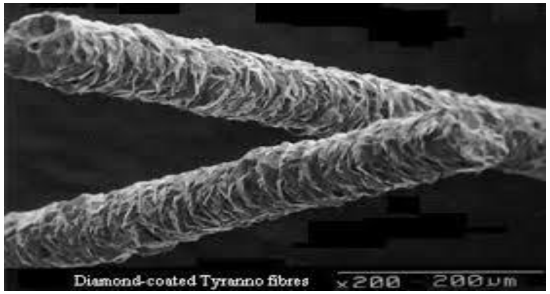
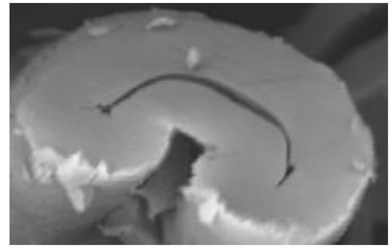
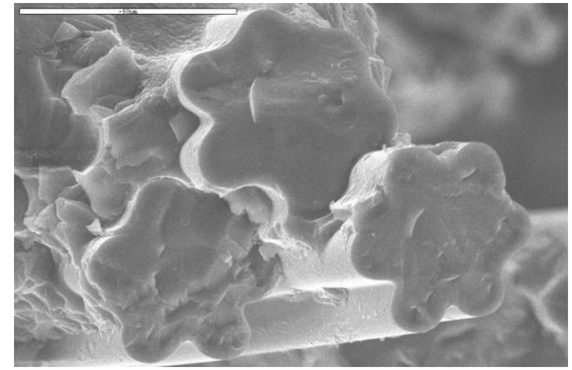
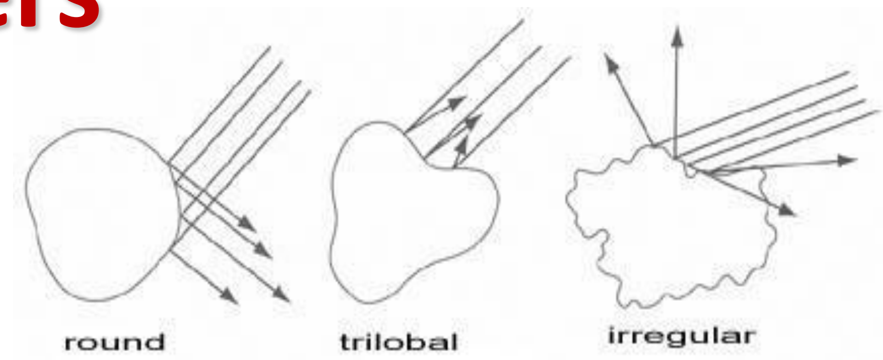


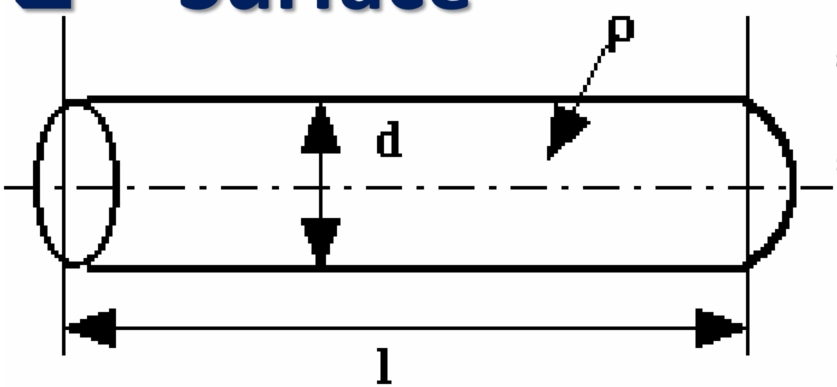


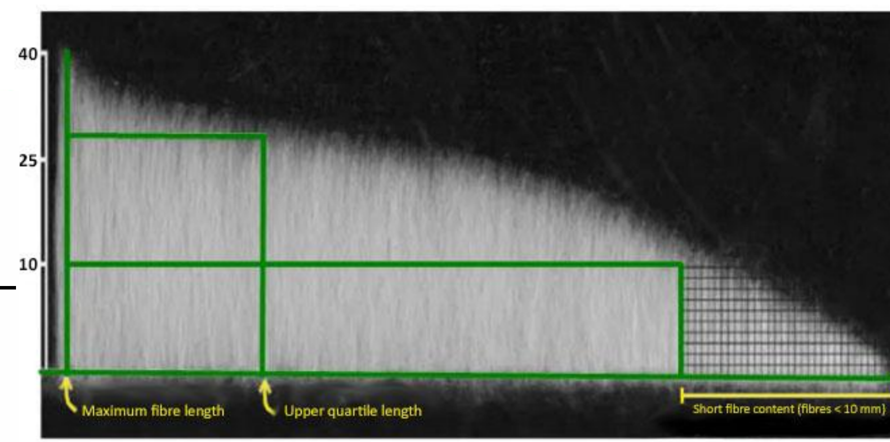


Geometry of fibers

- ❑ Fiber length
- ❑ Fineness
- ❑ Cross-section
- ❑ Surface







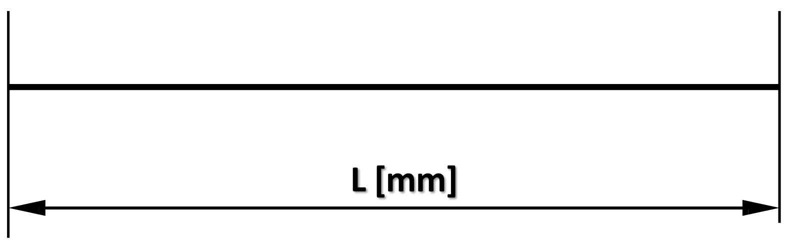
Length of fibers

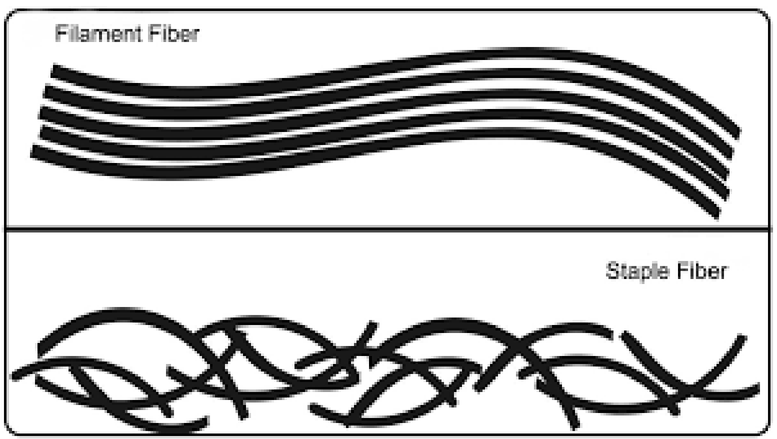
Range between the ends of straightened fibers without undulation and strain

