HACKTEX VIRTUAL TRAINING MATERIALS
MOOC on ADVANCED TEXTILES MANUFACTURING INDUSTRY
Learning unit 4
Lesson 3

Characteristic properties of smart textiles and their characterisation

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CHARACTERISTIC PROPERTIES OF SMART TEXTILES AND THEIR CHARACTERISATION

LU 4.3

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Contents

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1. GENERAL STANDARDS FOR SMART TEXTILES – TERMS AND DEFINITIONS

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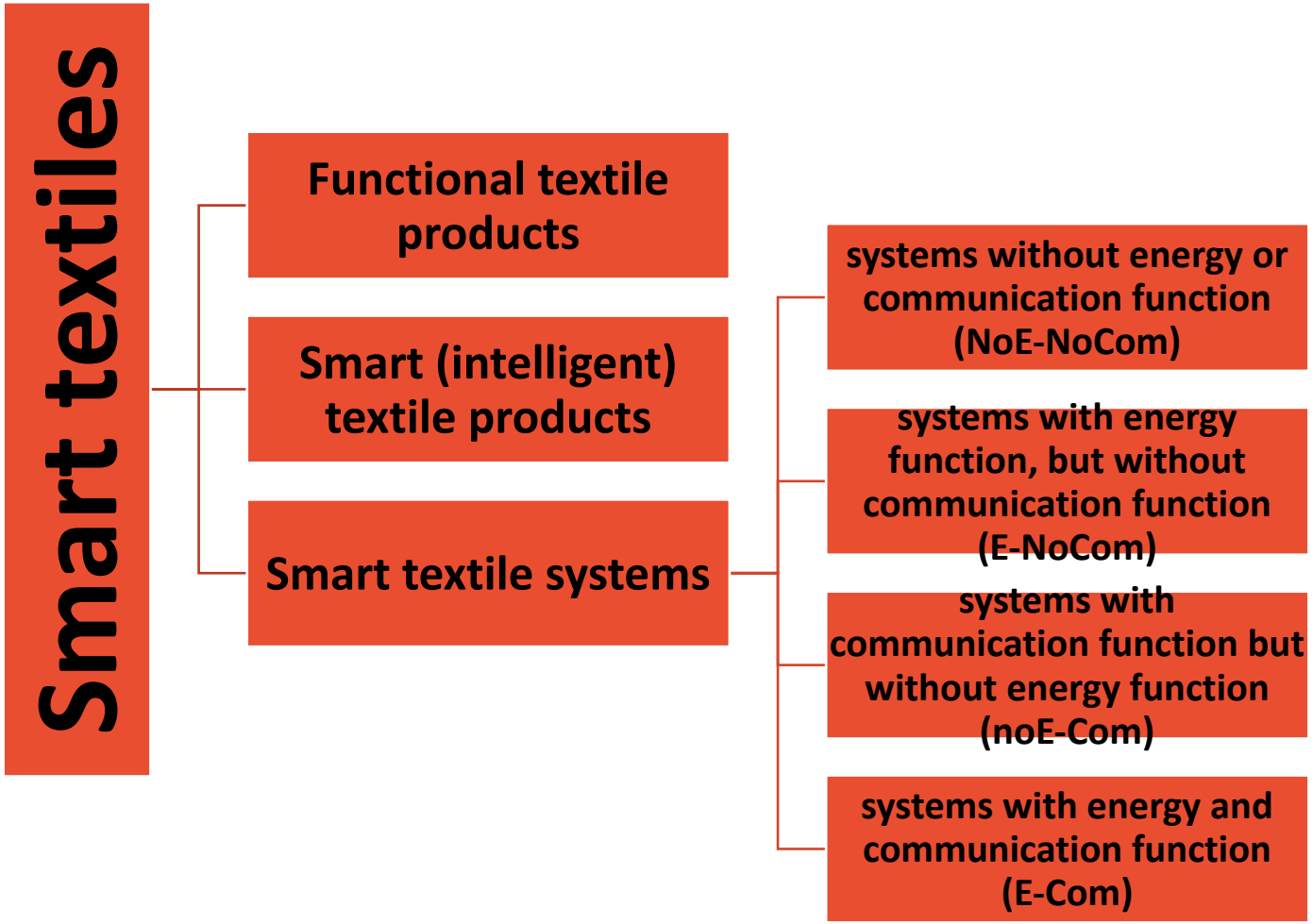
CEN ISO/TR 23383:2020 Textiles and textile products - Smart (Intelligent) textiles - Definitions, categorisation, applications and standardization needs (adopted from ISO/TR 23383:2020)



