# WACOSIT® gives your ideas profile.
# Perfectly shaped and cost-effective.

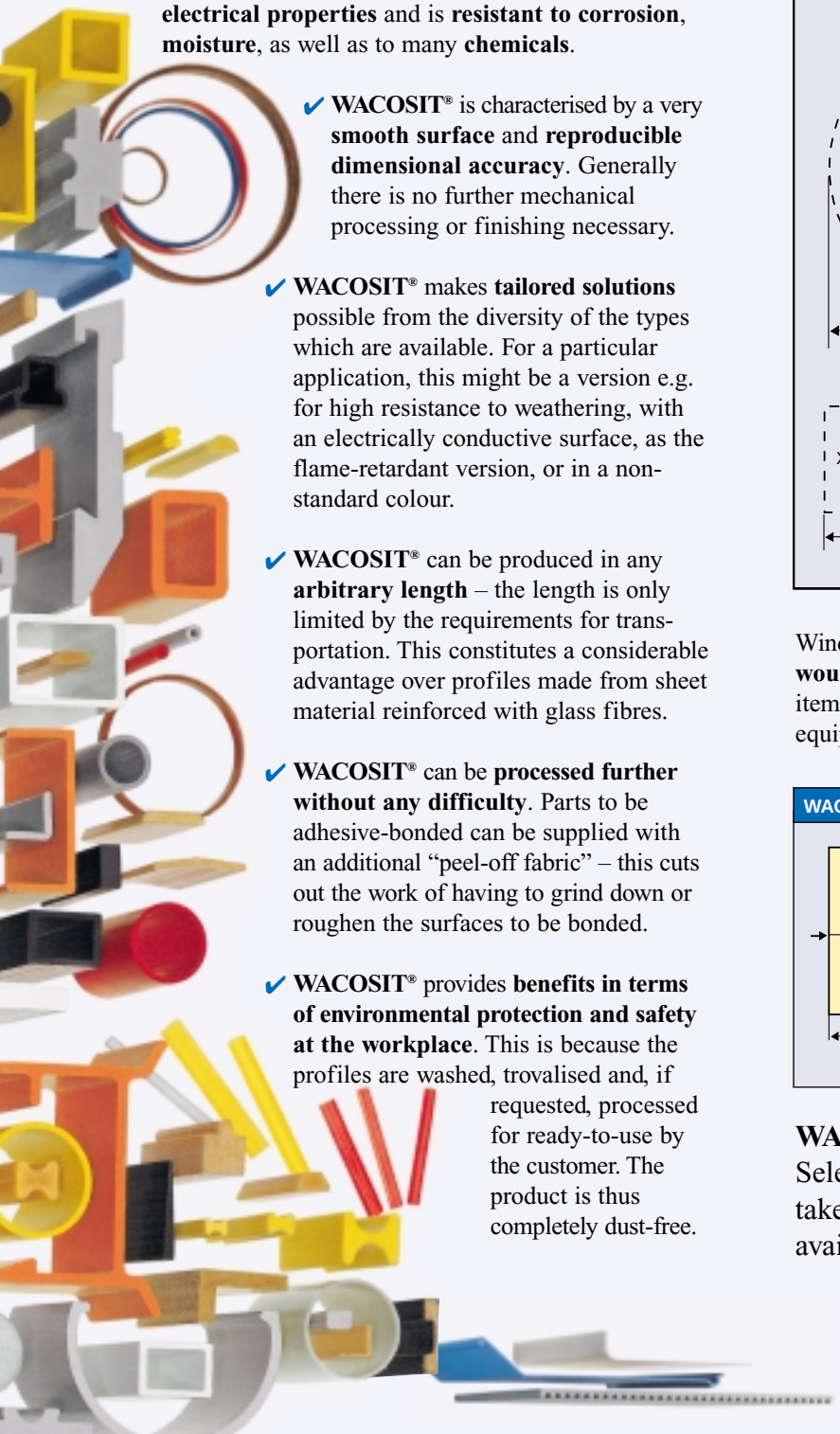

*In good shape by* KREMPEL GROUP

# WACOSIT®- the pultrusion answer for »a thousand« jobs

Under the designation **WACOSIT®** we supply fibre-reinforced

- ✔ **Pultruded plastic profiles**
- ✔ **Wound components**
- ✔ **Guying elements**

Because of their characteristics for specific applications, there are **many advantages** given by these:

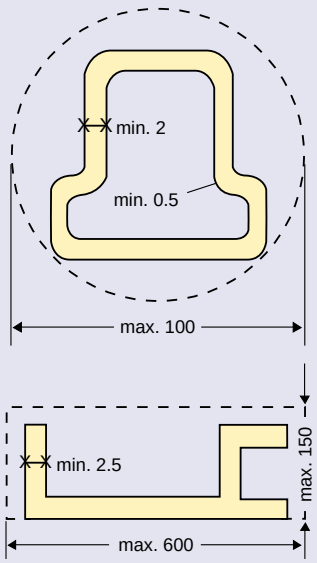


- ✔ **WACOSIT®** has good **mechanical, thermal** and **electrical properties** and is **resistant to corrosion**, **moisture**, as well as to many **chemicals**.
- ✔ **WACOSIT®** is characterised by a very **smooth surface** and **reproducible dimensional accuracy**. Generally there is no further mechanical processing or finishing necessary.
- ✔ **WACOSIT®** makes **tailored solutions** possible from the diversity of the types which are available. For a particular application, this might be a version e.g. for high resistance to weathering, with an electrically conductive surface, as the flame-retardant version, or in a non-standard colour.
- ✔ **WACOSIT®** can be produced in any **arbitrary length** – the length is only limited by the requirements for transportation. This constitutes a considerable advantage over profiles made from sheet material reinforced with glass fibres.
- ✔ **WACOSIT®** can be **processed further without any difficulty**. Parts to be adhesive-bonded can be supplied with an additional "peel-off fabric" – this cuts out the work of having to grind down or roughen the surfaces to be bonded.
- ✔ **WACOSIT®** provides **benefits in terms of environmental protection and safety at the workplace**. This is because the profiles are washed, trovalised and, if requested, processed for ready-to-use by the customer. The product is thus completely dust-free.

## WACOSIT® profiles

Tools are available for selection from more than **5000 pultruded WACOSIT® profiles**, the exact dimensions for which can be taken from the applicable WACOSIT® profile list. We will of course **customise** a profile to your specifications.

### WACOSIT® manufacturing options by the »Pultrusion« method

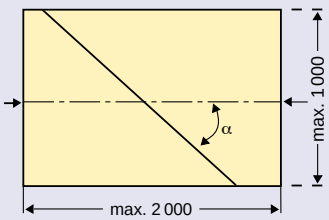



| | |
|---|---|
| Max. component size: | 100 mm |
| Max. cross-section area: | 6 000 mm² |
| Min. wall thickness: | 2 mm |
| Min. wall radius: | 0.5 mm |
| **Standard tolerances:** | |
| Dimensions < 20 mm: | ± 0.15 mm |
| Dimensions > 20 mm: | ± 0.2 mm |
| Straightness per running metre: | ± 20 mm |

| | |
|---|---|
| Max. component width: | 600 mm |
| Max. component height: | 150 mm |
| Max. cross-section area: | 6 000 mm² |
| Min. wall thickness: | 2.5 mm |
| **Standard tolerances:** | |
| Dimensions < 100 mm: | ± 0.5 mm |
| Dimensions > 100 mm: | ± 1.5 mm |

Winding mandrels are available for more than 500 **WACOSIT® wound components**. These mandrels are high-precision items from our own machining shop. Thus we are best equipped to fulfil your requirements.

### WACOSIT® manufacturing options by the »Filament-winding« method




| | |
|---|---|
| Max. component diameter: | 1 000 mm |
| Max. component length: | 2 000 mm |
| Fibre angle α: | 15° - 89° |
| **Standard tolerances:** | |
| Internal diameter: | ± 0.1 mm |
| Length: | ± 0.5 mm |
| Other tolerances subject to agreement | |

**WACOSIT®** can resolve your **design assignment**: Select from the extensive **supply programme** and take advantage of the intensive technical **support** available for the application in question.

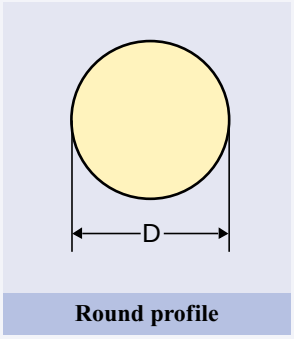
## WACOSIT® guying elements

For optical-fibre cables, we supply guying elements made from glass filaments impregnated with epoxy resin in standard lengths of up to 12 600 m. Other lengths are also available on request. From the carefulness in mutually matching the starting materials and a special processes in manufacturing, our fibre-reinforced components are characterised by high mechanical strength and rigidity, outstanding static and dynamic load-bearing properties, excellent electrical insulation characteristics and favourable behaviour towards stresses from bending and flexing. All guying elements are given a surface coating of a special lacquer.