STAPLE FIBERS – high variability

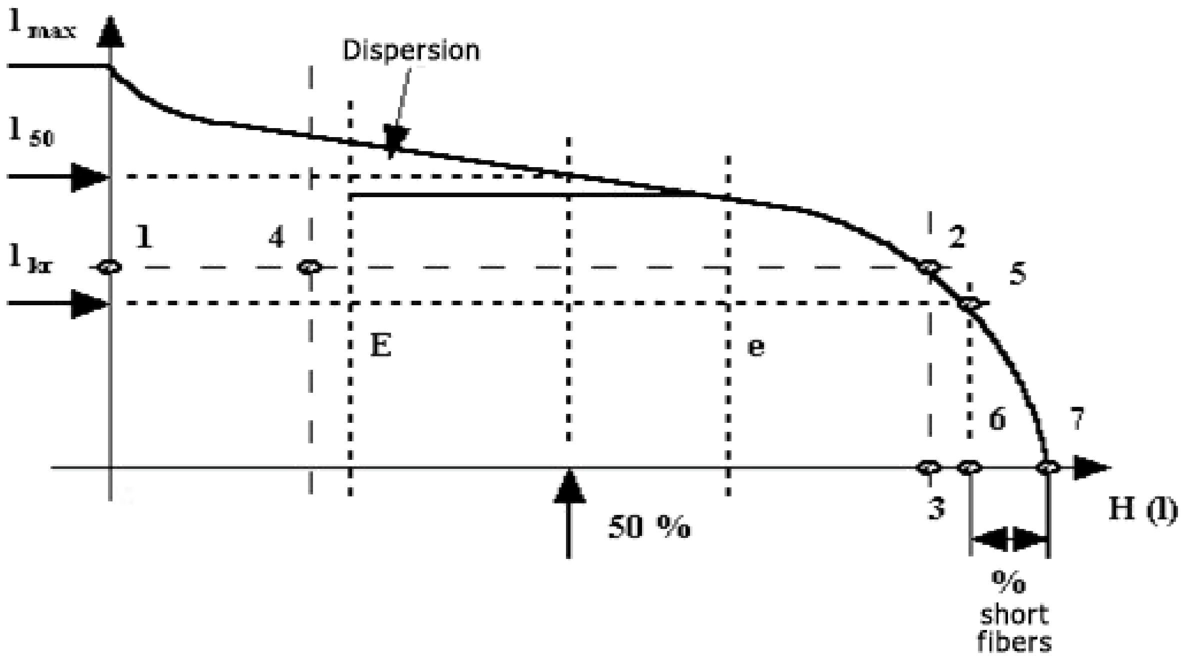
Typical for natural fibers

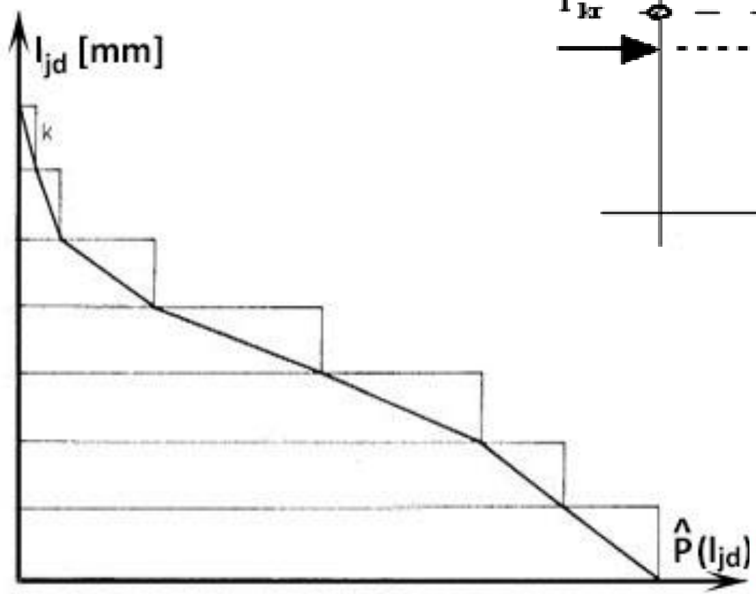
Staple diagram – **STAPL**





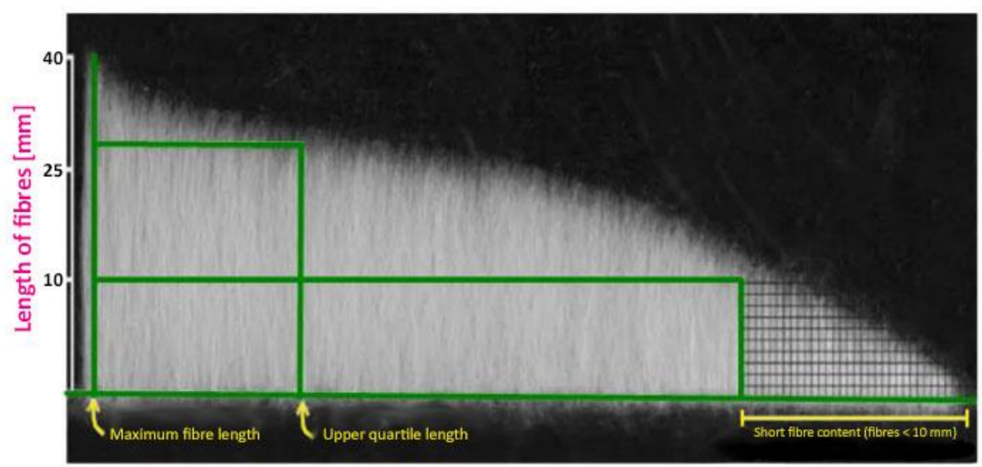
Staple diagram





$$P(l) = -\int_{l_{max}}^{l} f(l)dl =$$

$$= 1 - \int_{0}^{1} f(l)dl = 1 - F(l)$$



Methods of length measurement

Direct methods

measurement of individual fibers