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2. STANDARDS FOR DESIGN AND MANUFACTURING SMART TEXTILES

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2.1. STANDARDS FOR DESIGN AND MANUFACTURING OF E-TEXTILES

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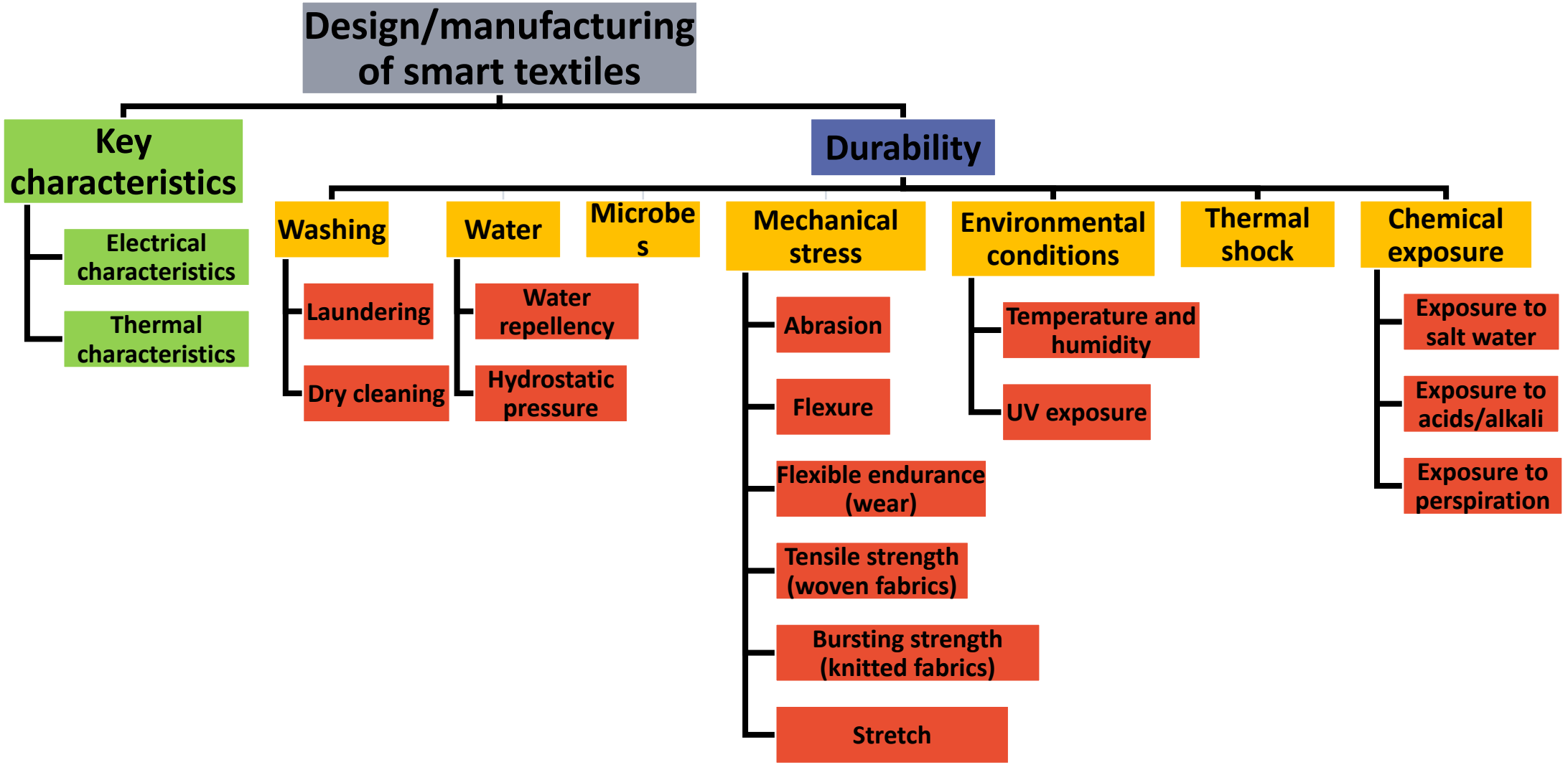
IPC-8921-2019 Requirements for Woven, Knitted and Braided Electronic Textiles (E-Textiles) Integrated with Conductive Yarns and/or Wires



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IPC-8952 Design Standard for Printed Electronics on Coated or Treated Textiles and E-Textiles

- Specific design details,
- Materials, material processing (coating of the textile substrate),
- Evaluation of mechanical properties, electrical properties, thermal management,
- Interconnections and quality assurance for printed electronics on coated or treated textile substrates.

IEC TR 63203-250-1:2021 Wearable electronic devices and technologies - Part 250-1: Electronic textile - Snap fastener connectors between e-textiles and detachable electronic devices

Use cases of conductive snap fasteners applied as electrical connectors for e-textile products available on the market.