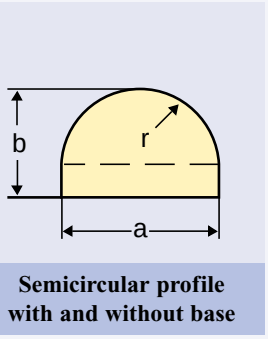
| Standard dimensions of WACOSIT® guying elements (in mm)[1] | | | | |
|---|---|---|---|---|
| 1.0 | 1.5 | 1.7 | 1.8 | 2.0 |
| 2.1 | 2.2 | 2.3 | 2.4 | 2.5 |
| 2.6 | 2.7 | 2.8 | 3.0 | 3.3 |

[1] other dimensions available on request

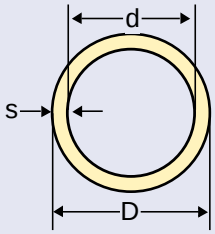
## Standard programme of WACOSIT® »Profiles«



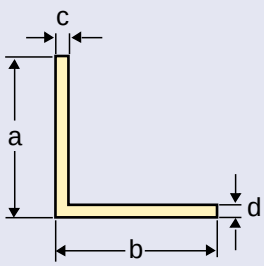

**Round profile**



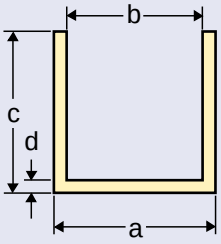

**Semicircular profile with and without base**



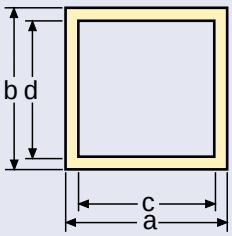

**Tubular profile**



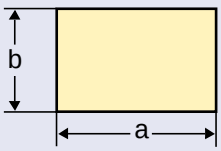

**Corner profile**



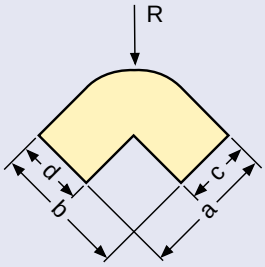

**U-profile**



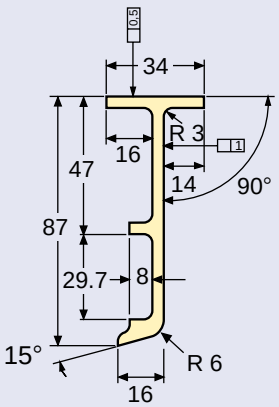

**Rectangular tube profile**



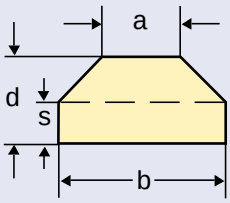

**Rectangular profile**



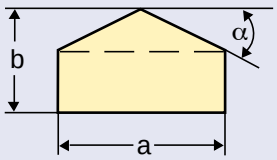

**Elbow profile**



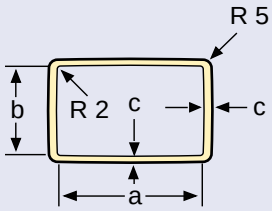

**Customised profiles**



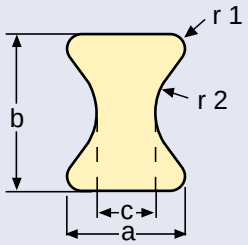

**Trapezoidal profile with and without base**



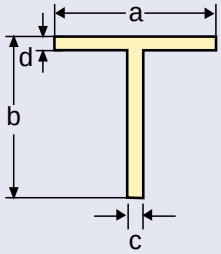

**Wedge profile with and without base**




**Wound tube**




**Dogbone profile**




**T-profile**

# Design and characteristics

**WACOSIT® profiles** are realised by the **"Pultrusion method".** Reinforcing fibres are impregnated with synthetic resins and cured continuously in a heated mould.