Indirect methods

analysis through categorized fiber mass

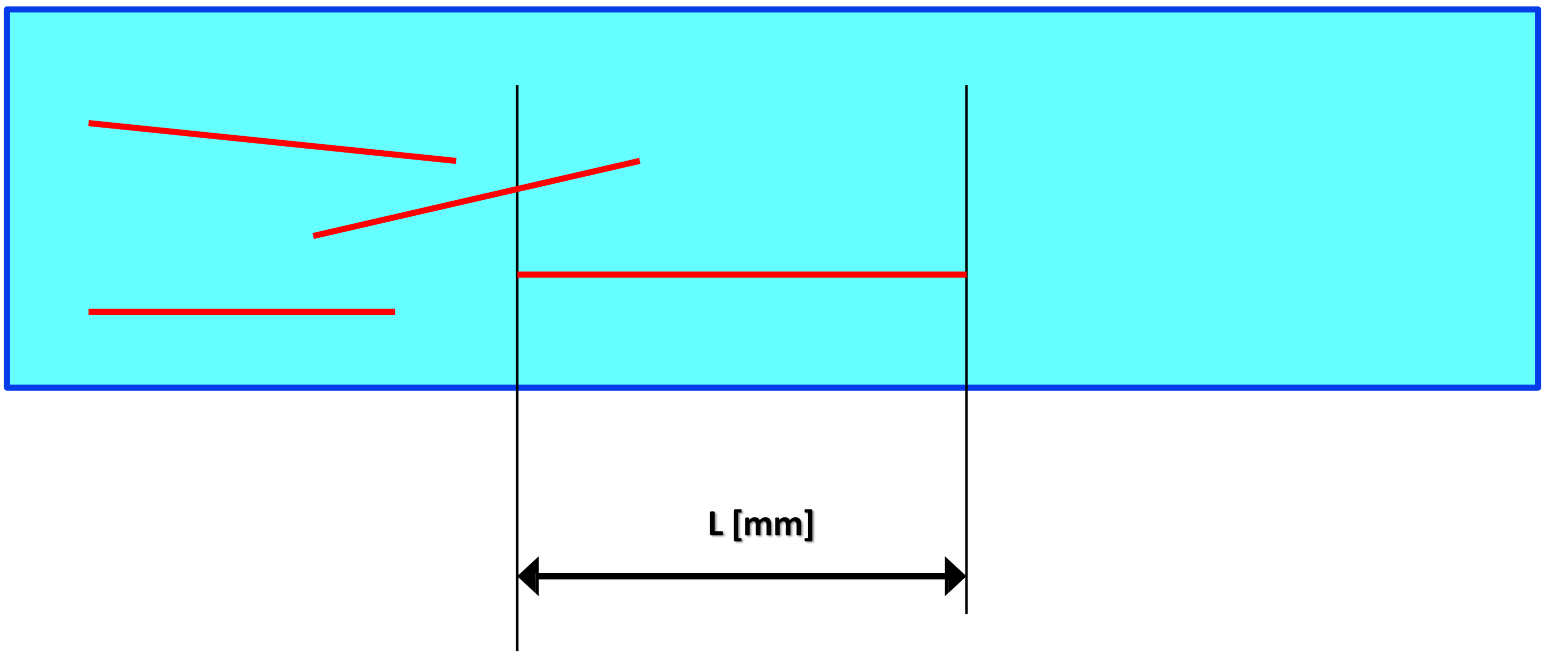
optical methods

Staple diagram - Fibrogram

light scattering trough tuft fibers

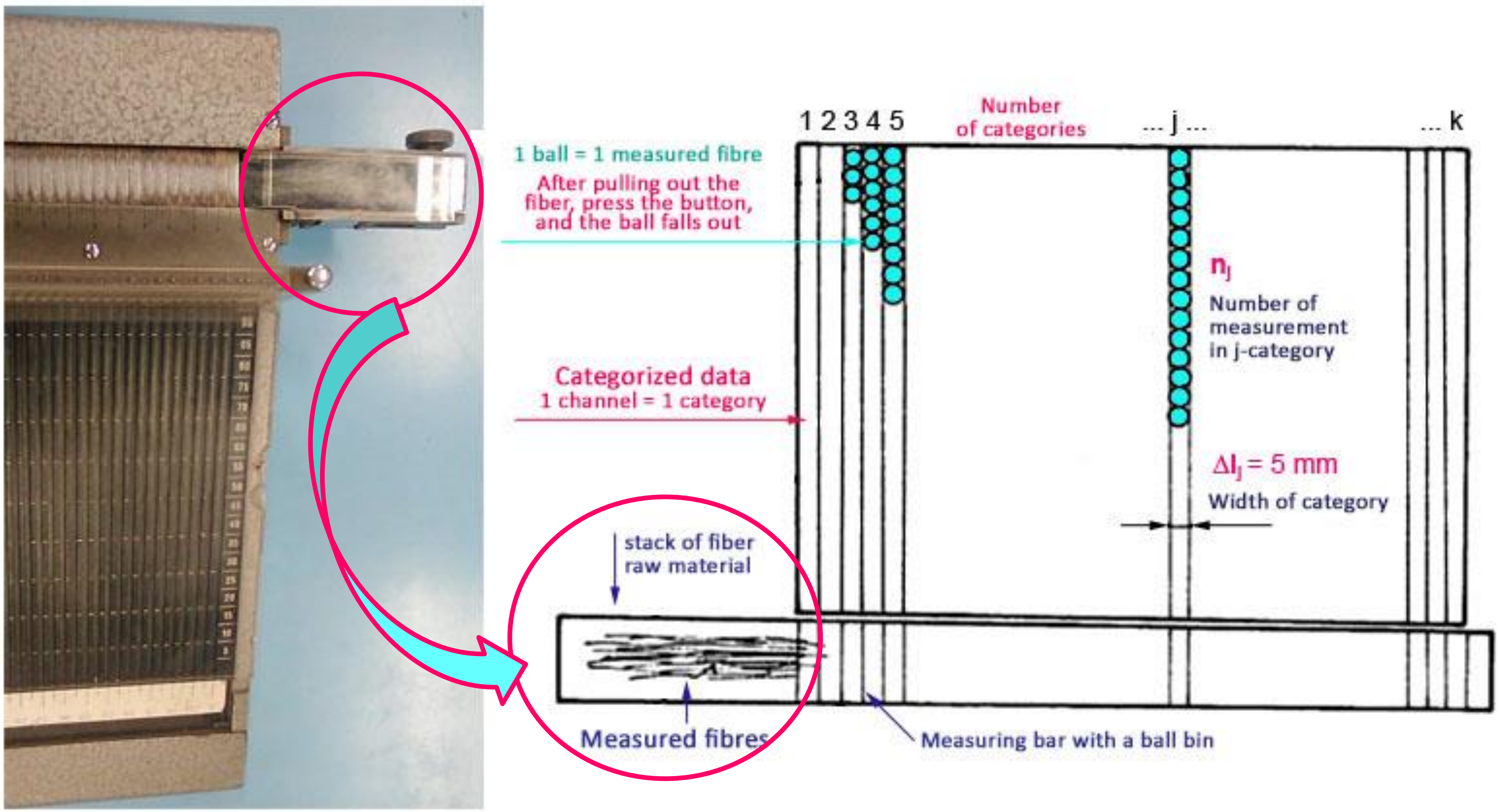
Direct measurement I.

Use of glass plate

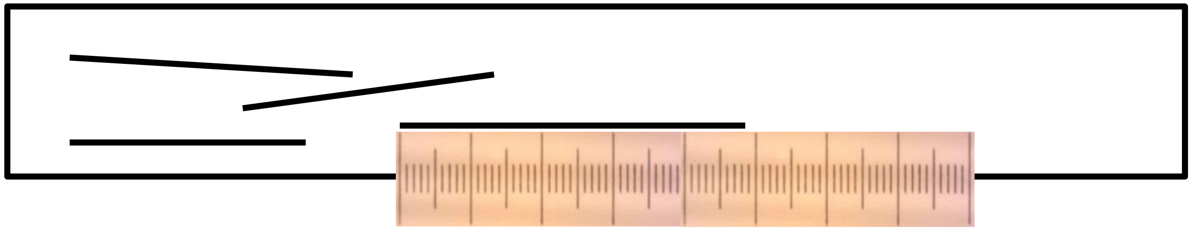


Direct measurement II.

Use of ball sorter



Direct measurement III.