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2.2. STANDARDS FOR DESIGN AND MANUFACTURING OF PPE

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Standards for design and manufacturing of PPE

ISO 13688:2013 Protective clothing — General requirements	EN ISO 11612:2015 Protective clothing. Clothing to protect against heat and flame. Minimum performance requirements	CEN/TR 17620:2021 Guidelines for Selection, Use, Care and Maintenance of Smart Garments Protecting against Heat and Flame
Ergonomics, innocuousness, size designation, aging, compatibility,	General heat performance - resistance to heat, flame spread, dimensional changes and mechanical strength (materials, seams)	Selection - risk assessment, required level of protection, product optimization, testing, compatibility
Marking of protective clothing and information to be provided by the manufacturer with the protective clothing	Heat transmission - convective heat, radiant heat, molten aluminium/iron splash, contact heat	Use - training, introducing PPE into service, routine examination, in service evaluation and monitoring, frequency of cleaning on type of smart garment
		Care - label, marking and instruction for use, cleaning, drying, decontamination, storage Maintenance - inspection, repairs and alterations, disposal

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3. STANDARDS FOR PERFORMANCE EVALUATION OF SMART TEXTILES

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3.1. PERFORMANCE EVALUATION OF CONDUCTIVE TEXTILES, SMART TEXTILES/ E-TEXTILES/WEARABLES, WITH ELECTRONIC COMPONENTS

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Electrical resistance R [Ω] reflects the opposition exerted by an object when an electrical current passes through it.

Electrical conductance G [Siemens] shows how easy the electrical current passes through an object.

$$R = \frac{V}{I} \qquad G = \frac{I}{V} = \frac{1}{R}$$

Electrical resistivity ρ [Ω m] measures how strongly a material with certain dimensional characteristics resists the passing of an electric current. **Electrical conductivity σ [Siemens/m]** is a measure of the ability of the material to conduct an electrical current. It is the inverse of resistivity.

$$\rho = R \times \frac{A}{l}$$

Where R = resistance (Ω), A = area of the cross section of the object (m^2) and l = its length (m)

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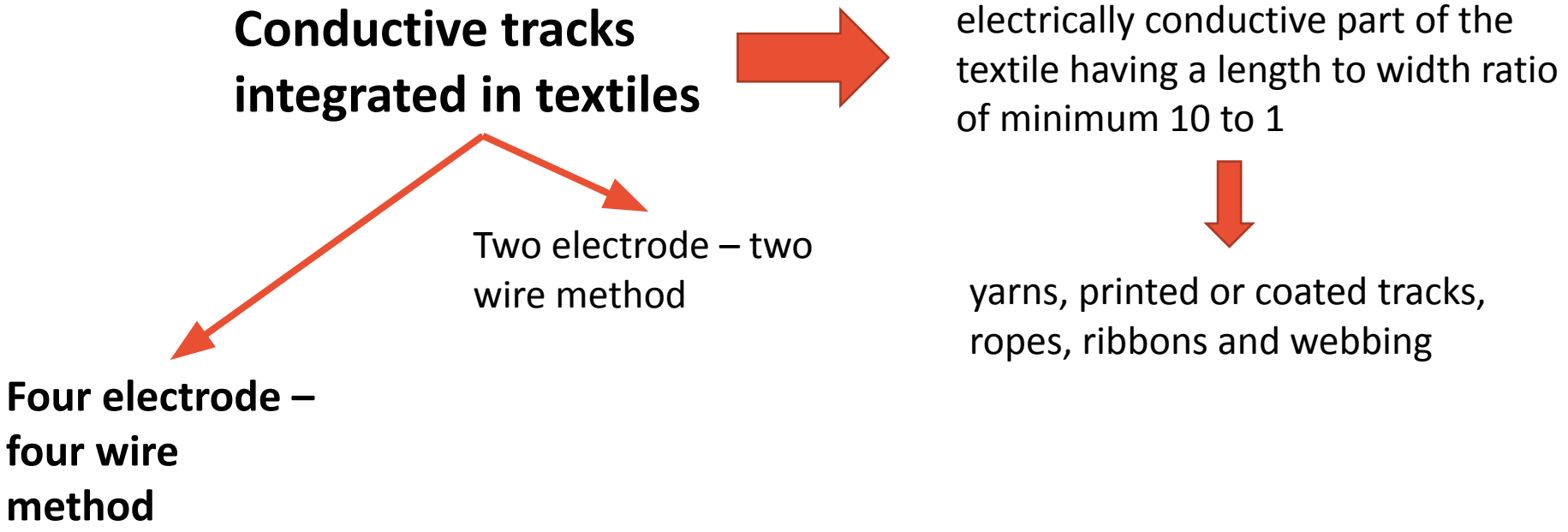
EN 16812: 2016 Textiles and textile products - Electrically conductive textiles - Determination of the linear electrical resistance of conductive tracks

Linear electrical resistance of conductive tracks, defined as electrically conductive part of the textile having a length to width ratio of minimum 10 to 1.



