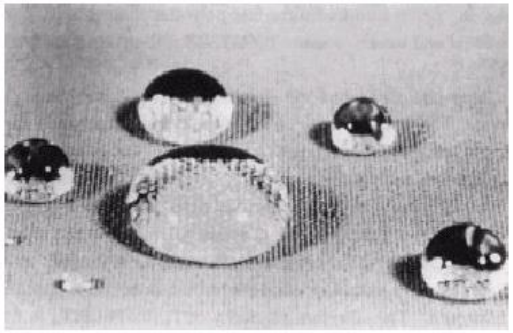
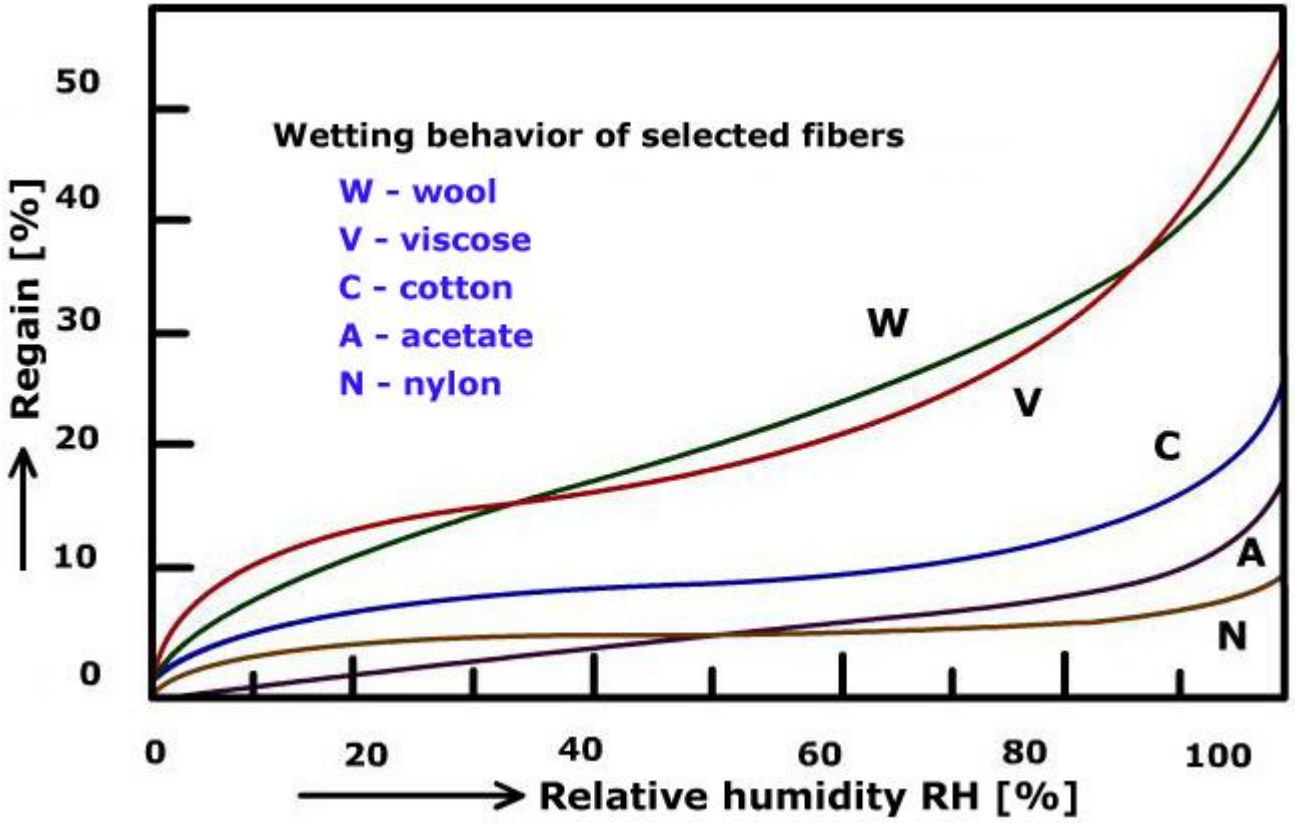


Moisture management of Textile materials

- Moisture measurement
- Weighing of samples



Relative humidity RH

$$RH = \frac{\Phi}{\Phi_{max}} \cdot 10^2 [\%]$$

Relative humidity RH [%]

dependant on temperature

Φ [g.m^{-3}]

Absolute air moisture
Volume density of water vapour

Mass of water vapour [g] embedded in volume unit of air [m^{-3}]