Absolute frequency n

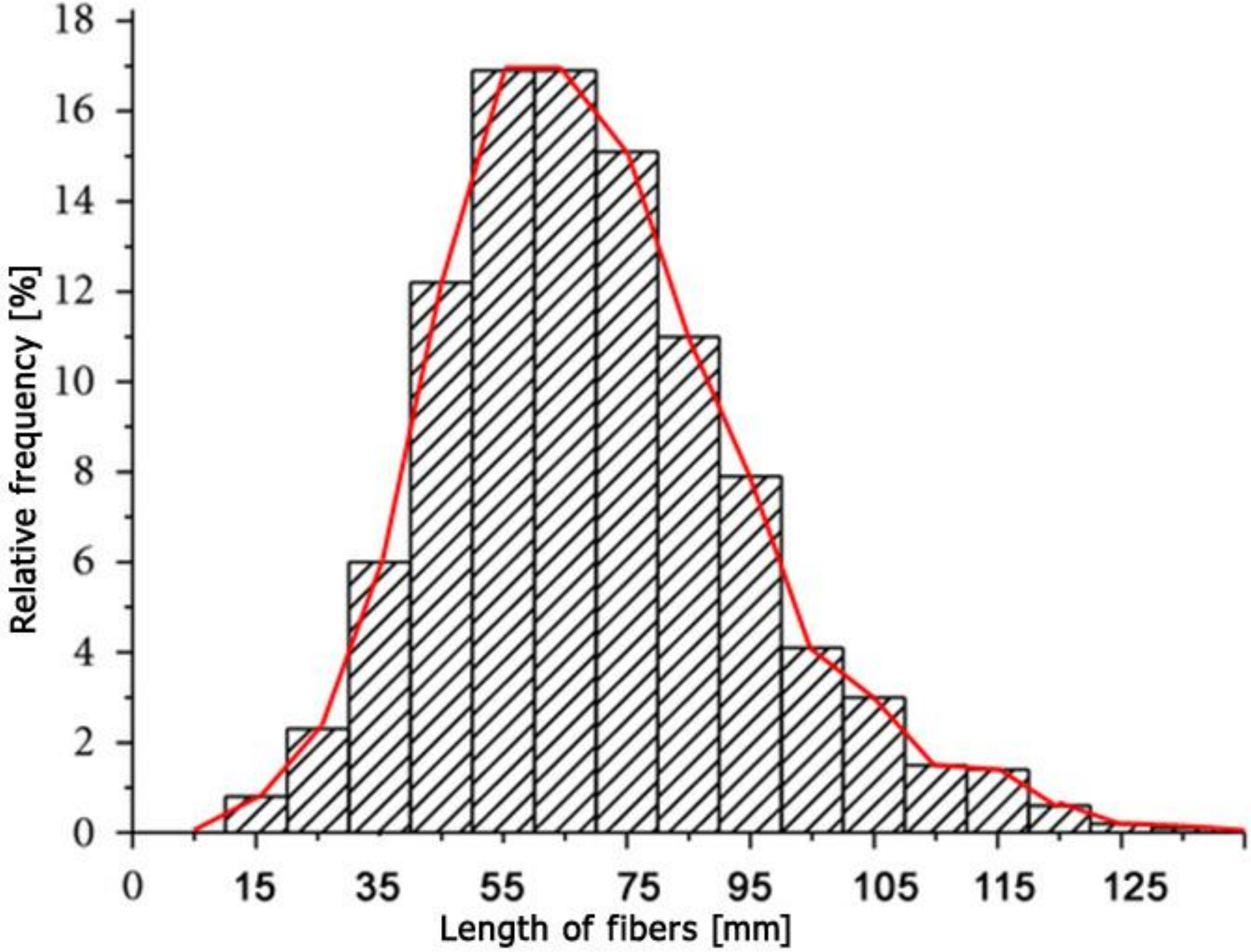
$n = \Sigma n_j$

Relative frequency f

$f_j = (n_j / n) * 100$

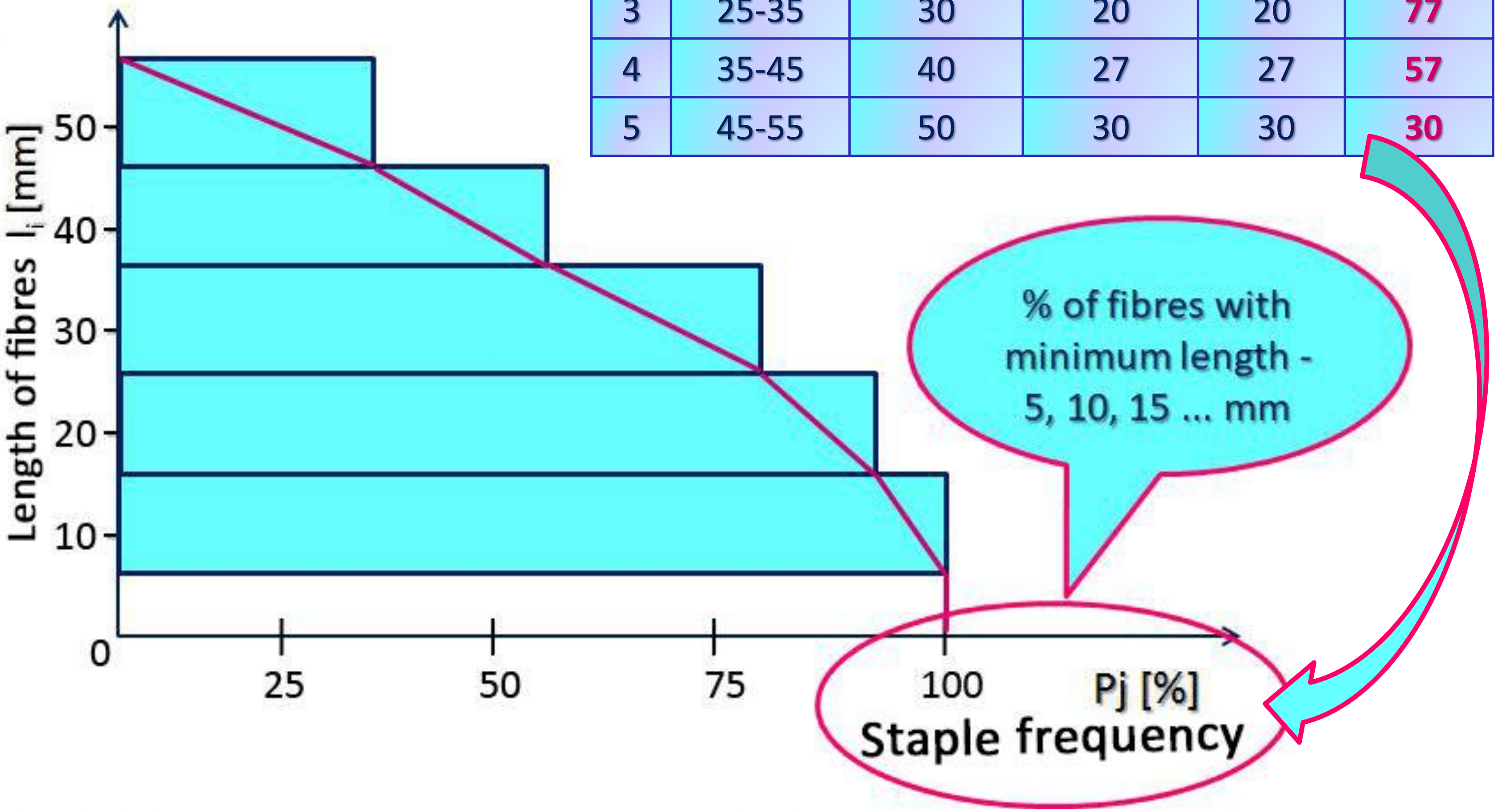
j	l_{jd} - l_{jh} [mm]	l_j [mm]	Number of measurement	n_j	f_j [%]
1	10-20	15	𝍸 𝍸	10	10
2	20-30	25	𝍸 𝍸 |||	13	13
3	30-40	35	𝍸 𝍸 𝍸 𝍸	20	20
4	40-50	45	𝍸 𝍸 𝍸 𝍸 𝍸 ||	27	27
5	50-60	55	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	30	30
			Σ	100	100

Histogram of fiber lengthes



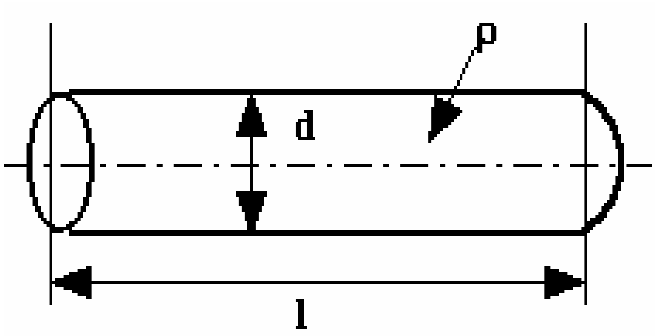
Staple diagram

j	l_{jd} - l_{jh} [mm]	l_j [mm]	n_j	f_j	P_j
1	5-15	10	10	10	100
2	15-25	20	13	13	90
3	25-35	30	20	20	77
4	35-45	40	27	27	57
5	45-55	50	30	30	30



Indirect methods

- Estimation from mass of fibers
- Presumption:
  - All fibers have same size of cross-section S [m^2]
  - Volume density ρ [kg/m^3] is constant
  - Mass of one fiber depends only on fiber length