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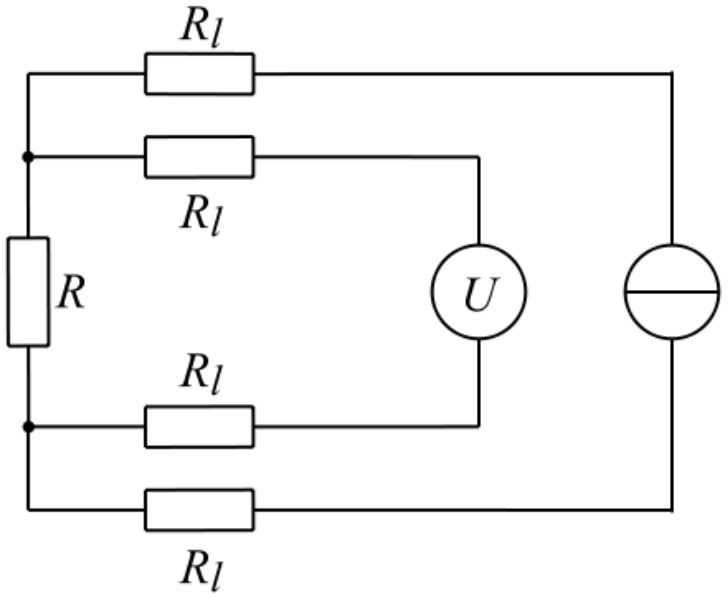
Testing equipment:

- source of DC current,
- voltmeter,
- contacting electrodes with flat surfaces,
- calibrated ruler,
- insulating square surface

Linear electrical resistance

$$R_l = \frac{R}{d} = \frac{V/I}{d}$$

R = V/I is the resistance [Ω]
d is the distance between the electrodes for the voltage measurements [mm]



Electric diagram for the four electrode – four wire method
Source:https://commons.wikimedia.org/wiki/File:Vierleitermessung.svg, credit CaZeRillo

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EN IEC 63203-201-1:2022 Wearable electronic devices and technologies - Part 201-1: Electronic textile - Measurement methods for basic properties of conductive yarns

Electrical characteristics	• Linear resistivity (according to EN ISO 16812) • Fusing current
Perspiration resistance	• Variation of linear resistivity
Detergent resistance	• Variation of linear resistivity

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EN IEC 63203-201-2:2022 Wearable electronic devices and technologies - Part 201-2: Electronic textile - Measurement methods for basic properties of conductive fabrics and insulation materials

- **Electrical properties**
  - Sheet resistance
  - Fusing current
  - Electric insulation properties
- **Resistance to factors**
  - Perspiration resistance
  - Detergent resistance

Sheet resistance Rs

$$R_s = R \times \frac{W}{L}$$

R = linear resistance R measured in the longitudinal direction, using the four wires-four electrodes method
W and L = sample dimensions

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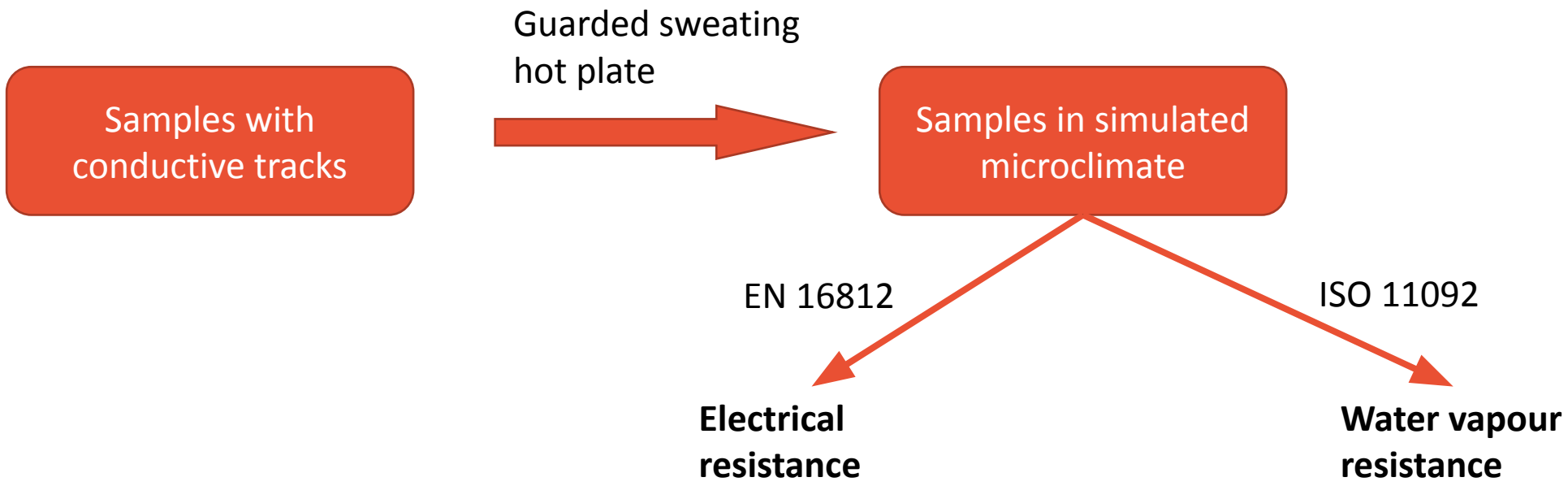
IEC 63203-201-3:2021 Wearable electronic devices and technologies - Part 201-3: Electronic textile - Determination of electrical resistance of conductive textiles under simulated microclimate



