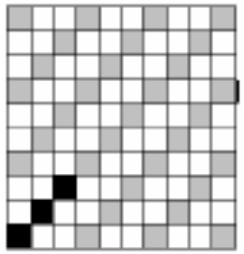
Wovens - design parameters

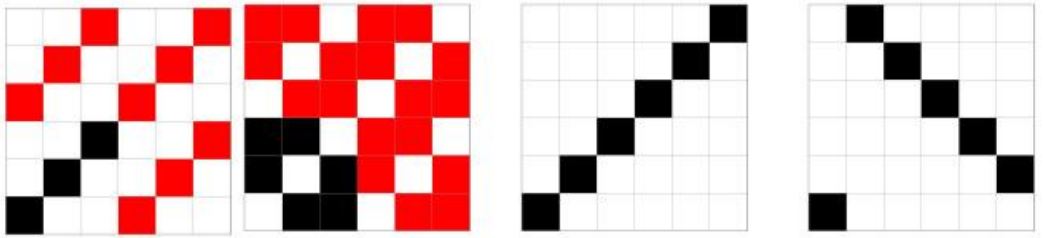
PLAIN





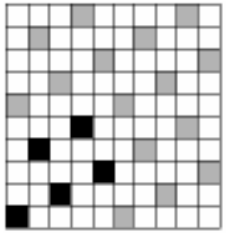
TWILL

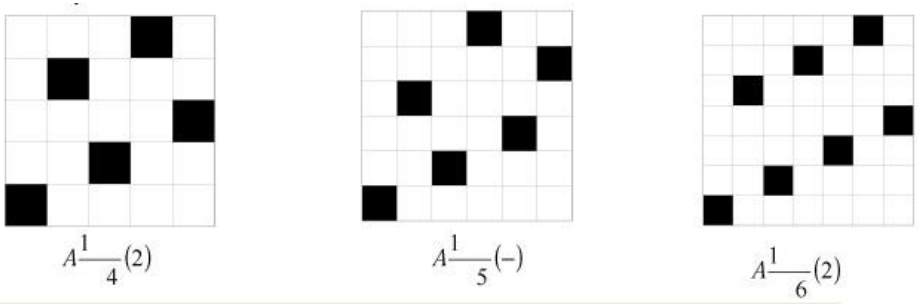




$K\frac{1}{2}(Z)$ $K\frac{2}{1}(Z)$ $K\frac{1}{4}(Z)$ $K\frac{1}{4}(S)$

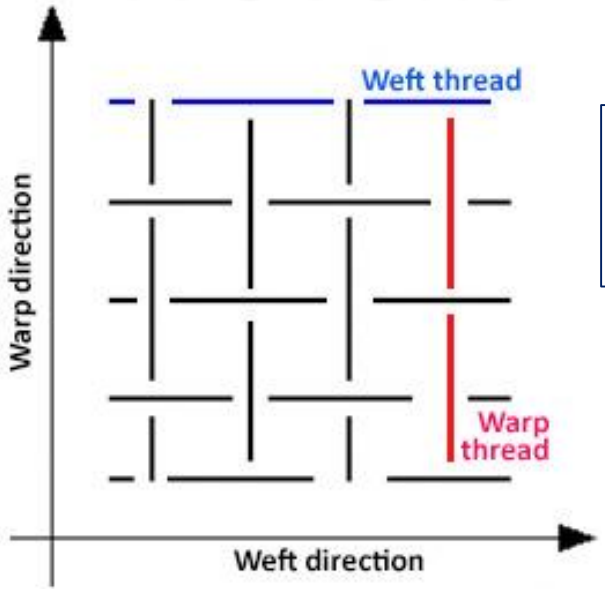
SATIN

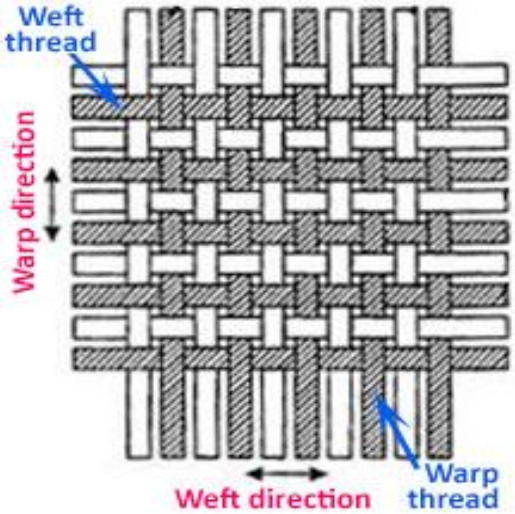




$A\frac{1}{4}(2)$ $A\frac{1}{5}(-)$ $A\frac{1}{6}(2)$

Wovens - warp, weft density





number of threads in direction of warp, and weft

$$D = \frac{n}{l} \left[\frac{threads}{100} mm^{-1} \right]$$

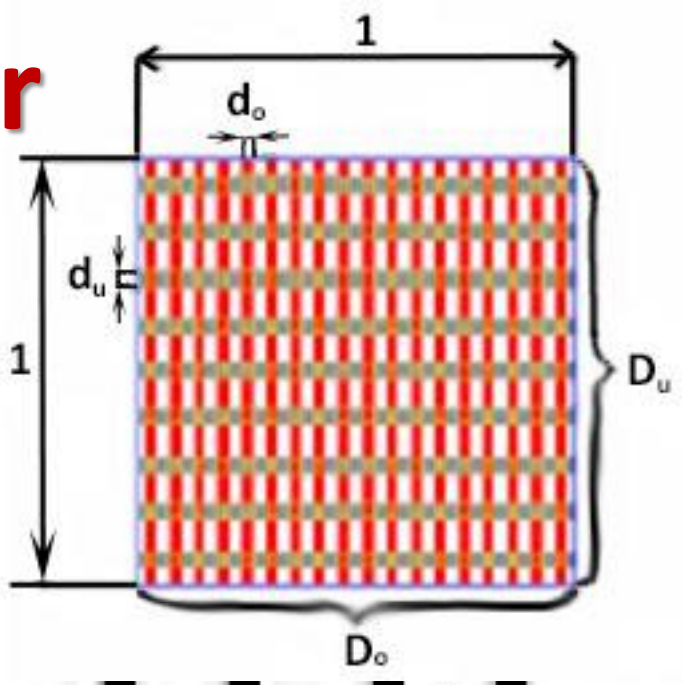
ISO 7211-2:1984 - Textiles - Woven fabrics - Construction - Methods of analysis – Part 2: Determination of number of threads per unit length