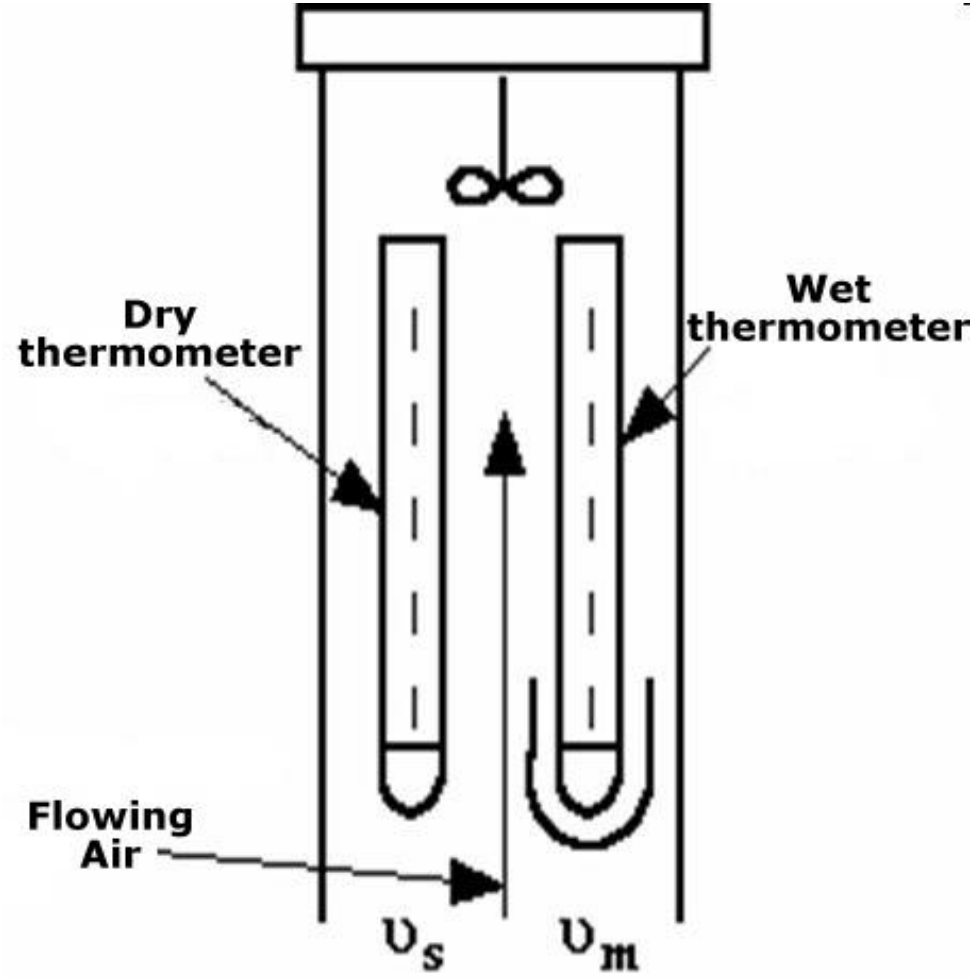
Φ_{max} [g.m^{-3}]

maximum air moisture possible in given temperature (dew point)

Mass of water vapour in air, that gives 100 % humidity of air

Mass of water vapour is driven by air temperature.

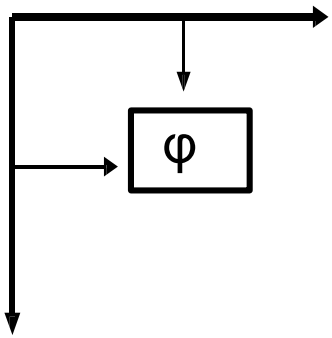
Asman‘s psychrometer



Psychrometric difference

$[\vartheta_S - \vartheta_M]$

Related to Air Humidity



$[\vartheta_s - \vartheta_M]$

Air temperature	Temperature difference													
°C		1	2	2,5	3	3,5	4	4,5	5	5,5	6	6,5	7	7,5	8
0		80	60	51	41	32	22	13	4						
2		82	64	55	47	38	30	21	13	5					
4		84	67	59	51	44	36	29	21	14					
6		85	70	63	56	48	41	35	26	21	14	8			
8		86	72	66	59	53	46	40	34	27	21	15	6		
10		87	74	68	62	56	50	44	39	33	27	22	16	11	6
12		88	76	70	65	59	54	48	43	38	33	28	23	18	13
14		89	78	72	67	62	57	52	47	42	37	32	28	23	19
16		89	79	74	69	64	60	55	50	46	41	37	33	28	24
18		90	80	76	71	66	62	58	53	49	45	41	37	33	29
20		91	81	77	73	68	64	60	56	52	48	44	40	37	33
22		91	82	78	74	70	66	62	58	54	51	47	43	40	39
24		91	83	79	75	71	68	64	60	57	53	50	46	43	40
26		92	84	80	76	73	69	66	61	59	55	52	49	46	43
28		92	84	81	77	74	71	67	64	60	57	54	51	48	45
30		93	85	82	78	75	72	68	65	62	59	56	53	50	47
32				83	79	76	73	70	67	64	61	58	5	52	49
34								71	68	65	62	59	57	54	51

Wetting of textiles

Ireversible

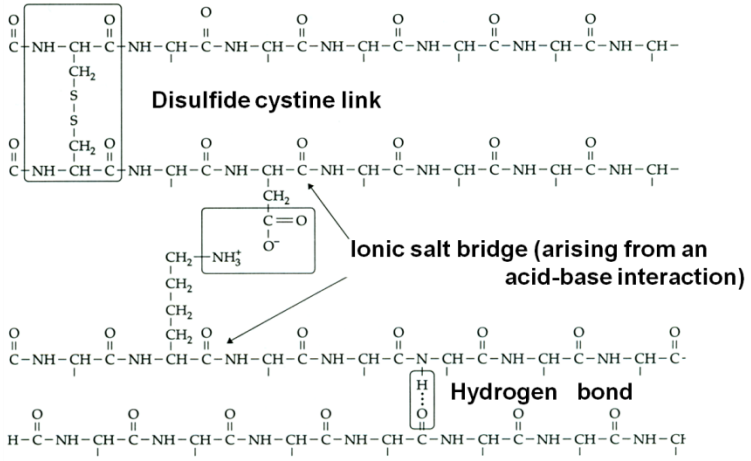
Water molecules are bonded in fiber molecular structure

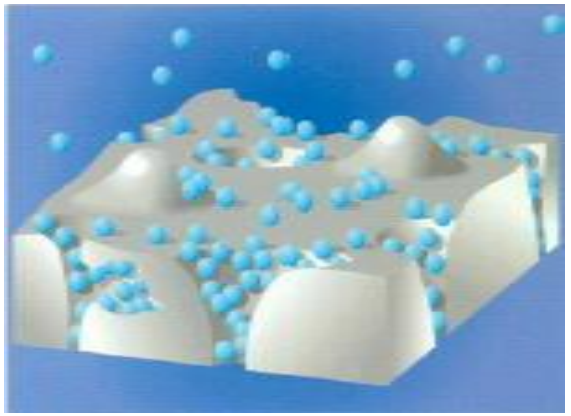
Moisture removal leads to damage of fiber