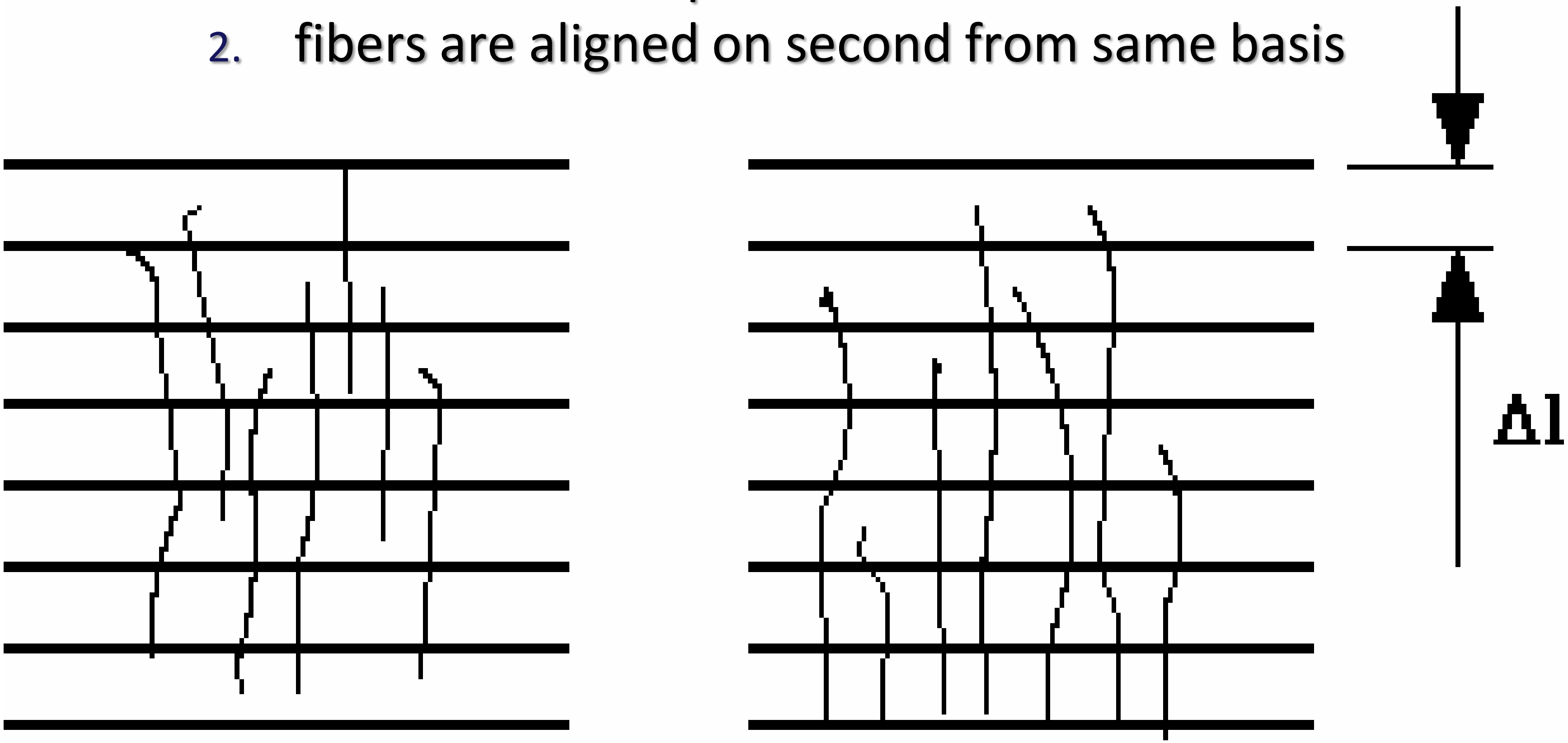


$$m_v = S * \rho * l = k * l$$

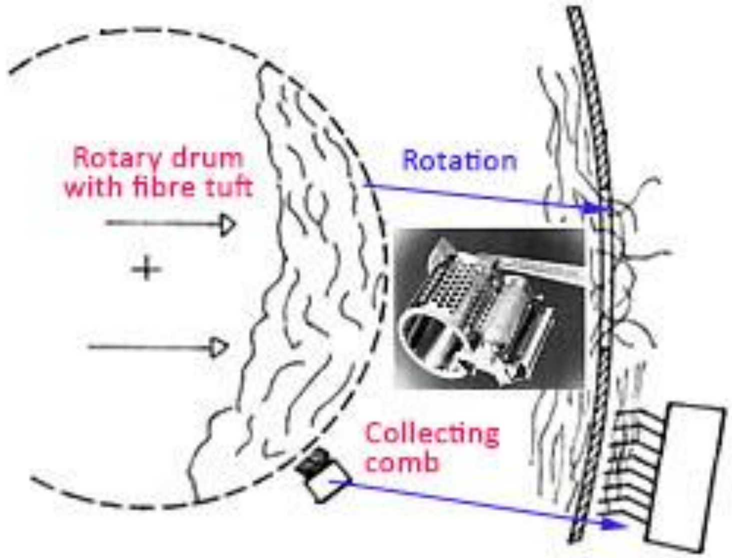
m_v	⇒	fiber mass	[kg]
S	⇒	cross-section	[m^2]
ρ	⇒	volume density	[$kg.m^{-3}$]
l	⇒	fiber length	[m]

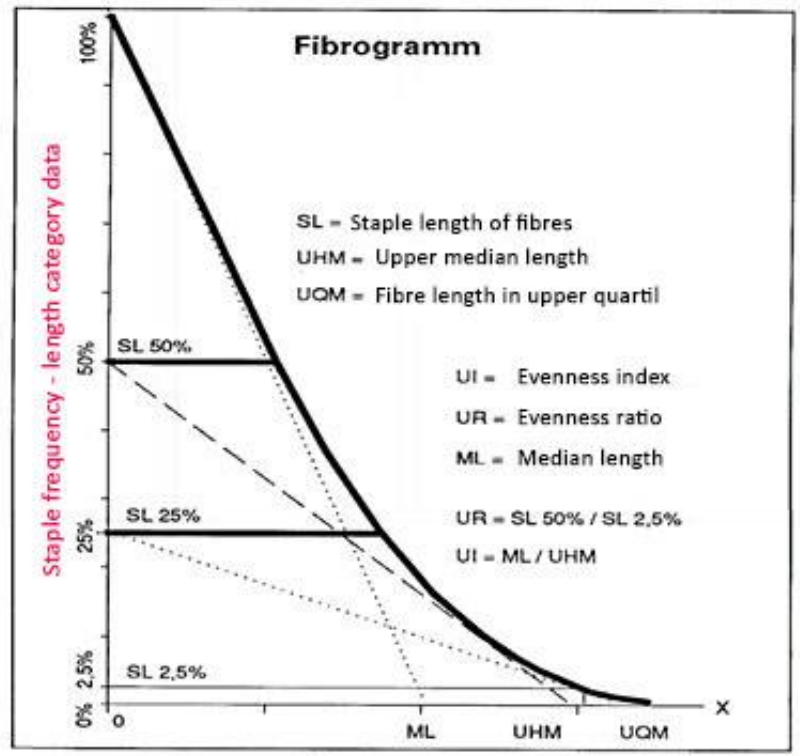
Use of comb sorter

- **Two comb sorters:**
  1. tuft of fibers are placed in first sorter
  2. fibers are aligned on second from same basis