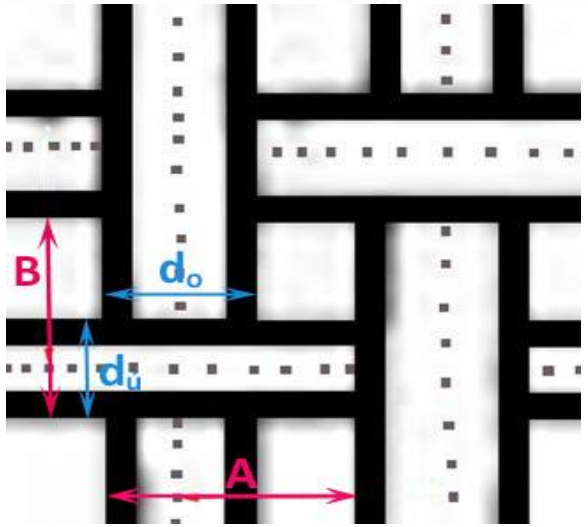
Woven - cover factor

Area covered by fabric threads expressed in %

$$Z = Z_o + Z_u - Z_o Z_u$$

Zo = do/A
Zu = du/B

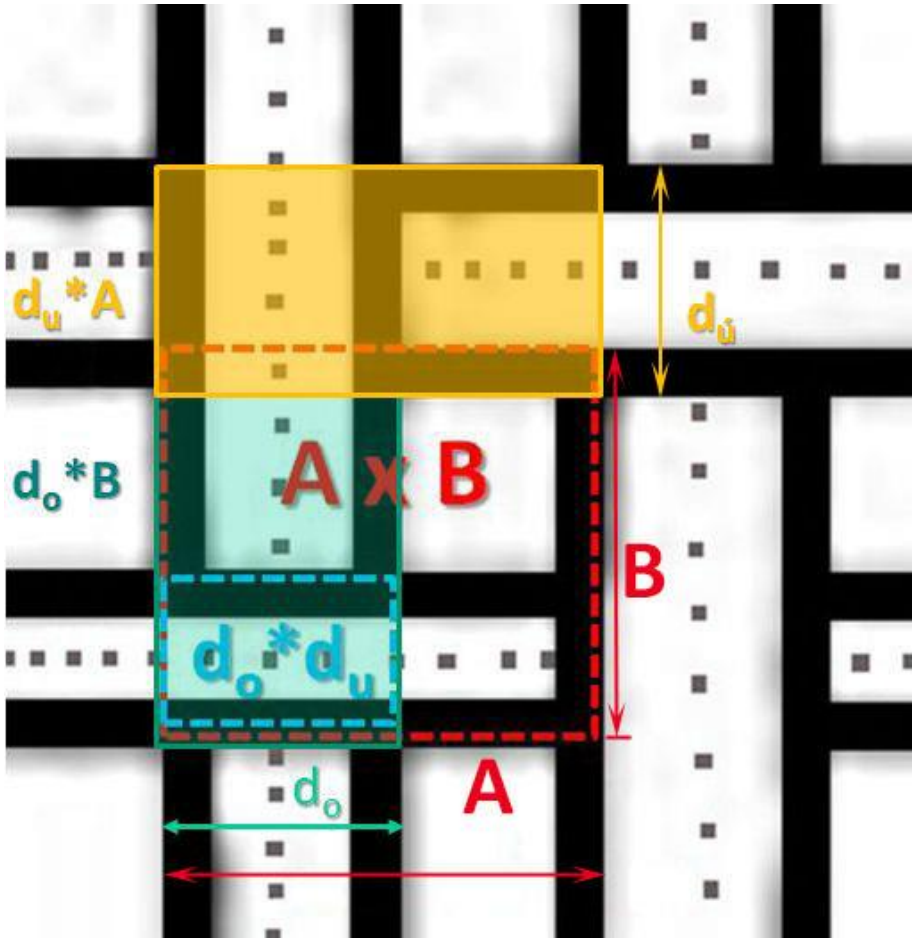




- diameter of warp thread d_o [mm]
- diameter of weft thread du [mm]