Reversible

Water molecules are bonded on fiber surfaces

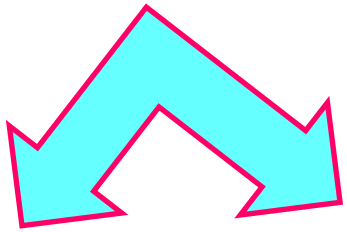
Water can be removed (fiber can be dried)





Sorption properties of fibers

Wettability of fibers



Hydrophobic

(non-wettable)

polypropylene – 0,1-0,8 %

polyester – 0,8-1,5%

Hydrophilic

(wettable)

cotton – 8,5%, wool – 18%

viscose 11-13%

PA6, PA66 – 4,5-6,5%

Moisture management

- **Standardized moisture regain**
  - Mass of material with normalized moisture content
- **Dry mass**
  - Mass of dry (dried) material
- **Regain allowance (reprisa)**
  - Allowed moisture content in fibrous material
  - It is calculated for normalized humidity RH=65%

Regain allowances

Fiber type	Regain allowance fibers [%]	Regain allowance yarns [%]
Cotton	8,5	8,5
Flax	12	10
Wool - carded	17	17
Wool - combed	17	18,25
Rayon	11	11
Polyamide	5,75	5,75
Polyester	0,70	0,70
Polyacrylonitrile	1,0	1,00
Polypropylene	0,1	0,10

Testing of moisture regain

Specimen for moisture testing

Samples must be stored in air-proof containers

Material is first dried

drying is run under standardized conditions until the difference in the mass of specimen between two successive measurements is no more than **0,01 %**

Method of Conditioning

Hot air, infrared or microwave drying

Water content in fiber

$$r = \frac{m_K - m_S}{m_S} \cdot 10^2 = \frac{m_{water}}{m_S} \cdot 10^2 \ [\%]$$

r ⇒ relative water content [%]

$\mathbf{m_K}$ ⇒ mass of wet/conditioned fibers [g]
(T=20°C, ϕ = 65%)

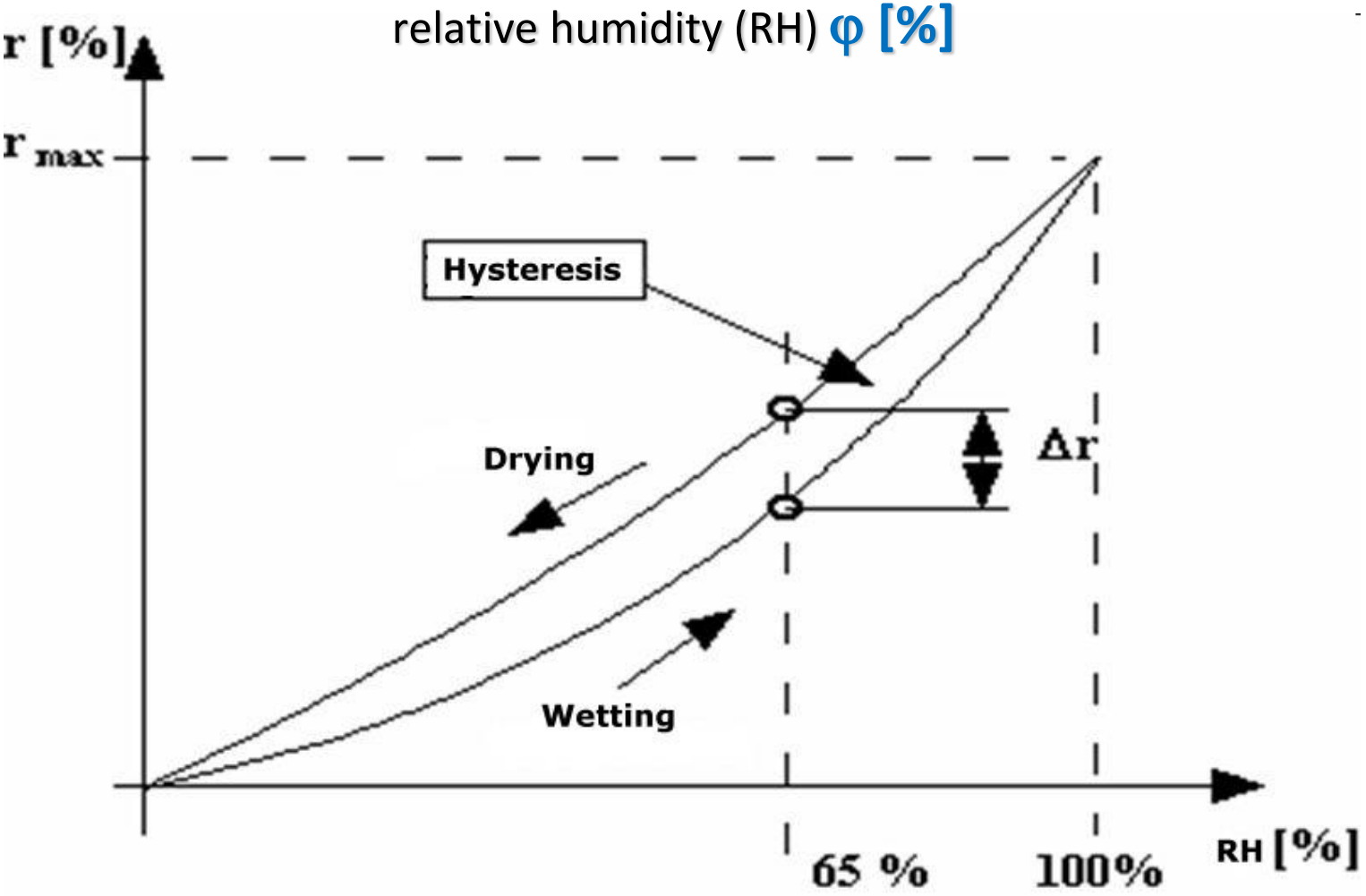
$\mathbf{m_S}$ ⇒ mass of dried fibers [g]
(standard drying T=50°C, ϕ = 10-25%)