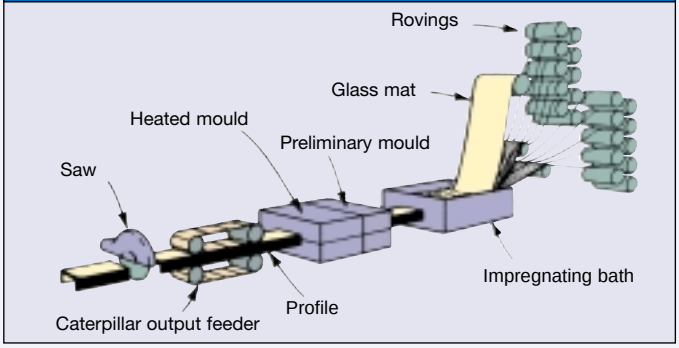
Besides **glass fibres**, **WACOSIT® profiles** can be strengthened by **carbon fibres** or by **aramide fibres**. Variants of these are also available to best meet the differing requirements.

Thus for example, there are also the R, S and T types of glass fibres available. These are characterised by **better mechanical properties** over the more commonly used E type of glass fibre.

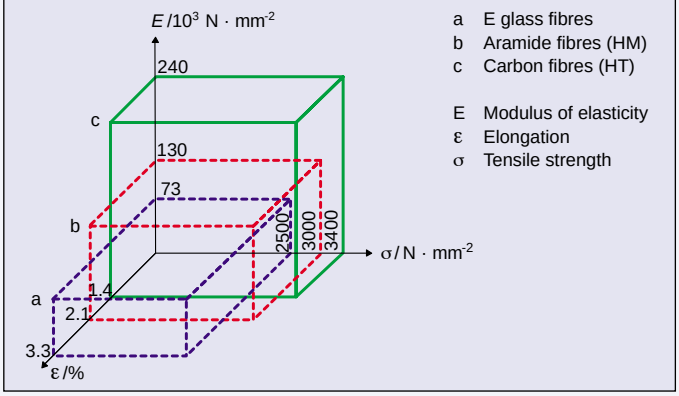
Alongside **rovings**, there are also other **fabric structures** such as **tapes** and **warp-knit complexes** which are also used in engineering **WACOSIT® profiles**.

When subjected to mechanical loads, **glass fibres**, **carbon fibres and aramide fibres** exhibit an almost linear behaviour in elasticity until breakage occurs. The elasticity behaviour of **glass fibres** is **isotropic**, i.e. the same properties are shown in all directions. Unlike this, **carbon fibres** and **aramide fibres** exhibit **anisotropic behavior**, that is to say there are preferred directions – this is a property of major significance in many design and construction assignments.

## Continuous-operation pultrusion



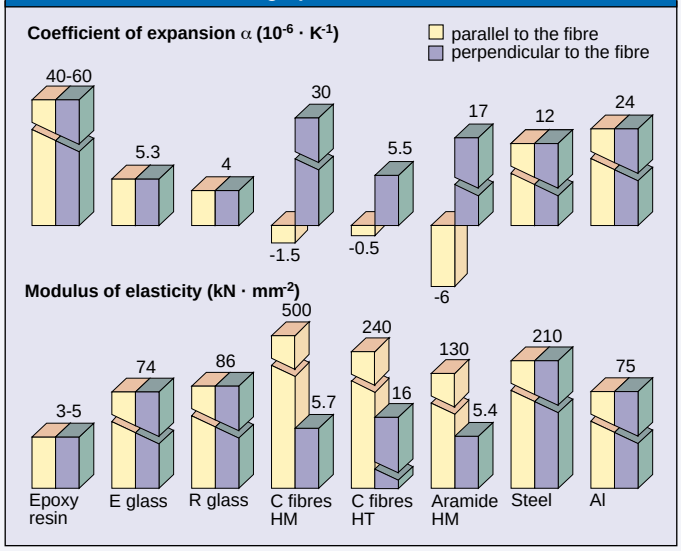

## Properties of reinforcing fibres in comparison




a E glass fibres
b Aramide fibres (HM)
c Carbon fibres (HT)

E Modulus of elasticity
ε Elongation
σ Tensile strength

## Characteristic values of high-performance fibres




In the fibre composite, the mechanical strength and the modulus of elasticity are determined by the reinforcing fibre used whereas the thermal behaviour, abrasion resistance and resistance to chemical attack are all dependent in the first instance on the matrix.