- Zo [-] warp cover factor
- Zu [-] weft cover factor

A [mm] – warp thread pitch
B [mm] – weft thread pitch

$$Z = Z_o + Z_u - Z_o Z_u$$



$Zo = do/A$
$Zu = du/B$

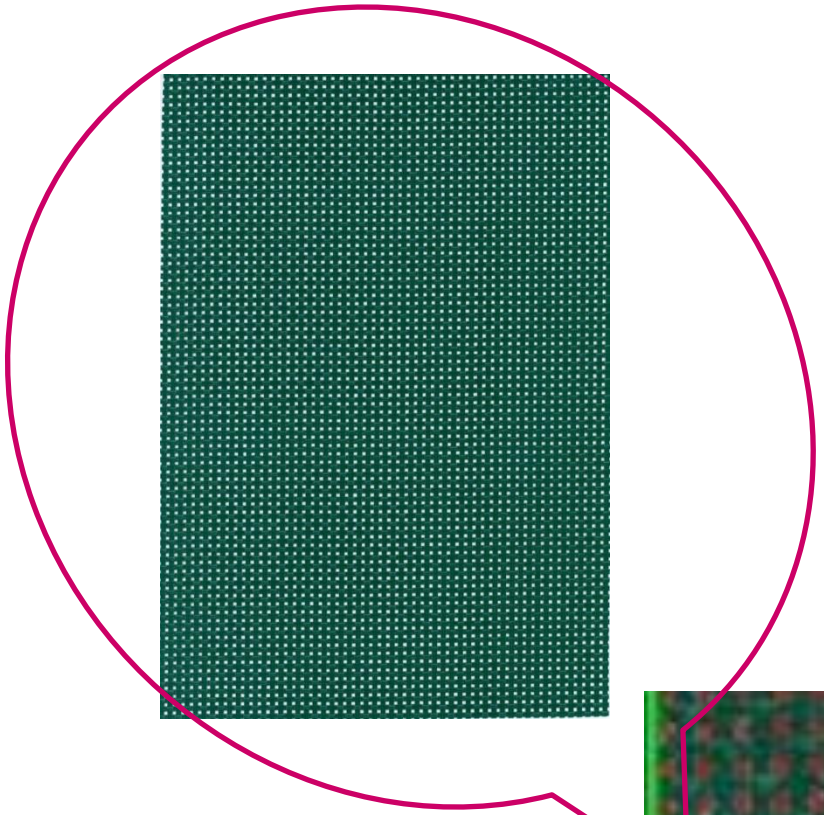
$A\ [mm] = 1/D_o\ [mm^{-1}]$
$B\ [mm] = 1/D_u\ [mm^{-1}]$

