Guideline

Methodology of uses

Standard data sheet template for preforms – composite sector

CELC
EUROPEAN CONFEDERATION OF FLAX AND HEMP

2019

Manual for the Technical Datasheets Flax & Hemp Preforms

Random mats, weaves, non-crimp fabrics, UD layers, rovings/yarns

The structure of the datasheets is the same for first four preforms. It is divided in four main parts:

- Description of the fibres,
- Description of the fabric,
- Mechanical properties of the laminate and
- Additional information

The fifth, yarn/roving data sheet is divided differently in five main parts:

- Composition of the roving/yarn,
- Description of the roving/yarn,
- Mechanical properties of impregnated bundle in a composite and
- Additional information

All data are measured following international standards, in line with glass and carbon fibre benchmarks. *For every property that is mentioned in the datasheet, the related standard (ISO-standard) is mentioned.*

The guideline is set in order to help in comparing in a reliable and objective way the characteristics and properties of different preforms coming on the market.

1) Identification of the preform

Here a name and/or identification (code, number…) for the preform should be given. It is important that this name is only referring to **one** preform. Every other type (e.g. having a different areal weight) should have another name.

2) Description of the fibres and fabric/preform

This is information which should be known from the production of the preform. Therefore, this information should be provided by the producers of the preform themselves. If rovings or yarns are used for the production of the preform it is **mandatory** to attach the corresponding datasheet of the roving/yarn producer or spinning company. In this case, the roving/yarn properties (for example linear density) will not be repeated on the preform datasheet. The **density of flax and hemp is** fixed at 1,45g/cm^3. So always the same density should be used, as this gives a better impression to the composite part manufacturers. Measuring the density of fibres is not a straightforward technique and therefore very expensive. By fixing the density this can be avoided.

For all properties which have to be measured, it is important that **the standards mentioned in the data sheet are followed.**

One of the unique properties of flax and hemp fibre preforms is their large areal volume compared with glass fibre preforms having the same areal weight. In other words, a higher fibre volume fraction is reached in a flax or hemp fibre composite when the same weight of reinforcement is used. This makes flax and hemp fibre preforms an excellent choice for light weight designs. The areal volume is mentioned in the footnote of the datasheets and is calculated as follows. The areal weight is divided by the flax fibre density, which we propose to fix at 1,45g/cm^3. Keep in mind that with mixed fibres the density will be different. This result has to be divided by 1000 to obtain the correct units (areal weight in g/m^2, areal volume in mm^3/mm^2, density in 1,45g/cm^3):

$$areal\ volume = \frac{areal\ weight}{density} * \frac{1}{1000}$$

3) Mechanical properties of the laminate

This information is very important for composite part manufacturers. It is **mandatory** to present the mechanical properties for at least one of the two laminates. However, sharing the properties of the preform in combination with both a thermoset and thermoplastic matrix is encouraged. In case the preform producer cannot measure the properties themselves, a testing laboratory or research institute should be asked to do perform these tests.

At least the following information related to the production of the composite test samples is required. Any further information is valuable and can be mentioned in the "additional information" section.

- **Stacking sequence** (*it is recommended that all layers have the same orientation, for instance all weave layers positioned in warp direction. If not, the lay-up should be specified*)
- **Composite manufacturing process**
- **Name of the matrix** (*it is mandatory to attach the datasheet of the matrix material*)

Recommendations:

- A fiber volume fraction (V_f) of minimum 25% ± 5% is recommended. However, in case of thermoplastic composites where the thermoplastic matrix is already present in the preform (for instance by using commingled yarns) the fibre volume fraction is fixed and cannot be changed.
- Keep track of the warp and weft direction for weaves, and of the machine and cross direction for random mats and non-crimp fabrics.

Calculation of the fibre volume fraction:

A flax or hemp fibre density of 1.45 g/cm^3 (ρ_{fibre}) is considered for the calculations of the fibre volume fraction in the composite V_f , using the following Equation 1:

$$Vf\,(\%) = \frac{\rho_{surf} \cdot N}{10 \cdot \rho_{fibre} \cdot h} \qquad \text{(Eq. 1)}$$

Where ρ_{surf} is the areal weight (g/m^2) and ρ_{fibre} is the density (g/cm^3) of the fibers, *N* is the number of layers used and *h* is the composite laminate thickness (in mm).
A second method can be used to determine the fibre volume fraction: using the weight of the fibre and the weight of the composite, it is possible to calculate the fibre volume fraction (Eq.2) with the hypothesis that there is no porosity.

$$V_f(\%) = \frac{\frac{m_f}{\rho_f}}{\frac{m_f}{\rho_f} - \frac{m_c - m_f}{\rho_{res}}}\, x\, 100 \qquad \text{(Eq. 2)}$$

Where ρ_{res} is the density of the resin (in g/cm^3), m_f is the mass (in grams) of the fibres and m_c is the mass of the impregnated bundle.

The **mechanical properties** should be **measured according to the standards** mentioned in the datasheet. Otherwise the presented values make no sense. Also know that just mentioning the standard is not enough, one really has to work according the instructions of the standard. It is important that **two** stiffness values are mentioned. The first one measured between 0 and 0.1% strain, the second one between 0.3 and 0.5% strain. For the **non-crimp fabrics,** it is important that it is made very clear which direction the tests were performed. In this case a drawing of the stacking sequence will be very useful in case of complex fabrics.