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3.2. PERFORMANCE EVALUATION OF SMART TEXTILES WITH PHASE CHANGE MATERIALS (PCMs)

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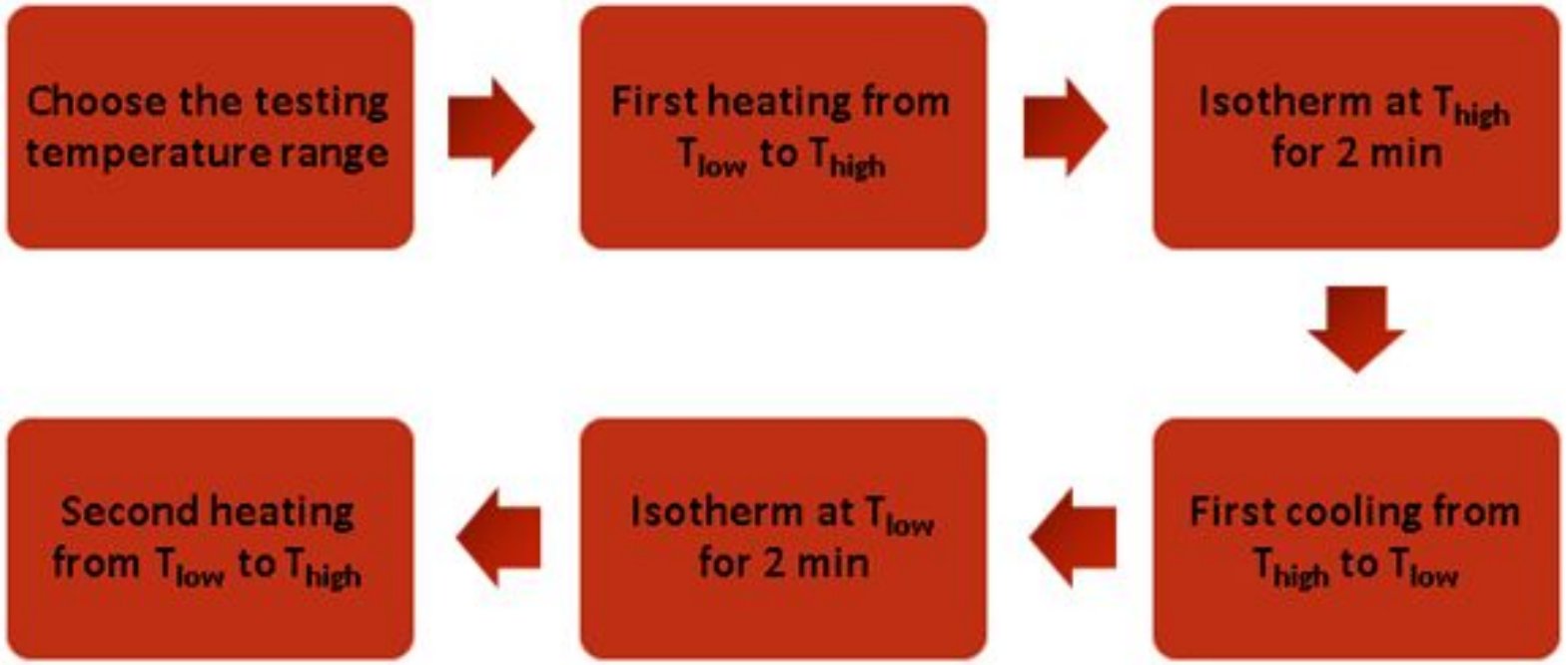
CEN/EN 16806-1:2016 Textiles and textile products - Textiles containing phase change materials (PCM) - Part 1: Determination of the heat storage and release capacity

Textile fibres, yarns and fabrics (woven and knitted fabrics, nonwovens) containing phase change materials (PCM)

- Enthalpy of fusion and crystallization
- Phase change temperatures

Differential scanning calorimetry (DSC), EN ISO 11357-1:2023



Enthalpy of fusion / crystallization

$$\Delta H_f \text{ or } \Delta H_c = \Delta H_{cal} \times \frac{A \times m_{cal}}{A_{cal} \times m}$$

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3.3. PERFORMANCE EVALUATION OF SMART TEXTILES WITH SHAPE MEMORY MATERIALS