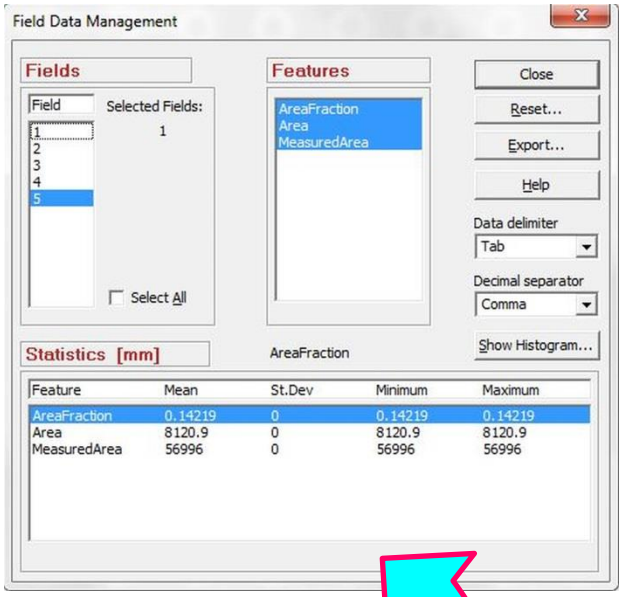
Area covered by threads

$d_u*A + d_o*B - d_o*d_u$

Completely covered area

$A * B$





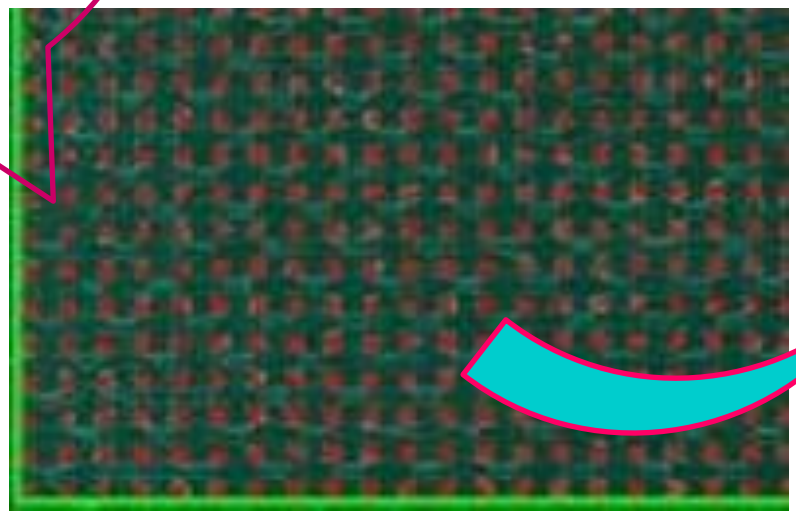
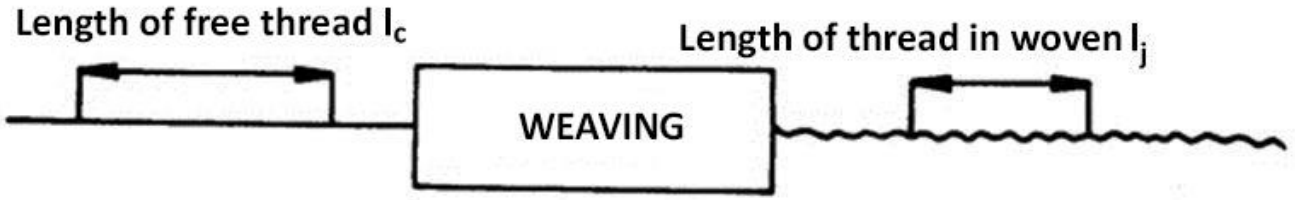


Image analysis

Woven - crimp factor



- Crimp ε_T [%]:

$$\varepsilon_T = \frac{l_c - l_j}{l_j} \cdot 10^2 = \frac{\Delta l}{l_j} \cdot 10^2 \ [\%]$$

- Crimp ratio K_T (E_T) [-]