**Polyester**, **vinyl ester and epoxy resins** are used in making **WACOSIT® profiles**.

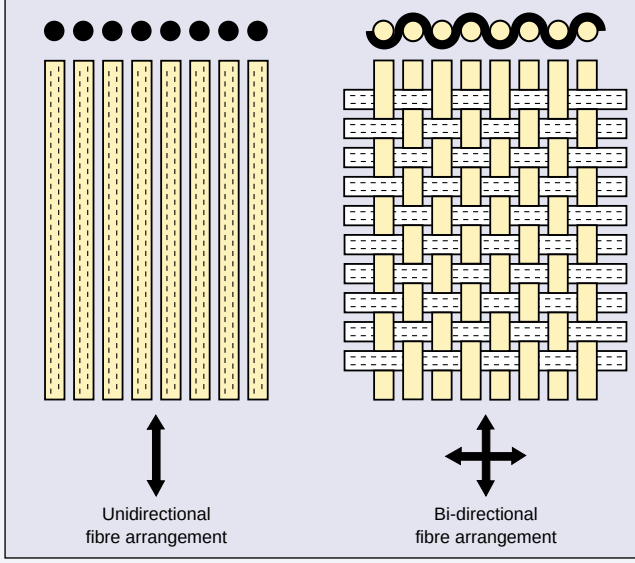
**Comparison of matrix systems**

| Matrix system | Continuous temperature (°C) | Failure strain (%) | Tensile module (GPa) |
|---|---|---|---|
| **Polyester resins** | 155 | 2 - 5 | 3.6 - 4.7 |
| **Epoxy resins** | 180 | 2 - 10 | 2.8 - 3.6 |
| **Vinyl ester resins** | 160 | 5 - 7 | 3.4 - 3.5 |

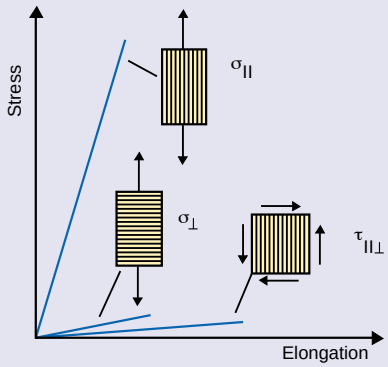
Needed for a theoretical analysis of the fibre composite are the elasticity and mechanical strength in the unidirectional single layer. In the case of an unidirectional material structure in the **same direction as the fibre orientation**, **higher mechanical strength and stiffness** values are given than for traverse or shearing stresses.

**Additional fabric tape** and **glass matting** can be used to give **WACOSIT® profiles** a **better compressive strength** and **sheering resistance** properties.

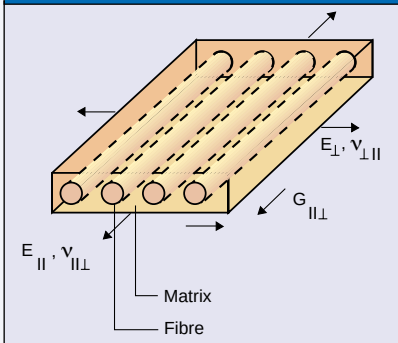
**Fibre arrangement in profiles**




**Stress / elongation behaviour of unidirectional fibre composites**




**Characteristic values of unidirectional fibre composites**




$E_{II}$ Modules of elasticity, longitudinal
$E_{\perp}$ Modules of elasticity, transverse
$G_{II\perp}$ Shear modules
$\nu_{\perp II}$ Transverse contraction coefficient
$\nu_{II\perp}$ Transverse contraction coefficient

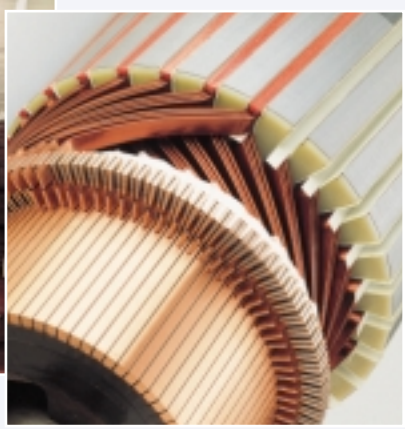
**WACOSIT® profiles** can also be taped with rovings in a criss-cross pattern to **improve the mechanical properties even further**.