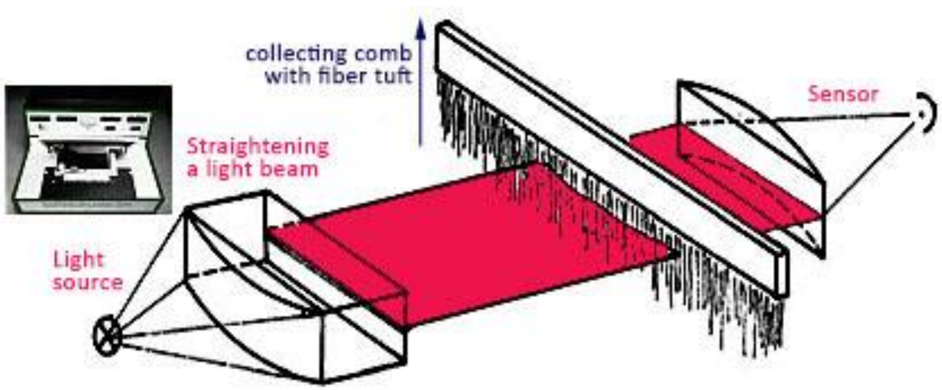


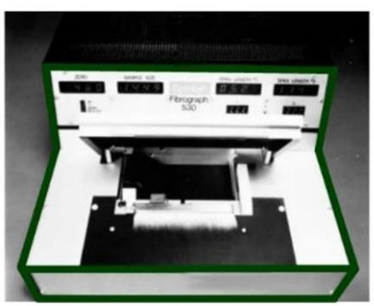
FIBROSAMPLER

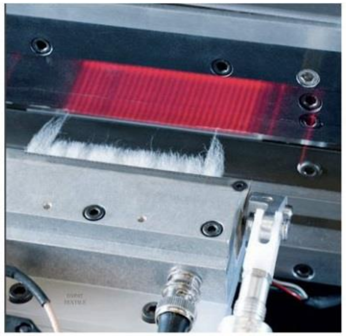




FIBROGRAPH







Fiber fineness

$$T_v = \frac{m\,[g]}{l\,[km]} \quad [tex]$$

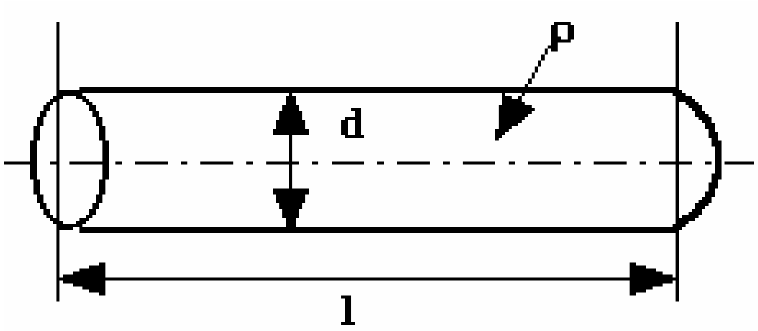
Methods for fineness estimation:

- Optical microscope for measurement of cicrcular fiber diameters or for analysis of fiber cross-section
- Gravimetric method
- Vibration method
- Airflow method

ISO 1973:1995

Textile fibres — Determination of linear density — Gravimetric method and vibroscope method

Estimation from fiber diameter



$$\overline{T}_v = \frac{\pi}{4} \cdot \left(\overline{d}\right)^2 \cdot \rho_{vk} \cdot K \ [tex]$$

d ⇒ diameter of fiber in [μm] recalculated on [m]

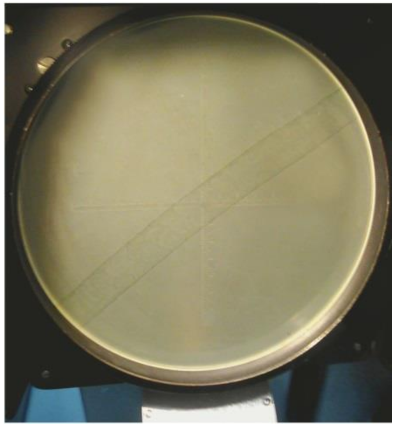
ρ_{vk} ⇒ volume density of fibers [kg.m^{-3}]

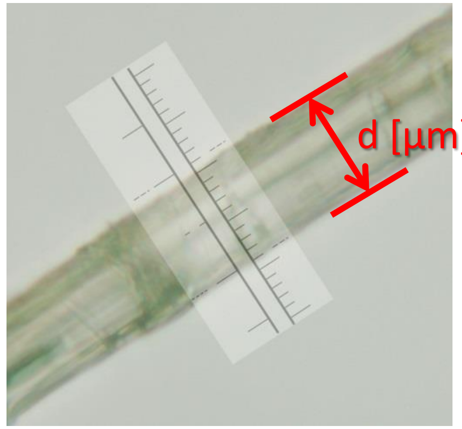
l_v ⇒ fiber length[m]

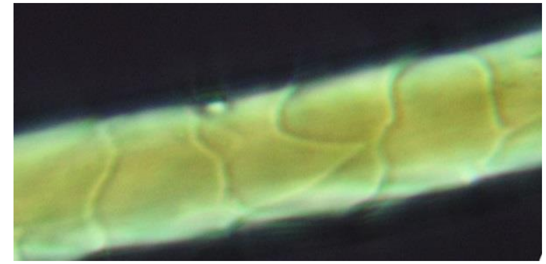
K ⇒ unit converter for [tex≈g/km] (here K = 10^6)

T_v ⇒ range for fibers 0,1 – 0,9 tex = 1 – 9 dtex!!!

Use of optical microscope



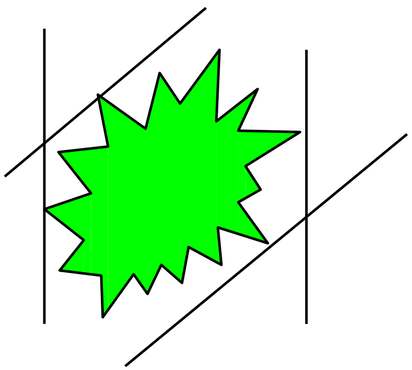




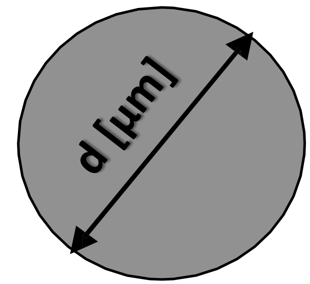
$n = \sum n_j =$ ***100 measurement***

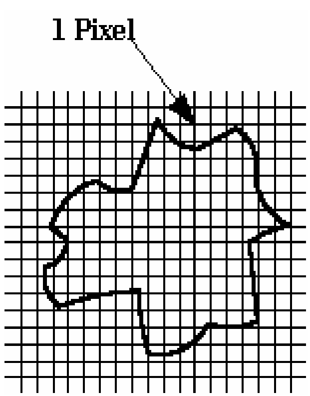
j	d_{jd} - d_{jh} [µm]	d_j [µm]	zápis	n_j	f_j [%]	F_j [%]
1	11-13	12	𝍸 𝍸	10	10	10
2	13-15	14	𝍸 𝍸 |||	13	13	23
3	15-17	16	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	30	30	53
4	17-19	18	𝍸 𝍸 𝍸 𝍸 𝍸 ||	27	27	80
5	19-21	20	𝍸 𝍸 𝍸 𝍸	20	20	100