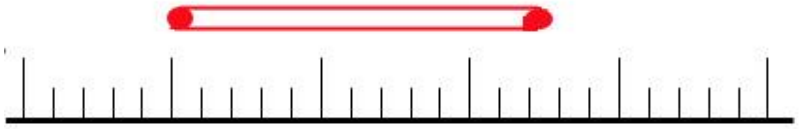
$$K_T = \frac{l_c}{l_j} \ [\%]$$

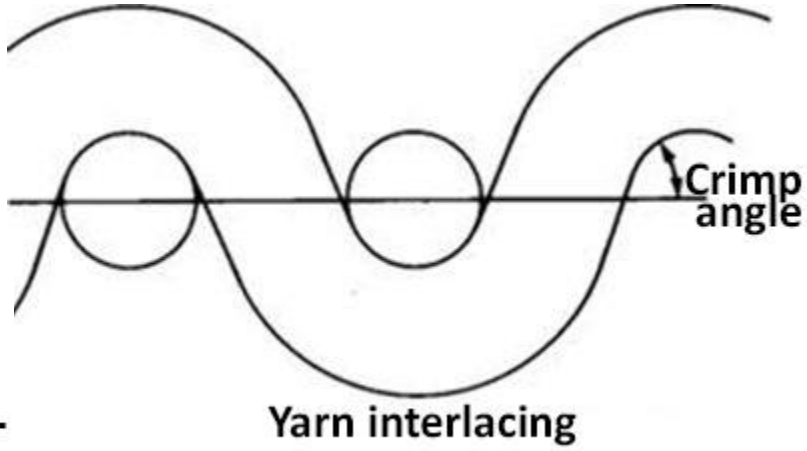
- Take up P_T[%]:

$$P_T = \frac{\Delta l}{l_c} \ [\%]$$

Crimp analysis

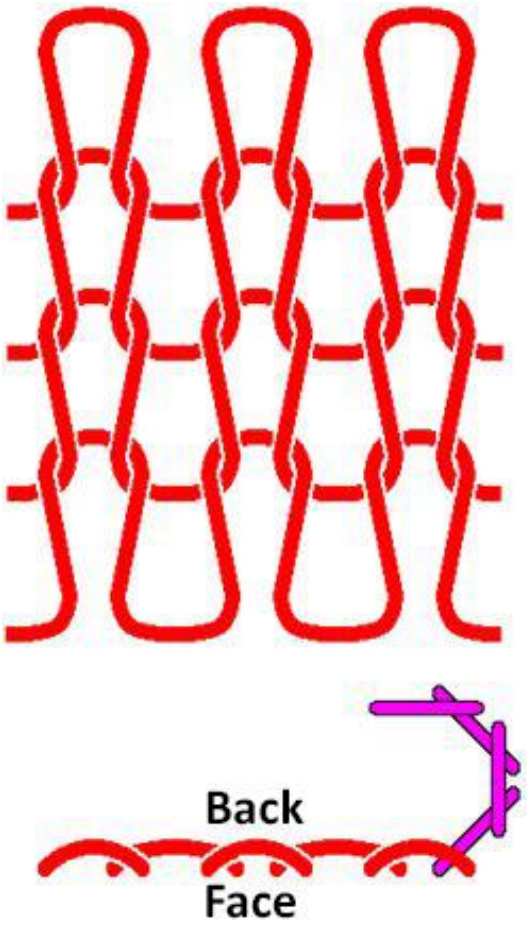
- Length of woven specimen, cut on 100 x 100 mm in warp/weft direction ⇒ l_j [mm]
- The warp/weft threads are drawn out of the fabric, stretched thread length is measured ⇒ l_c [mm]
- $l_j = 100$ mm
- $l_c = l_j + \Delta l$