Whereas for **calculating the elasticity behaviour** of conventional materials (= isotropic materials) it suffices as a rule to know the modulus of elasticity (E), the shear modulus (G) and the coefficient of traverse contraction (n). The case of fibre composites (= anisotropic materials) needs four mutually independent parameters: $E_{II}$, $E_{\perp}$, $\nu_{\perp II} = \nu_{II\perp} \cdot E_{II} / E_{\perp}$, $G_{II\perp}$, since the values in the longitudinal and traverse directions are different.

**Typical values for physical characteristics of unidirectional and fabric-reinforced layers** [1]

| Property | | Unit of measure | Unidirectional GRP | Unidirectional CRP | Fabric-reinforced GRP | Fabric-reinforced CRP |
|---|---|---|---|---|---|---|
| **Modulus of elasticity** | $E_{II}$ | GPa | 38 | 145 | 29 | 66 |
| **Modulus of elasticity** | $E\perp$ | GPa | 8 | 9 | 26 | 66 |
| **Shear modulus** | $G_{II\perp}$ | GPa | 4 | 4.5 | 6 | 4 |
| **Traverse contraction** | $\nu_{\perp II}$ | - | 0.26 | 0.3 | 0.12 | 0.04 |
| **Tensile strength** | $\sigma_{IIz}$ | MPa | 1060 | 1310 | 480 | 375 |
| **Tensile strength** | $\sigma_{\perp z}$ | MPa | 31 | 43 | 440 | 368 |
| **Compressive strength** | $\sigma_{IId}$ | MPa | 610 | 1220 | 390 | 279 |
| **Compressive strength** | $\sigma_{\perp d}$ | MPa | 118 | 168 | 305 | 278 |
| **Shear strength** | $\tau_{II\perp}$ | MPa | 72 | 48 | 133 | 46 |
| **Density** | $\varphi$ | g/cm³ | 2 | 1.6 | 2 | 1.6 |

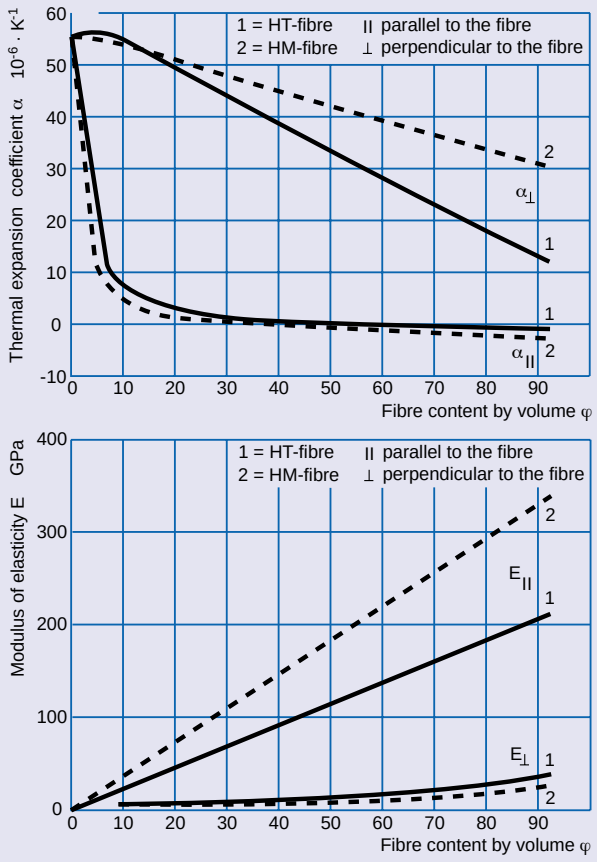
[1] **60% fibre content by volume; epoxy resin**



The customary rules when applied for mixing give on the one hand an estimation for the **mechanical properties** which is sufficiently accurate, whereas on the other hand – while considering the composite components of matrix and fibre – the **coefficient of thermal expansion** for the profile can be calculated.

The **fibre content of WACOSIT®** is about **60% by volume**. Of importance besides the mechanical properties are the electrical and thermal characteristics.