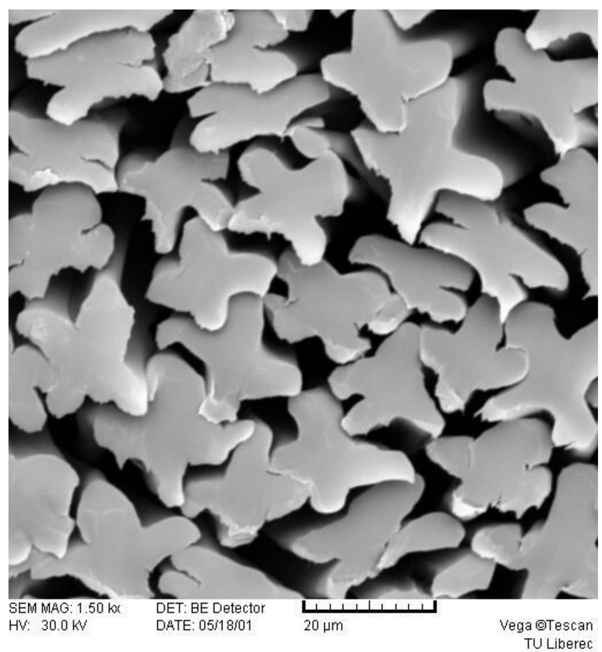
Estimation from fiber cross-section

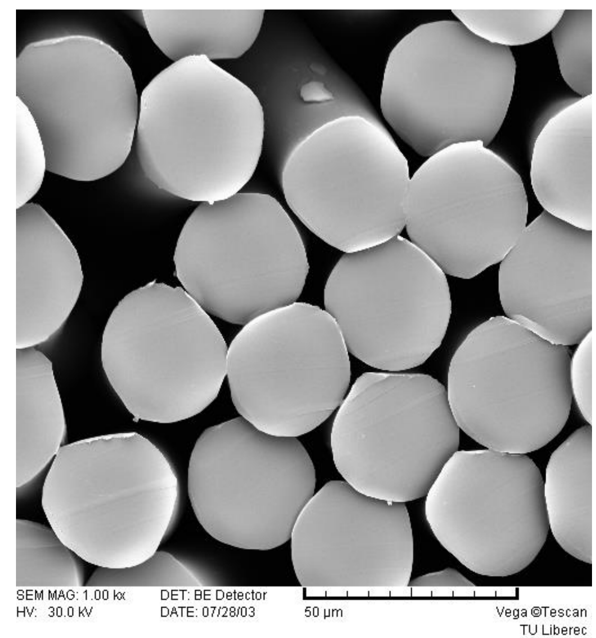


$$\overline{T_v} = S_v \cdot \rho_{vk} \cdot 10^6 \ [tex]$$









Use of gravimetry

- exact estimation of fiber length
- weighing of fiber tuft
- used for multifilaments

$$T_v = \frac{m_{sv}}{l_{sv} \cdot n_v} \; [mg \cdot m^{-1}] = [tex]$$

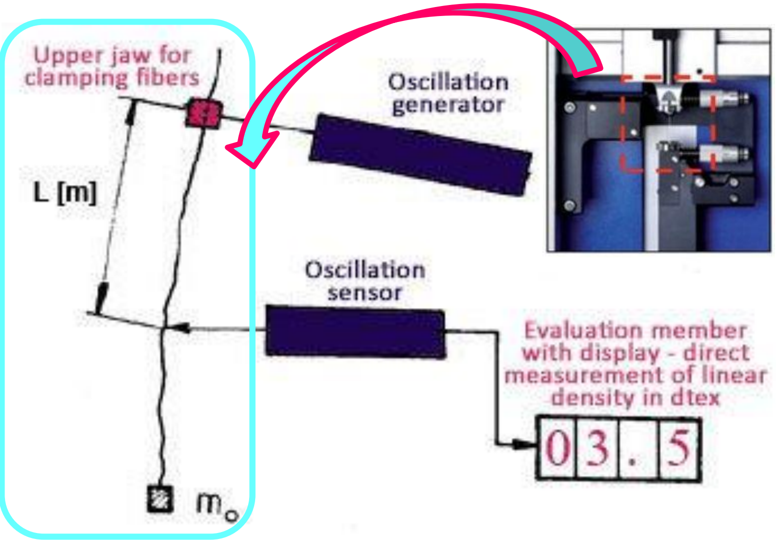
m_{Sv} ⇒ mass of fiber tuft [mg]

l_{Sv} ⇒ length of fiber tuft [m]

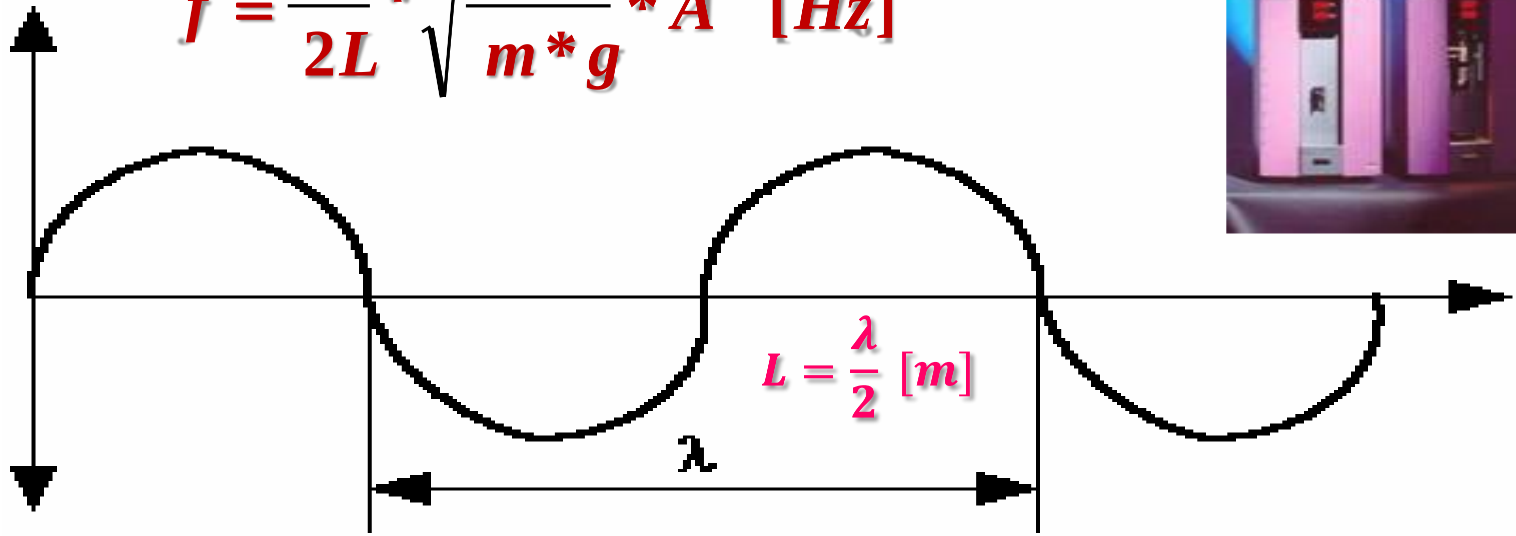
n_V ⇒ number of fibers in the tuft

Vibration method

- Based on frequency analysis of stabilized vibration of stretched fiber, e.g. Vibroscope