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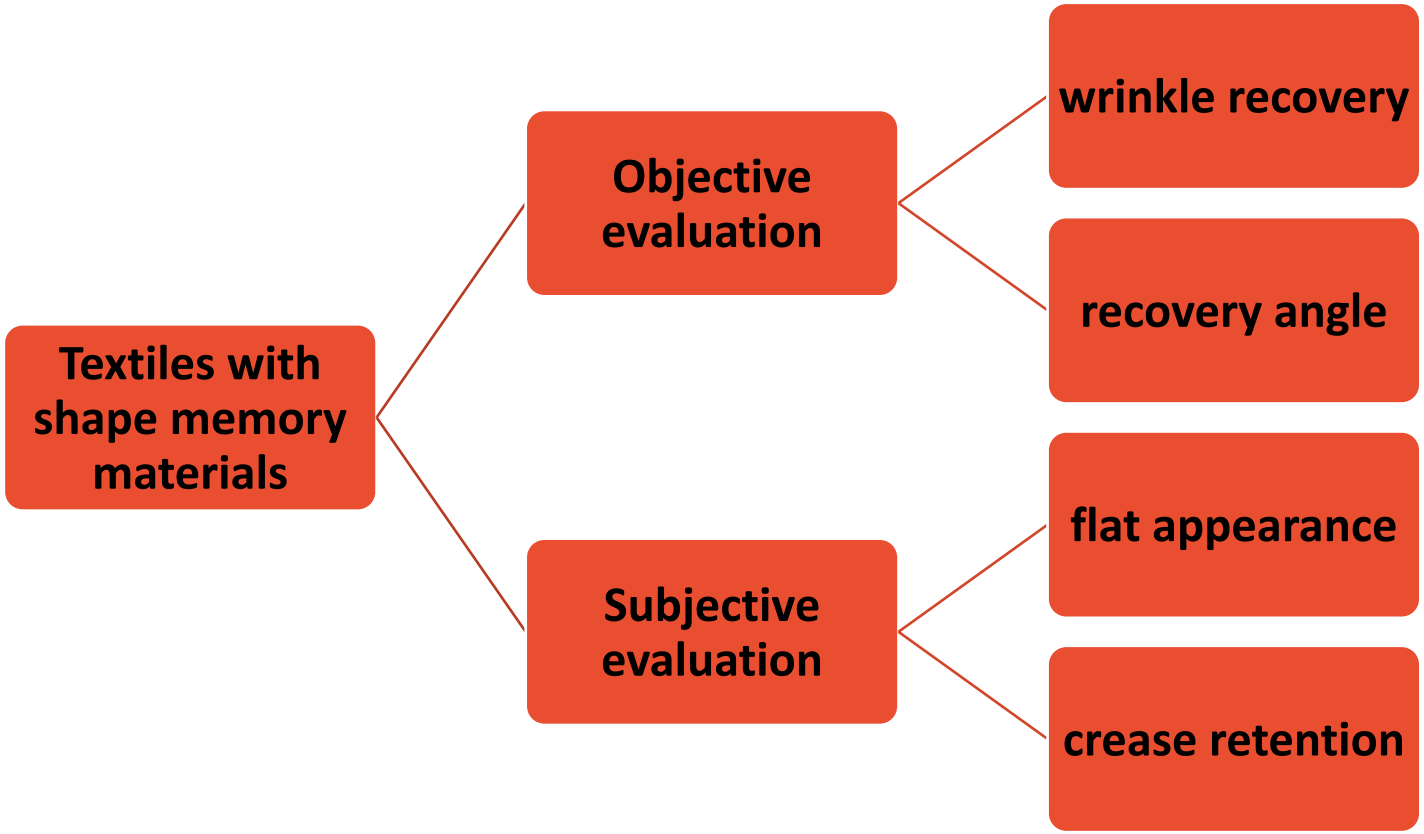

- ✔ AATCC TM 66:2017 Test Method for Wrinkle Recovery of Woven Fabrics: Recovery Angle
- ✔ ISO 9867:2022 Textiles — Evaluation of the wrinkle recovery of fabrics — Appearance method
- ✔ AATCC 88:2018 Test Method for Crease Retention in Fabrics after Home Laundering
- ✔ AATCC 124, Revision 18T, 2018 - Test Method for Smoothness Appearance of Fabrics after Home Laundering

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3.4. PERFORMANCE EVALUATION OF SMART TEXTILES FOR PROTECTIVE GARMENTS (PPE)

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EN 17673:2022 Protective clothing - Protection against heat and flame - Requirements and test methods for garments with integrated smart textiles and non-textile elements

Implementation of the requirements in EN ISO 13688 for smart textiles and nontextile devices

- ergonomics, safety, size designation, ageing, compatibility and protective clothing markings

Implementation of the requirements in EN ISO 11612 for smart textiles and nontextile devices

- evaluation of the integrated smart textiles and non-textile elements; penetration of hardware; heat resistance; limited flame spread; whole garment test against fire exposure on thermal manikin (optional)

Electrical safety and functionality of smart electronic components/devices

- use under variable temperatures; slow and fast change in temperatures; thermal safety; electrical safety; water and humidity resistance of smart textiles and non-textile devices; batteries; sinusoidal vibrations; safety towards electromagnetic fields; explosive zones