**Calculated coefficient of thermal expansion and modulus of elasticity for unidirectional carbon-reinforced plastic as a function of the fibre content by volume**



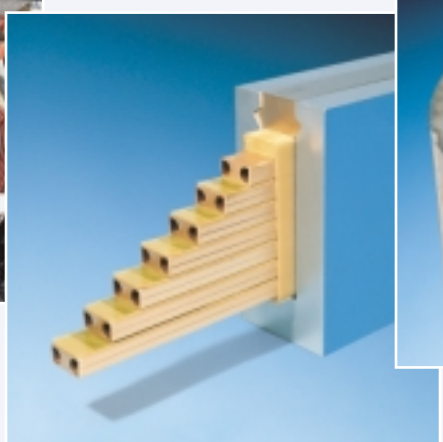

**Electrical and thermal properties of WACOSIT® profiles**

| Property | Unit | Glass-epoxy-profiles | Glass-Polyester profiles | Test method |
|---|---|---|---|---|
| **Electrical properties** | | | | |
| **Breakdown strength** | kV/mm | 10 | 10 | VDE 0303 T21 |
| **Dielectric constant** | - | 5 - 5.5 | 4.8 | VDE 0303 T4 |
| **Dielectric loss factor** | - | 0.03 | 0.03 | VDE 0303 T4 |
| **Surface resistivity** | Ω/□ | $10^{12}$ | $10^{12}$ - $10^{14}$ | VDE 0303 T30 |
| **Volume resistivity** | Ω · cm | $>10^{14}$ | $3 \cdot 10^{13}$ | VDE 0303 T30 |
| **Creepage current resistance** | CTI | 300 | 600 | VDE 0303 T1 |
| **Thermal properties** | | | | |
| **Thermal conductivity** | W/m · K | 0.23 | 0.20 | DIN 52612 |
| **Continuous temperature**[1)] | °C | 180 | 155 | VDE 0304 T21 ff |

[1)] For electrical machines of thermal class H or F

**Technical properties of WACOSIT® guying elements**

| | |
|---|---|
| **Proportion by weight** | 75 parts by weight of E glass<br>25 parts by weight of epoxy resin |
| **Specific weight** | 1.9 g/cm³ |
| **Temperature stability**<br>**Endurance stability**<br>**Short-term stability** | <br>80 °C<br>> 120 °C |
| **Tensile strength** | > 1,500 N/mm² |
| **Elongation at tear** | > 2.5 % |
| **Modulus of elasticity (tensile)** | > 50,000 N/mm² |
| **Coefficient of thermal expansion** | $6 \cdot 10^{-6}$/K |
| **Water absorption** | < 0.3 % |



# Processing and uses

**WACOSIT® profiles** can be **sawn**, **machined**, **turned**, **drilled**, **ground** and, up to a certain thickness, be **punched** as well. **Subsequent processing** of dimensionally accurate produced parts is **not normally necessary**. Processing requires the use of **hard-metal** or **diamond-tipped tools**. Wet processing is recommended to prevent dust emission and local overheating. Ventilation by extraction is necessary when dry processing. Attention shall be paid when processing carbon-epoxy that the dust thereby produced is electrically conductive. **WACOSIT® profiles, wound components** and **guying elements** have asserted themselves in many areas of applications as dependable constructional parts.

| Areas of use | Electrical engineering |
|---|---|
| **WACOSIT® type** | Glass-epoxy<br>Glass-polyester |
| **Advantages** | High breakdown voltage and creepage current resistance, good mechanical and thermal properties |
| **Applications** | **Electrical machinery construction:** slot wedges, slot inserts, supports, interleaves, banding rings, shaft insulation, mountings, ladders, and others<br>**Transformer construction:** Making cooling channels, tension rods, non-magnetic compressed constructions, clamping fixtures, supports, interleaves, ladders, and others<br>**Switchgear construction:** actuating rods, tension rods, spacers, supporting structures, shafts, fastening devices, and others<br>**General electrical engineering:** Tension rods in synthetic-resin suspension insulators, winding formers for resistance wires (wound components), brush holders, busbar spacers, terminal strips, guying systems for antenna masts, and others |