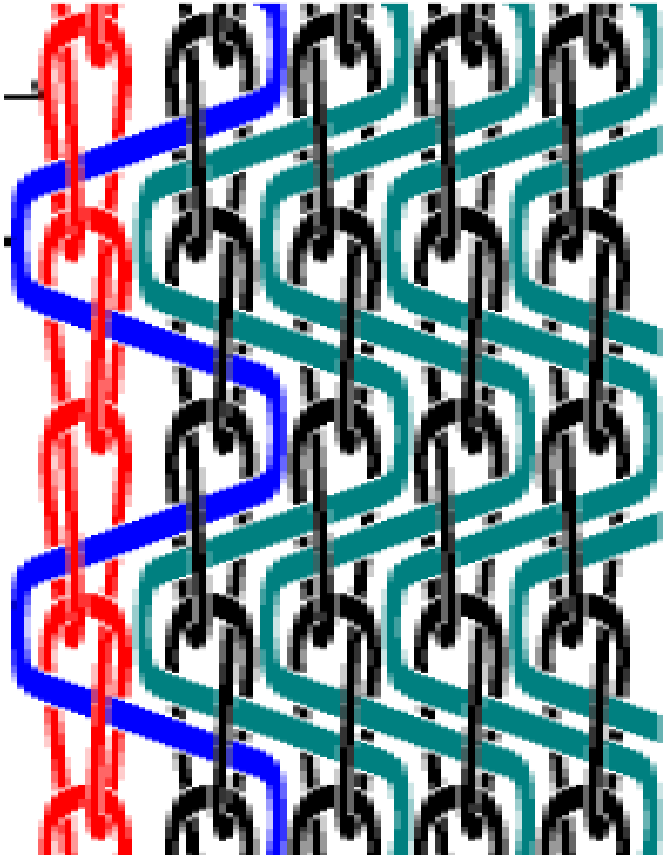


Knitted fabric

Weft-knitted



Warp-knitted



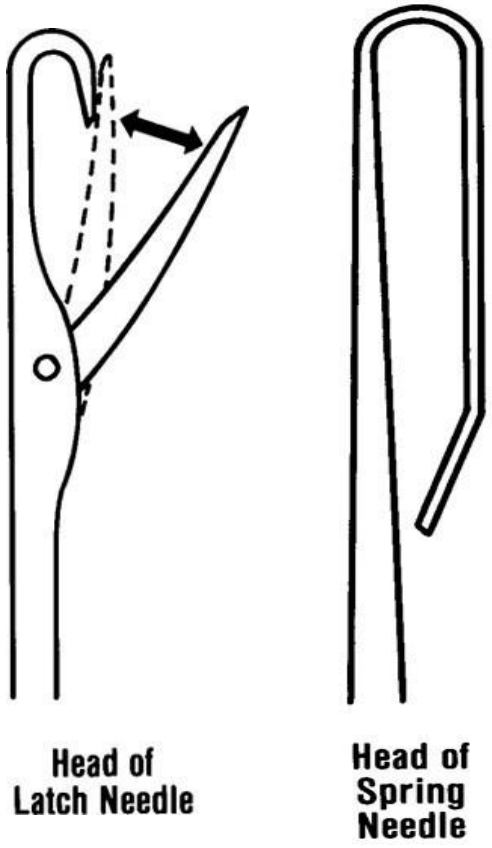
Knitted structure – loops (stitch)