Evaluation of smart textiles and smart non-textile devices and elements after heat and flame testing

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4. STANDARDS FOR EVALUATING THE DURABILITY OF SMART TEXTILES

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4.1. WASHABILITY OF E-TEXTILES

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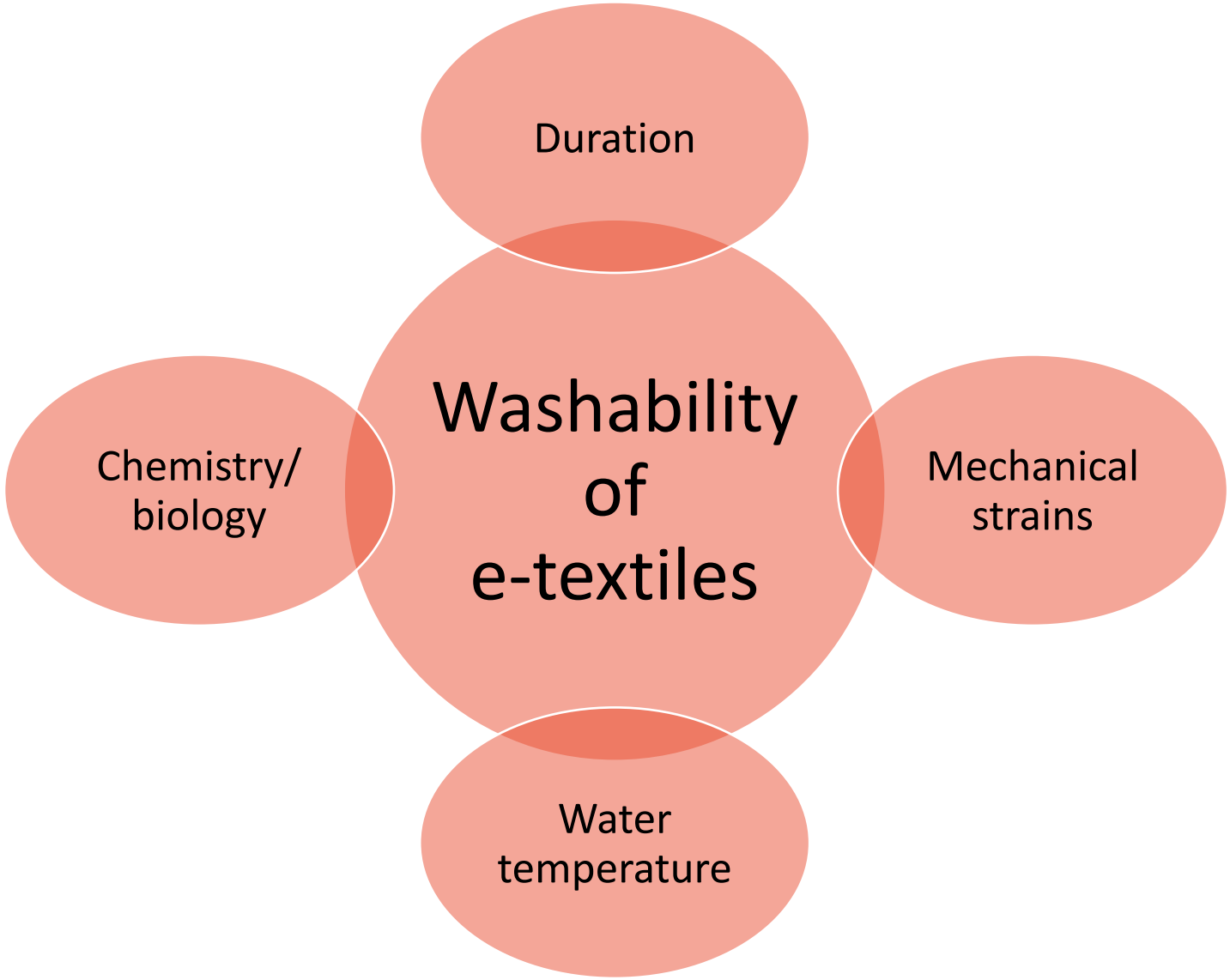