ISO 17 614: 2014

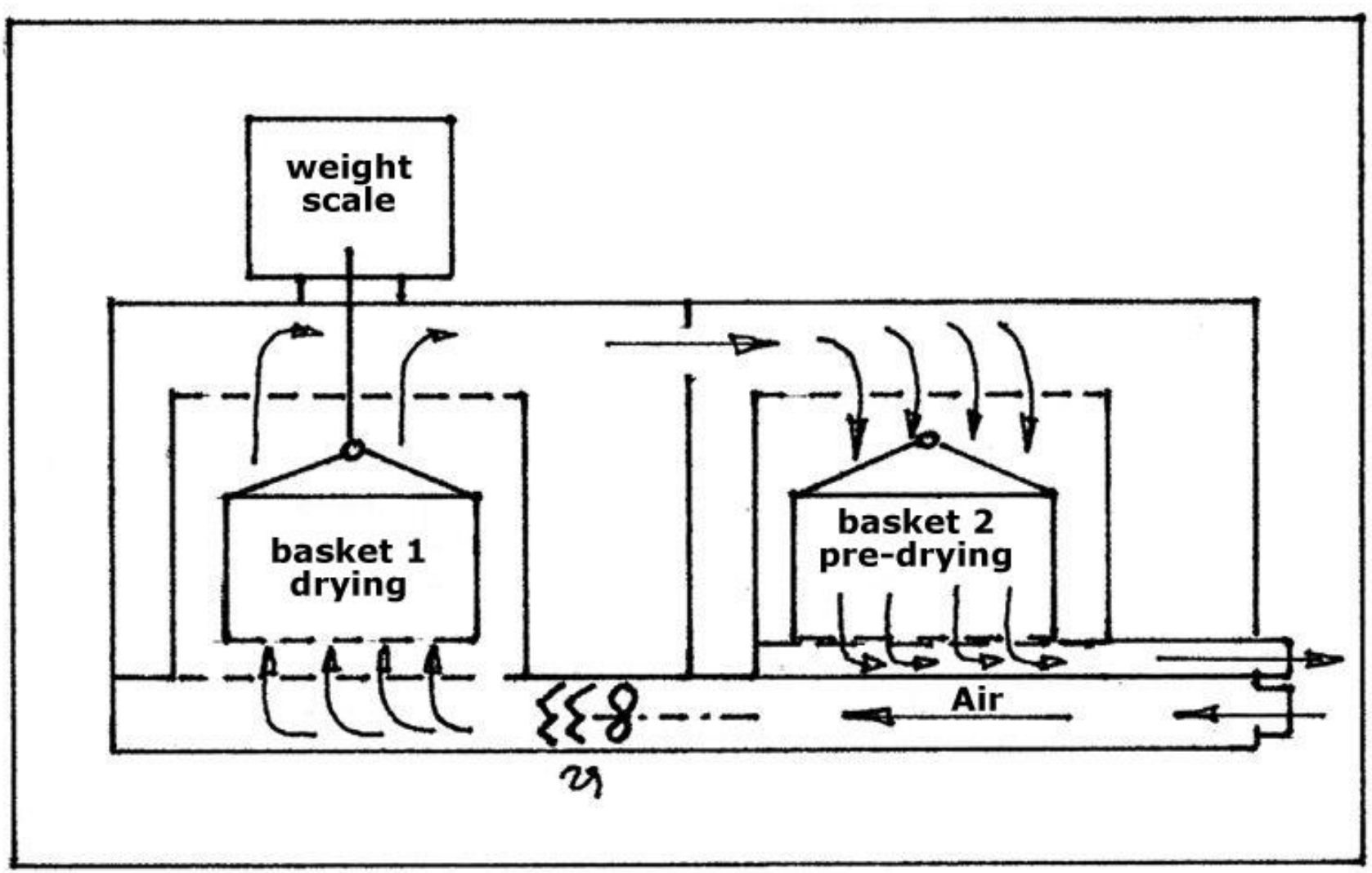
„ Textiles – Determination of moisture drying rate“

Sorption-desorption isotherm

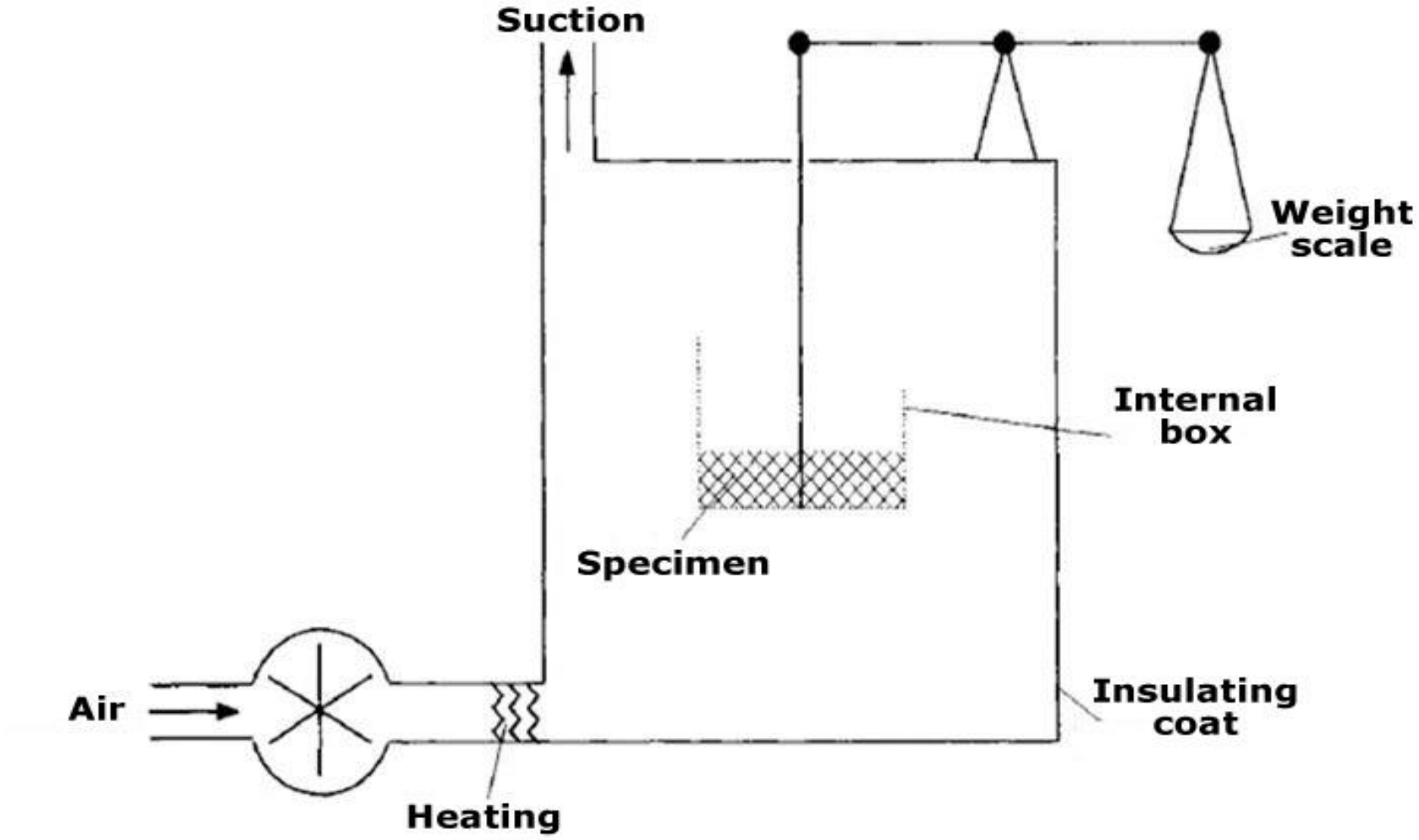
Relation between relative water content **r [%]** and relative humidity (RH) **φ [%]**