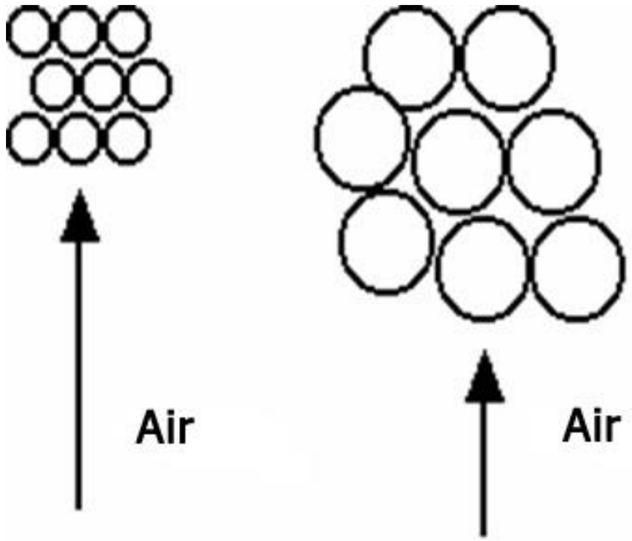


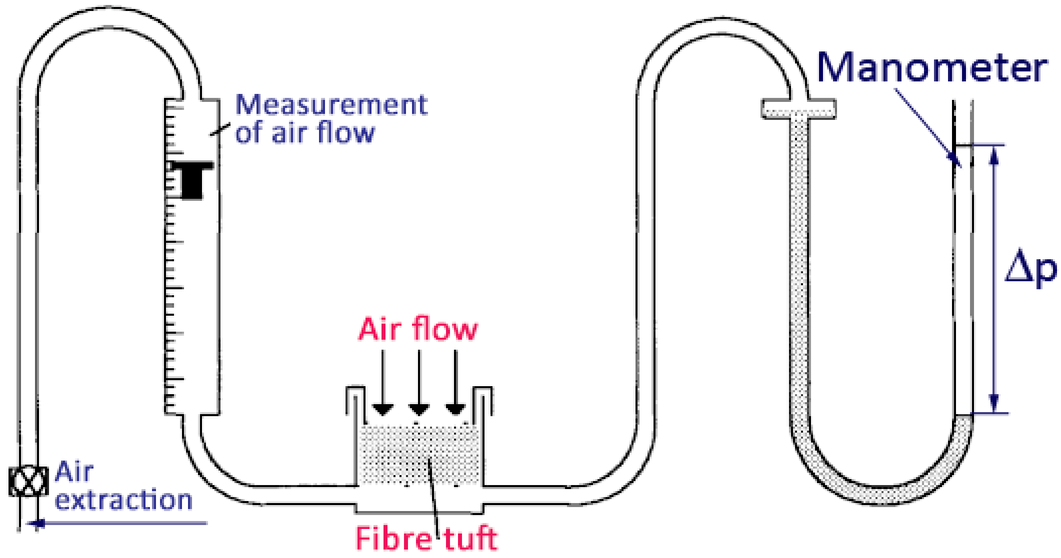
$$f = \frac{1}{2L} * \sqrt{\frac{F}{m * g}} * A \quad [Hz]$$



Airflow method

- Estimation of fiber tuft resistence to airflow
- Measurement of volume amount of transfered air!!!





$$Q = \frac{A_c}{16 \cdot k \cdot \eta \cdot L_c} \cdot \Delta P \cdot \frac{\varepsilon^3}{(1-\varepsilon)^2} \cdot d^2$$

$$d = \sqrt{\frac{Q}{K_g \cdot \Delta P} \cdot \frac{(1-\varepsilon)^2}{\varepsilon^3}}$$

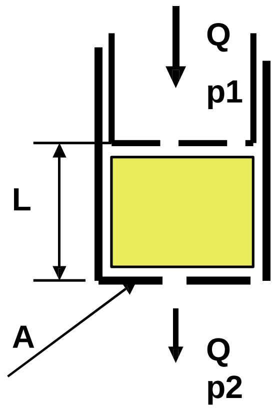
$$K_g = \frac{A_c}{16 \cdot k \cdot \eta \cdot L_c}$$

Q - airflow speed [m³/s]

$$\varepsilon = \frac{V_C - V_m}{V_C}$$

Δp - pressure drop [Pa]

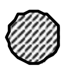
$$\bar{T}_v = \frac{\pi}{4} \cdot (\bar{d})^2 \cdot \rho_{vk} \cdot 10^6 \ [tex]$$



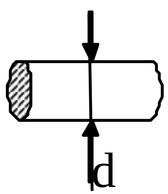
Cross-section and fiber surface

Cross-section

Circular

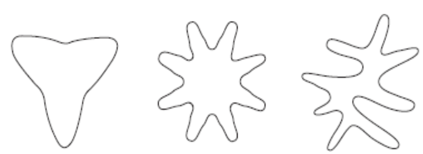


wool, synthetics
analysis of diameter

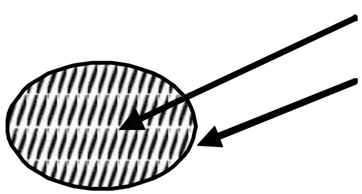


Non-circular

cotton, viscose, silk
analysis of cross-section shape

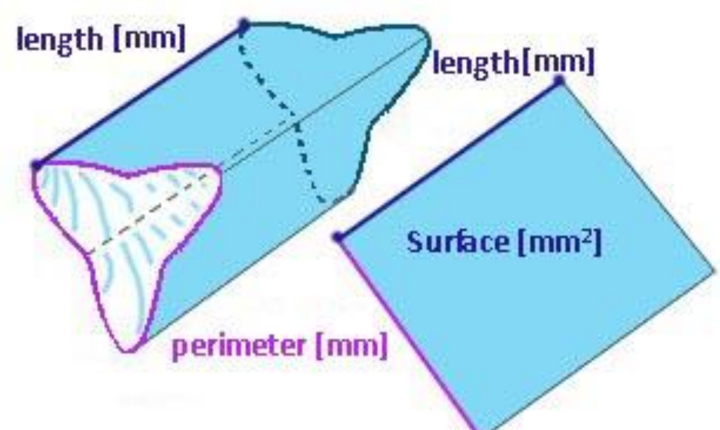


Cross-section characteristics:

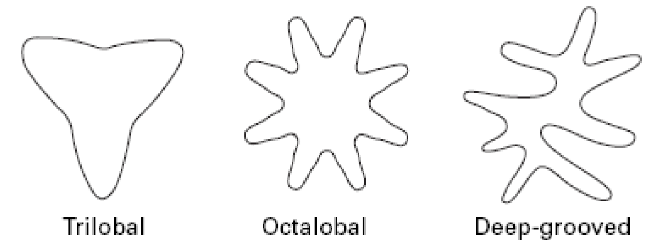


Area S [m^2]
Perimeter O [m]

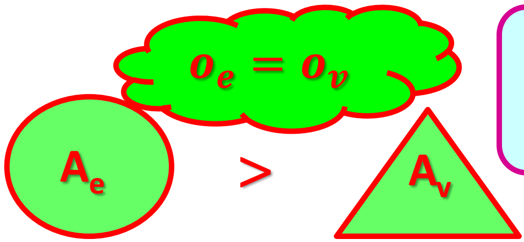
- Length — l [m]
- Volume density — ρ [$kg.m^{-3}$] (900 - 1560)
- Fineness — T [tex]
- Mass — m [kg]
- Volume — V [m^3]
- Fiber surface — P [m^2]
- Specific surface — S_p [$m^2.kg^{-1}$]



Use of fiber cross--section parameters



Circularity c



$$c = \frac{A_v}{A_e} \leq 1$$

Equivalent diameter d_e [μm]

$$O = \pi \cdot d_e \Longrightarrow d_e = \frac{O}{\pi}$$

Equivalent area A_e

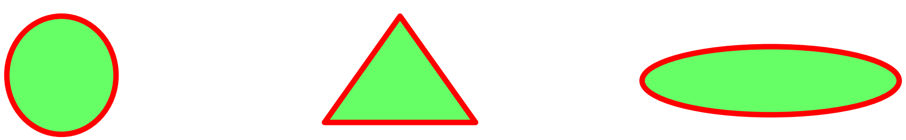
$$A_e = \frac{\pi \cdot d_e^2}{4} = \frac{O^2}{4\pi}$$

Circularity **c** by Pierce

$$c = \frac{A_V}{A_e} = \frac{A_V 4\pi}{O_V^2} = \frac{1}{(q+1)^2}$$

Unpacking of shape q

$$q = \left(\frac{O}{\pi d_R} - 1\right) = \left(\frac{\pi d_e}{\pi d_R} - 1\right) = \frac{1}{\sqrt{c}} - 1$$



q = 0 q = 0,09–0,12 q = 0,45–0,5

Advantage : **(q + 1)** correction factor

Ovality c_k

$$A_V = A_e$$

$$c_k = \frac{O_V}{O_e} = \frac{O_V}{2\sqrt{\pi A_V}}$$

$$c = \frac{1}{c_k^2}$$

$$O_N = O_e(q+1)$$
$$A_N = A_e/(q+1)^2$$