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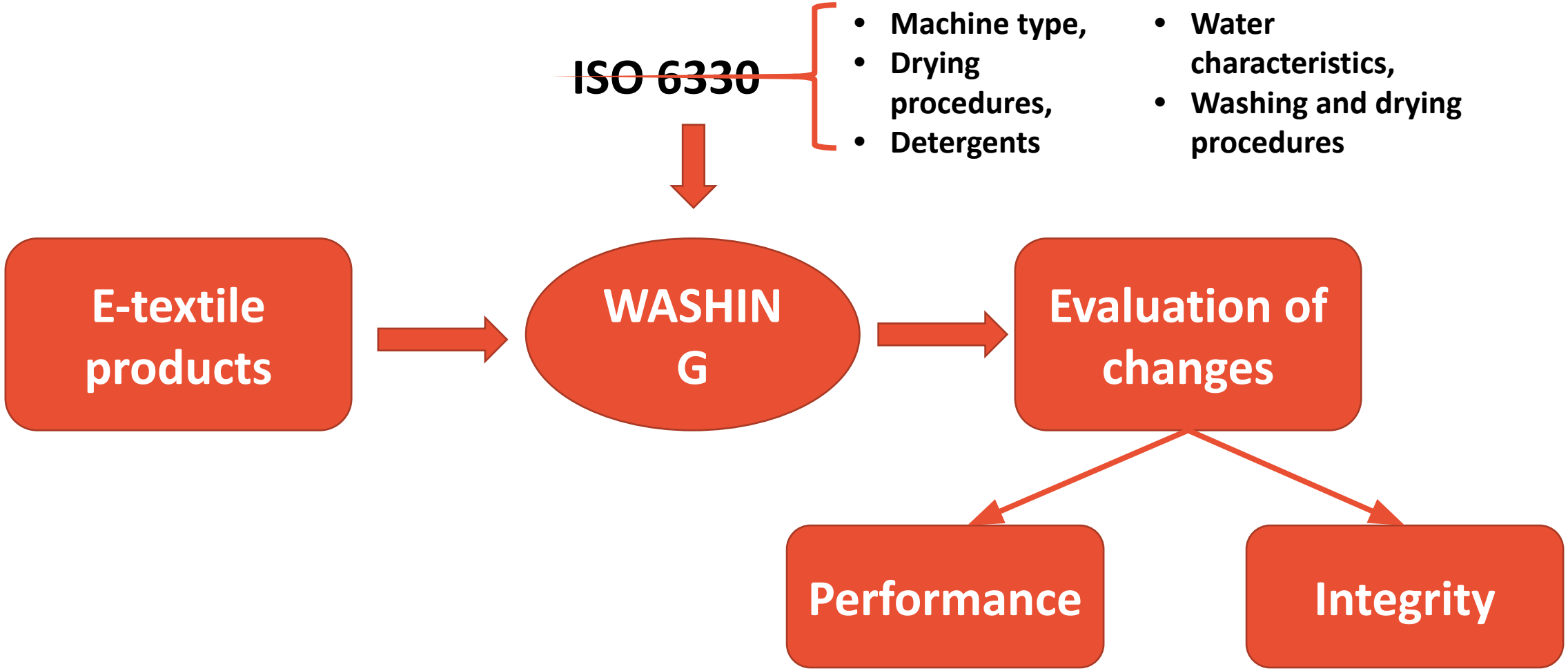

IEC 63203-204-1:2021 Wearable electronic devices and technologies - Part 204-1: Electronic textile - Test method for assessing washing durability of leisurewear and sportswear e-textile systems

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5. STANDARDS IN DEVELOPMENT

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Standards to be released by CEN/CENELEC

FprCEN/TR 17945 Textiles and textile products - Textiles with integrated electronics and ICT - Definitions, categorisation, applications and standardisation needs

Standards to be released by IEC

IEC 63203-201-4 Wearable electronic devices and technologies - Part 201-4: Electronic textile - Test method for determining sheet resistance of conductive fabrics after abrasion
IEC 63203-202: Passive electric parts for e textiles
IEC 63203-202-1: Passive e textile parts – Connectors for e textile applications
IEC 63203-203: E textile functional elements
IEC 63203-204: E textile systems (evaluation method for garment-type wearable systems)

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Standards to be released by IPC

A. General principles, textile motherboard, sensors, electronic modules, power supply
B. Mechanical performance – abrasion, tensile, shearing
C. Mechanical performance – flexing, bending, stretching, torsion
D. Performance under exposure to salt water, acids and alkalis, sweat and perspiration, microbes
E. Performance under exposure to water (water repellence, hydrostatics), UV radiation, temperature
F. Cleaning procedures – washing, drying and dry cleaning

IPC/JPCA-8911 Requirements for Conductive Yarns for E-Textiles Applications
IPC-8953 Design Standard for Embroidered E-Textiles
IPC-8922 Qualification and Performance Specification for Printed Electronics on Coated or Treated Textiles and E-Textiles

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Summary

- Standards for terminology, as establishing a common language is of utmost importance in this field.
- Standards for design and manufacturing, discussing guidelines for smart textile materials and products in terms of type of materials, structures, functionalization (integration of smart functions) and what characteristics should be considered when evaluating material/product performance.
- Standards for performance evaluation discuss one or more specific characteristics that are significant for the use of smart textiles, describing the testing method (sampling, equipment, test procedure) and the processing and presentation of test results. These standards are very important in R&D, for certification of products and as conformity criteria. Most of these standards refer to the performance of e-textiles/wearables.
- Standards referring to durability discuss the evaluation of external factors (mechanical, chemical, thermal and washing) have on the functionality of a smart product. This section presents the influence of washing on e-textiles.
- The last section lists standards to be released in the near future

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