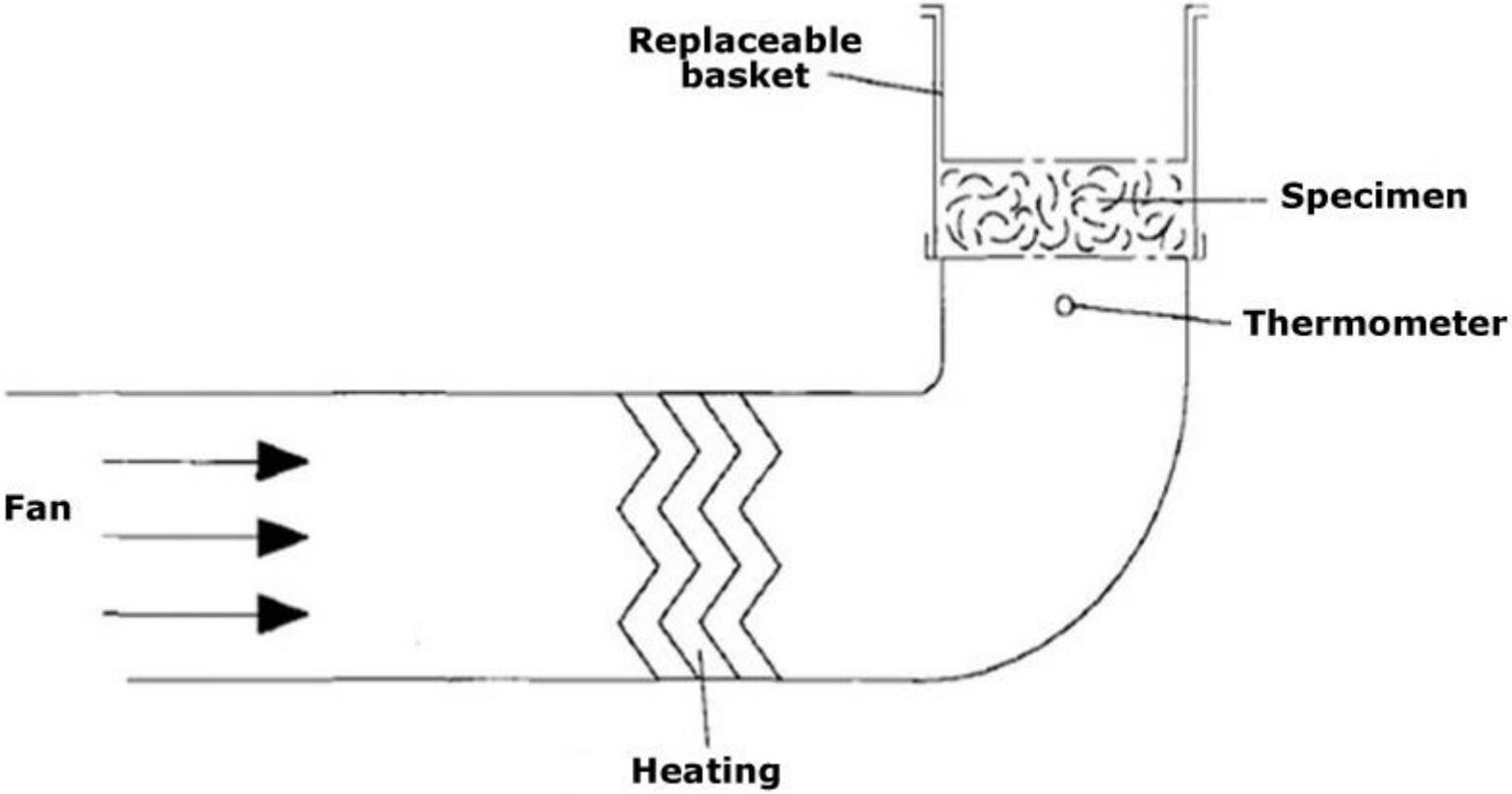
Conditioning device



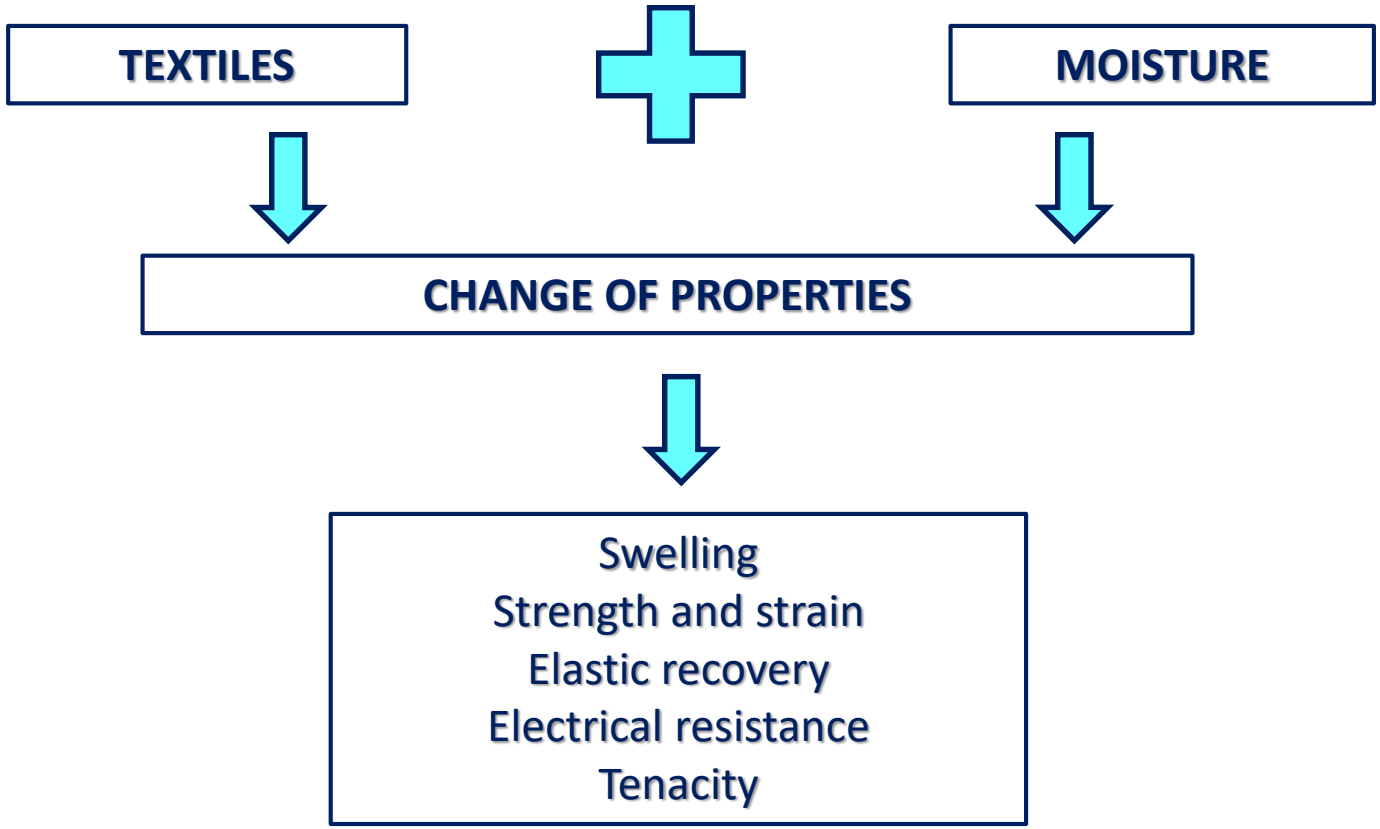
Conditioning box



Quick dryer

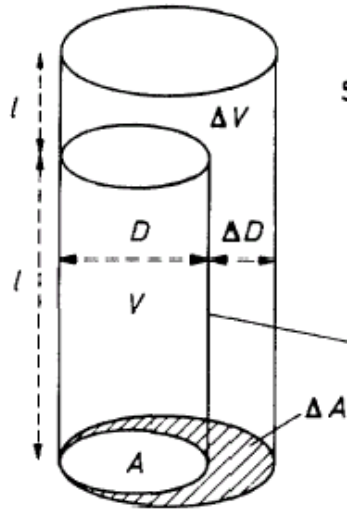


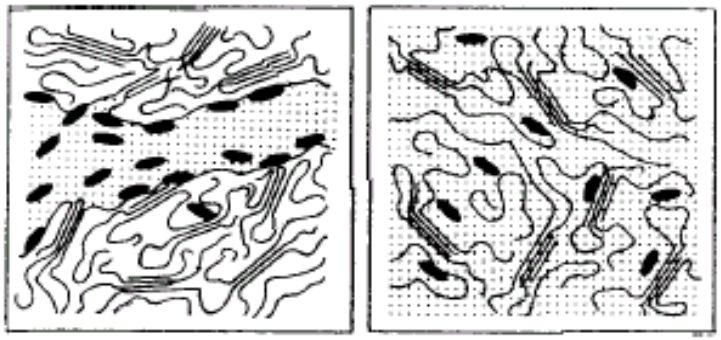
Sorption properties

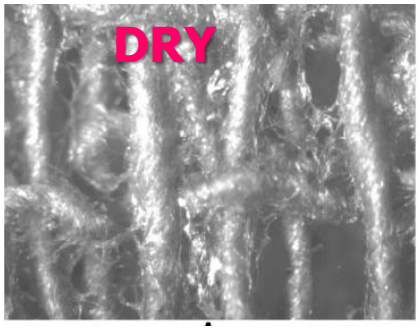


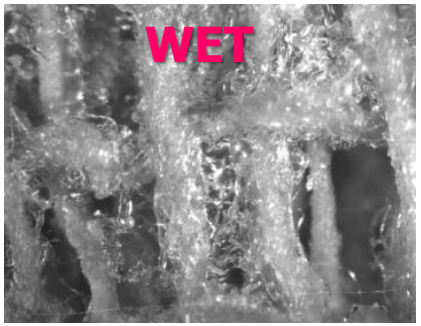
Swelling

Fiber	Transverse swelling		Longitudinal swelling [%]	Volume swelling [%]
	Diameter [%]	Area [%]		
Cotton	20, 23, 7	40, 42, 21		42, 44
Mercerised cotton	17	46, 24	0.1	
Viscose	25, 35, 52	50, 65, 67, 66, 113, 114	3.7, 4.8	109, 117, 115, 119, 123, 126, 74, 122, 127
Acetate	9, 11, 14, 0.6	6, 8	0.1, 0.3	
Wool	14.8 – 17	25, 26		36, 37, 41
Silk	16.5,16.3 – 18.7	19	1.3, 1.6	30, 32
Nylon	1.9 – 2.6	1.6, 3.2	2.7 – 6.9	8.1 – 11.0