- **Stitch density per area H_A**
  - column (wale) density

    H_C [n/10 mm]
  - row (course) density

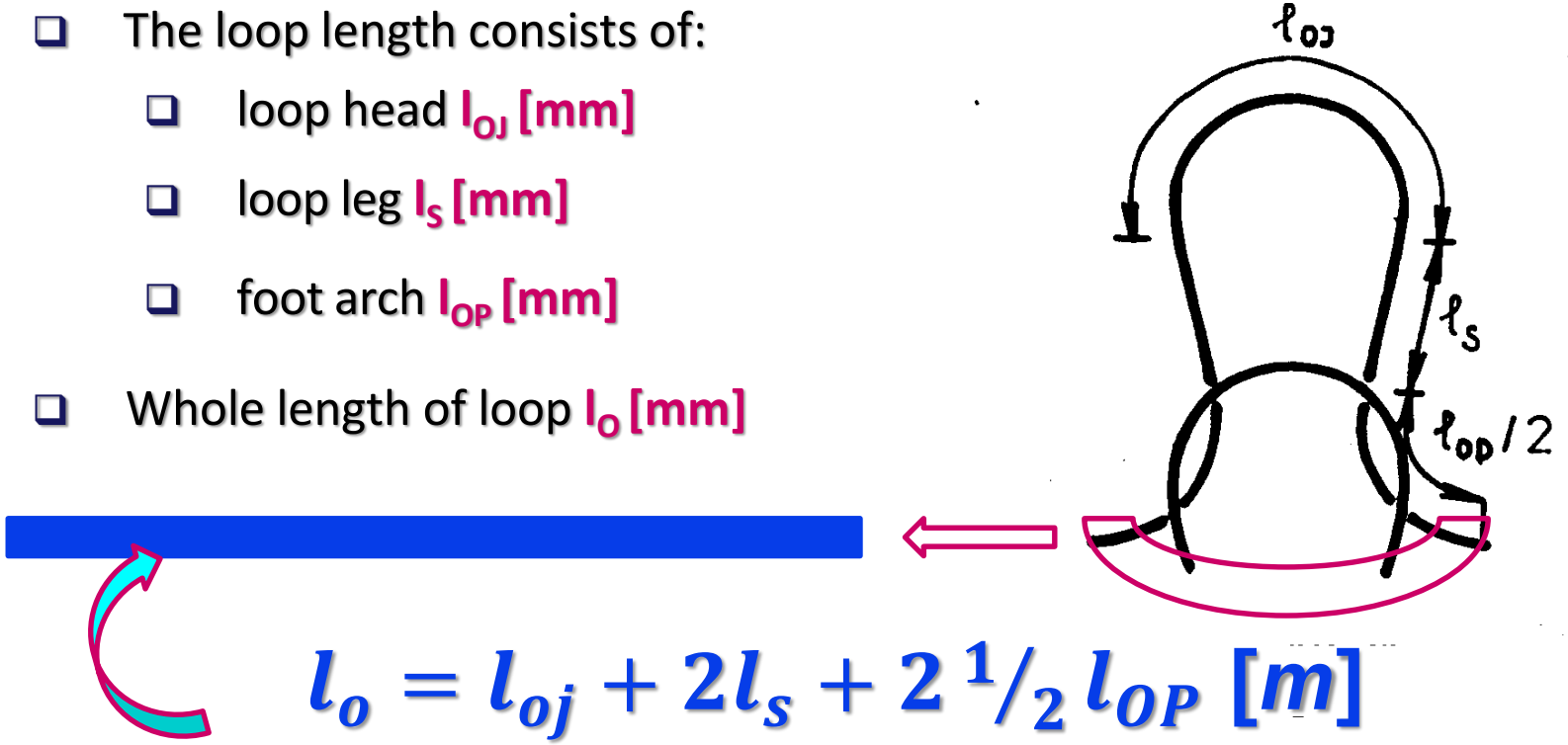
    H_R [n/10 mm]

$H_A = H_C * H_R$
$[n^2/100mm^2]$



Knitted – length of loop

- EN 14970:2006 "Textiles - Knitted fabrics – Determination of stitch length and yarn linear density in weft knitted fabrics
- The loop length consists of:
  - loop head l_{OJ} [mm]
  - loop leg l_S [mm]
  - foot arch l_{OP} [mm]
- Whole length of loop l_O [mm]

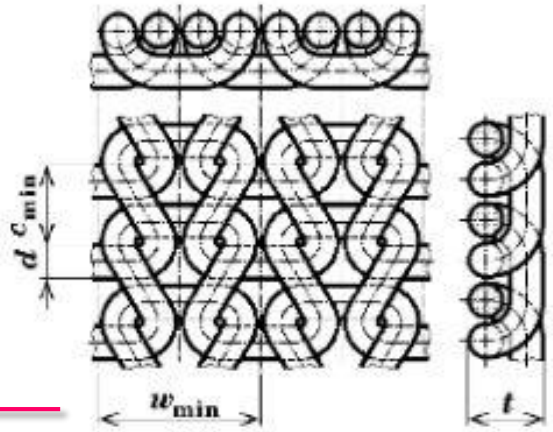


$$l_o = l_{oj} + 2l_s + 2\,{}^1\!/_2\, l_{OP}\ [m]$$

Knitted – coeff. of stitch density

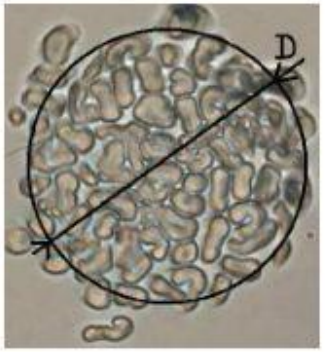
- **Coefficient of stitch density δ** calculated from loop length and yarn diameter:

$$\delta = \frac{l_o}{d} \text{ [1]}$$



- **Yarn diameter d:**
  - measured (microscope) or calculated from yarn fineness

$$d[mm] = \sqrt{\frac{4T[tex]}{\pi\rho[kg \cdot m^{-3}]}}$$



  - volume density of yarn $\rho_{nitě}$ consists of fiber density $\rho_{vláken}$, and yarn packing density!!!

$$\rho_{yarn} = \rho_{fibres} * \mu \text{ (yarn packing density)}$$