The calculation of the two Young's moduli E1 and E2:

The calculation of the modulus is made according to the ISO 527 for tensile testing and ISO14125 for flexural testing. The difference from the standard are that:

- E1: The stiffness calculated between 0 and 0,1% strain
- E2: The stiffness calculated between 0,3 and 0,5 % strain
- The strength at maximum strain
  → only samples which break in between the grips are valid
- The failure strain in %

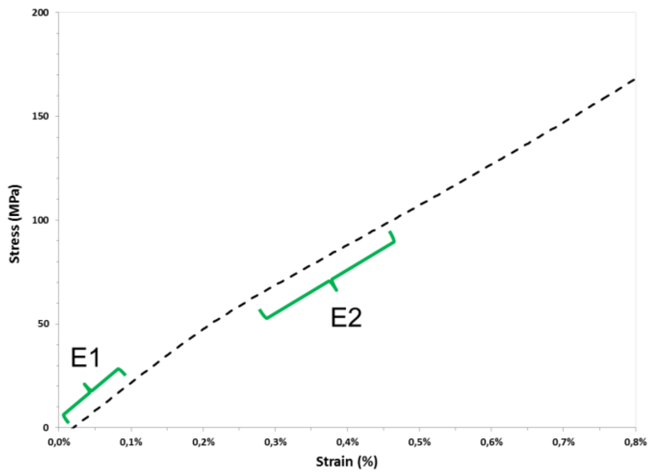

Figure 1: Zone where E1 and E2 should be calculated

Two values for the fibre stiffness are calculated because flax and hemp fibres tend to suffer from a decrease in stiffness around 0,2% strain when loaded in fibre direction. This non-linear stress-strain behaviour is characteristic for flax and hemp fibres. However, the relevance of stating two stiffness values decreases when the complexity of the preform increases. Therefore, two stiffness values are only required for the preforms where this data is most valuable for design purposes.

Back-calculated fibre/yarns properties *(only for roving/yarn data sheets)*:

For the roving/yarn data sheets, the Impregnated Fibre Bundle Test (IFBT) has to be used. Please see separate guidelines for IFBT sample manufacturing and testing, also provided by CELC. From the measured composite properties on this "impregnated fibre bundle", the following properties can be back-calculated:

- From an **impregnated roving** (having no twist!), the properties of **flax fibres**, as they are present and behave in a composite, can be determined
- From an **impregnated bundle of yarns** (having a certain twist), the properties of **(twisted) flax yarns**, as they are present and behave in a composite, can be determined

The back calculation the fibre/yarn properties is performed using the following formulas:

$$E_f = \frac{E_c - E_m + (1 - V_f)}{V_f}$$

$$\sigma_f = \frac{\sigma_c - \sigma_m + (1 - V_f)}{V_f}$$

Where, E_f is the modulus of the fibre, E_m is the modulus of the matrix and Vf is the fibre volume fraction, σ_f is the strength of the fibre and σ_m the strength of the matrix *(moduli are given in GPa, strengths in MPa)*. In the calculation, the σ_m is the stress in the matrix at the failure strain which can calculated assuming elastic deformation of the matrix: $\sigma_m = E_m \times \varepsilon_c$.

4) Additional information

In the next part one can mention other properties which could be of interest for a composite part manufacturer. It is an ideal environment to stress the unique properties of the preform and to describe some of the characteristics in more detail. For each datasheet a fitting template is prepared in order to facilitate the sharing of additional information. It is advised to use and mention the relevant standards were applicable.

It is **mandatory** to attach the datasheet(s) of the thermoset and/or thermoplastic matrix used for the production of the composite laminate. Where applicable, it is also **mandatory** to attach the datasheet(s) of the rovings/yarns used to manufacture the preform. Except of the former, the other sections of this part are **not mandatory** to fill out.

The template consists of a combination of the following subsections depending on the type of preform.

- **Certification** (*Refers to the certification of the flax or hemp fibre used for the production of the preform. For example: European Flax® certified*)
- **Additives**
- **Treatment:** In this part one has to fill out only non-confidential information. This means that one does not have to mention how the fibre or preform is treated, but **for which purpose**. This purpose can be: to compatibilize the fibre or preform with a certain matrix, or against moisture absorption, or for improved fire resistance. The recipes of the treatments are confidential, and should not be mentioned. When there is no treatment, one should also mention this.
- **Recommended storage and use conditions** (*This is important, otherwise the customers will never obtain the same properties*)
- **Suggestions for additional information:** In this section the preform producer is encouraged to share information outside the framework of the template. This may include data related to the advantages of flax and hemp preforms over their synthetic counterparts as for example the life cycle analysis and vibrational damping properties. One could also share additional information of the preform structure and drapability, and/or additional mechanical properties on composite level like fatigue- and impact properties. This is all useful data for the design of composite parts. Finally, the incorporation of various sales aspects could further strengthen the datasheet.

The preform producer commits to filling out the template with data and information according to the "manual of uses" in reference.
The characteristics and properties mentioned in the template should be measured following international standards. Preform producer commits to respect this policy and to fill out the appropriated data following the methods described in the international standards, and the guidelines provided.
The contents (=filled out data) of the technical data sheets are under the responsibility of the company providing the data sheets.