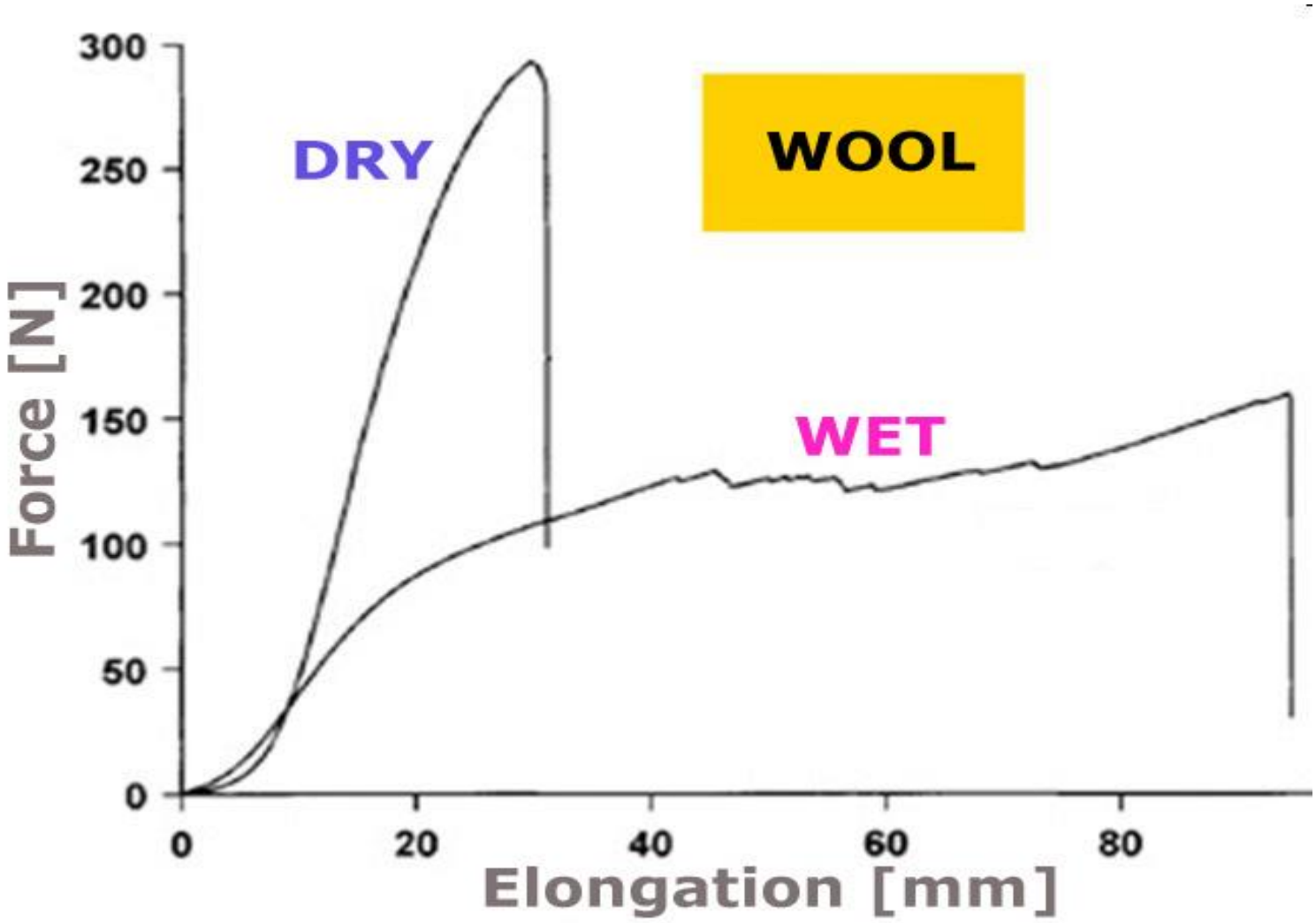




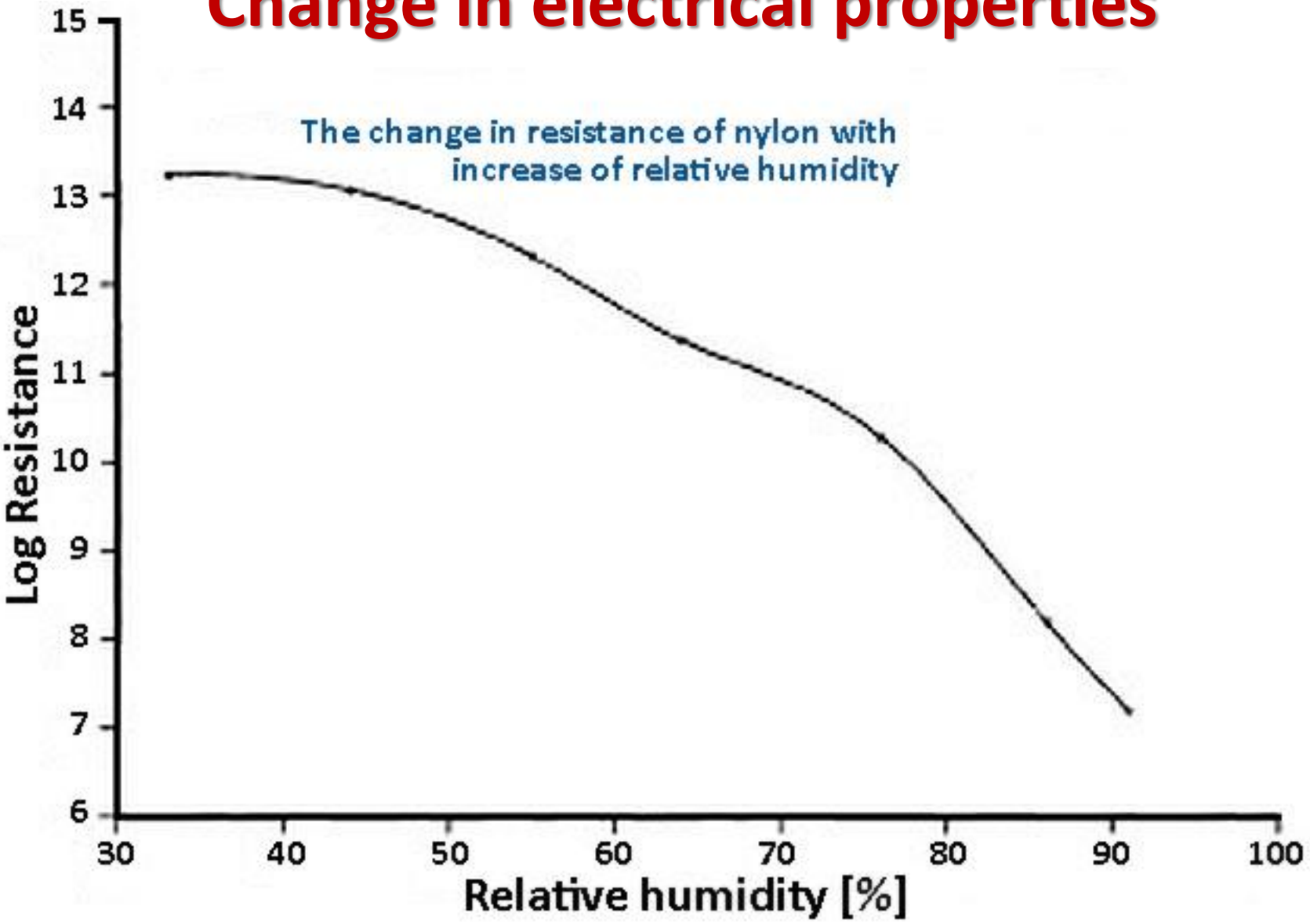
Changes in mechanical properties of fibers in wet state (RH = 100%), if compared to standard state (RH = 65 %) of fibers

Fibers	Change of properties in [-] Strength	Strain	Modulus
Cotton	1.11	1.11	0.33
Viscose	0.50	1.58	0.03
Silk	0.92	1.63	0.25
Wool	0.69	1.33	0.40
Polyamide	0.80	1.05	0.82
Acrylic	0.84	1.08	1.00
Polyester	1.00	1.00	1.00

Change in mechanical properties



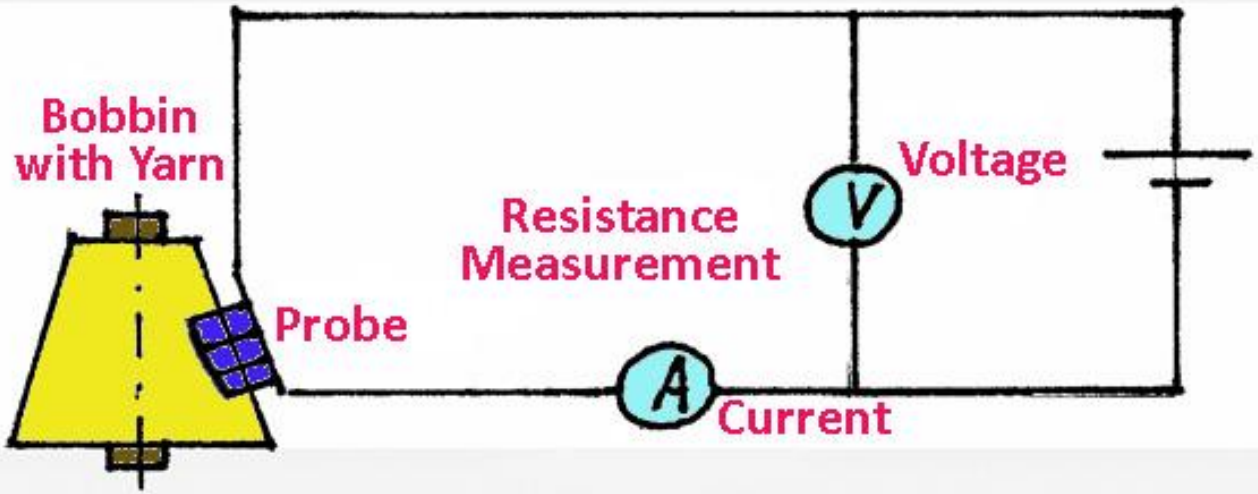
Change in electrical properties



Humidity measurement in industry

Electric devices for measuring humidity

The relationship between the relative resistance of the fibers, and changes of humidity



Humidity measurement using electrical resistivity

The measurement is based on known electrical reistance relationship with changes in humidity:

$$R = \frac{U}{I} = \frac{1}{S} \cdot R_M \quad [\Omega]$$

- **U** – Voltage [V]
- **I** – Current [A]
- **S** – Cross-section of „conductor“ (here fibers) [m^2]

$$R_M = \frac{k}{r^n} \quad [\Omega m]$$

- **R_M** – Specific resistance [Ωm]
- **r** – Fiber humidity [%]
- **k, n** – Empirical constants (65%, 20°C) – derived from the course of standardized resitance-humidity curve

Standardized humidity measurement in climate chambre ⇒
⇒ relative humidity from 25% to 100%
drop of electrical resistance ⇒ **k,r** empirical constants