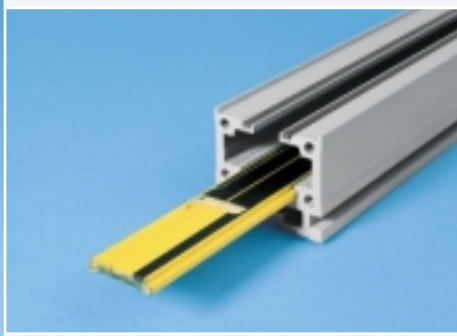
| Areas of use | Plant and machinery construction |
|---|---|
| **WACOSIT® type** | Glass-epoxy<br>Glass-vinyl-ester<br>Carbon-epoxy |
| **Advantages** | Low weight, good thermal conductivity, high dimensional stability, good resistance to chemicals, high mechanical strength |
| **Applications** | Papermaking machines, weaving looms, industrial ladders, wind power plants |

| Areas of use | Sport and recreation |
|---|---|
| **WACOSIT® type** | Glass-epoxy<br>Glass-polyester<br>Carbon-epoxy |
| **Advantages** | Low weight, good thermal conductivity, high dimensional stability, good resistance to chemicals, high mechanical strength |
| **Applications** | Kite construction, skis |

| Areas of use | Transportation and vehicle construction |
|---|---|
| **WACOSIT® type** | Glass-epoxy<br>Glass-vinyl-ester<br>Carbon-epoxy |
| **Advantages** | Low weight, good thermal conductivity, high dimensional stability, good resistance to chemicals, high mechanical strength |
| **Applications** | Constructional elements, winding supports |

| Areas of use | Construction and civil engineering |
|---|---|
| **WACOSIT® type** | Glass-epoxy<br>Glass-polyester |
| **Advantages** | Low weight, good thermal conductivity, high dimensional stability, good resistance to chemicals, high mechanical strength |
| **Applications** | Floor strips, platform edging in underground railway systems, heat bridges for windows |

| Areas of use | Cable industry |
|---|---|
| **WACOSIT® type** | Glass-epoxy<br>Glass-vinyl-ester |
| **Advantages** | Low weight, good thermal conductivity, high dimensional stability, good resistance to chemicals, high mechanical strength |
| **Applications** | Guying elements (stress-relief) in optical-fibre cables |



KREMPEL GROUP

# KREMPEL GROUP

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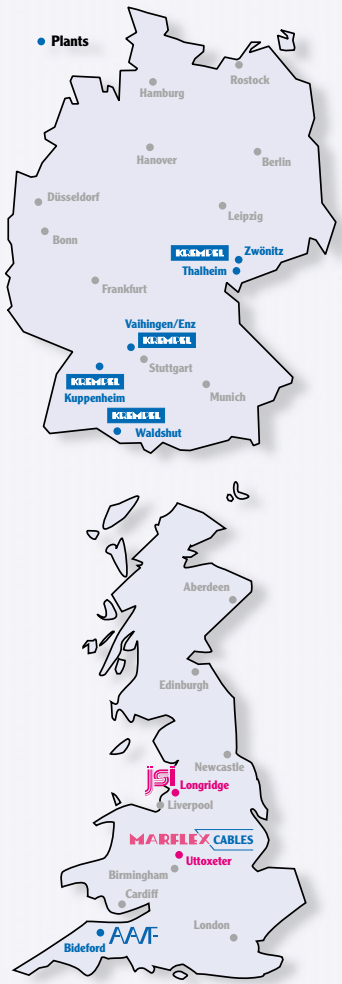


### Fibre composites

Prepreg systems with thermosetting and thermoplastic resins · Filament windings · Pultruded plastic profiles · Laminated tubes and rods · Plastic sheets · Moulded parts · Plastic mouldings – Injection and Compression · Machined precision parts · Component assembly

### Electrical insulations

Presspahn: Presspaper, pressboard, corrugated board · Multi-layer insulation materials · Prepregs · Mica products · Electrically conductive materials · Side and top ripple springs · Banding tapes · Woven tapes · Insulation sleevings · Tying cords · Sealing tapes · Silicone elastomer cables

### Base materials and special laminates

Materials for flexible printed circuits · Materials for Smart Cards · Sheets for solder frames · Laminates for solar engineering and in protection applications · Materials with self-adhesive coatings and special metal foils

### Authorised distributor for Du Pont

**In Germany, Austria and Eastern Europe:**
KAPTON® polyimide film
**In Germany, Austria, the Netherlands and Eastern Europe:**
TEDLAR® PVF protective film and release film
**In Great Britain:**
NOMEX® aramide paper

### Special products

Temperature-resistant cables and seals for domestic appliances · Special sleevings for automotive electrical applications

### Certification

All companies in the KREMPEL-GROUP are certified according to **ISO 9001**. Certain divisions are also certified to **QS-9000**. In addition to this, some products are **UL-listed** or are **UL-recognised components**. We shall be pleased to provide you with more detailed information.

## KREMPEL-GROUP distribution agencies

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