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Letoxit® LFX 162

Application
for production of laminated segments reinforced with glass, carbon or kevlar fibers. Usage - parts of airplanes, sailplanes, sport boats, carriage body….

Usage
Epoxy resin in the form of foil is designed for patent Letoxit® Foil Technology (LF Technology). LF Technology is a dry lamination technique, which is suitable especially for production of laminate structures with exactly defined reinforcement and resin content. If it is necessary to increase the amount of resin in a certain place, it is also possible to combine epoxy resin Letoxit® Foil with prepregs.

Letoxit® Foil LFX 162 can be applied for all types of reinforcement. Various types of glass, carbon or Kevlar fabrics or their combinations are mostly used. Unidirectional oriented reinforcements or 3D fabrics can be used, too. LFX 162 is suitable especially for production of sandwich structures and honeycomb constructions. The produced laminate has very good mechanical properties under stress in temperature range from -75°C to +100°C. Therefore it is used for manufacturing of aircraft parts and transport vehicles.

Type:
Epoxy resin, which contains a hardening system with increased tackiness

Appearance:
A resin is in the form of yellowish transparent foil, 0.1-0.7 mm thick with the surface area weight 120-800 g/m2 (according to the customer request). It is flexible and shapeable at indoor or increased temperature.

Lamination technique:
Laminate is made by laying foils and reinforcement in order to keep the required predetermined reinforcement/resin ratio. Required shape corresponding to the shape of laminated surfaces is cut out with scissors, knife or other tool from the Letoxit® Foil resin. Covering paper is pulled off the foil and the resin is put on the upper layer of the reinforcement. The resin foil pushed against the reinforcement a little and smoothened to avoid reinforcement folds. The reinforcement has to be loosened well to fill the mold perfectly. The second covering polyethylene foil is then pulled off and next reinforcement layer is applied. These steps are repeated until the desired amount of reinforcement layers is reached. It is recommended to work at the manipulation temperature – temperature range, which specifies processability of Letoxit® Foil. Below the manipulation temperature, this material is too brittle and it breaks and it is too shapeable and adhesive above this temperature range. The manipulation temperature is thus 15-35°C; the best processability is between 20 and 30°C. It is suitable to use hot-air gun for assembling of more difficult compositions or shaped surfaces, especially when warm table cannot be used.

It is possible to use either more layers of reinforcement alternately with the Letoxit® Foil resin or to use one thick layer of Letoxit® Foil resin and several layers of reinforcement. It is necessary to have at least one layer of reinforcement between the mold and the layer of Letoxit® Foil resin. The amount of Letoxit® Foil has to be high enough to fill up the vacant space in the reinforcement structure. Minimal amount of resin content can be calculated with following formula:

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$$m_{LF} / \rho_{LF} + m_R / \rho_R = t_C$$

where m_{LF} is a Letoxit® Foil area weight (g/m^2), ρ_{LF} is a Letoxit® Foil density (g/cm^3), m_R (g/m^2) is a reinforcement area weight (g/m^2), ρ_R is reinforcement density (g/cm^3) and t_C is composite thickness (μm). Area weight can be calculated for all layers of reinforcement or Letoxit® Foil. Examples of some reinforcement density can be found in the table.

Type of reinforcement	Density (g.cm^3)
E-glass	2.58
S2-glass	2.46
Carbon	1.76

Air has to be evacuated from the composition reinforcement-Letoxit® Foil before curing. Required pressure is 0.075-0.09 MPa. The composition has to be evacuated longer to achieve required pressure value in all parts of the laminate. It is important particularly for large products or products with high number of layers. It is recommended to perforate the Letoxit® Foil with a spiked roller; it allows better evacuation of air before curing. The evacuated composition is cured in the mold at increased temperature under vacuum or in a press or autoclave. Resin can be also added to prepregs by laying the Letoxit® Foil to a specified place, where increased amount of resin is needed. The processing of this composition is the same as in the case of prepregs. Careful evacuation of air and sufficient pressure difference reach perfect impregnation of fibers after temperature rise; thus the quality of the resulting composite is comparable with prepregs without necessity of autoclave use.

Curing:

Letoxit® Foil LFX 162 resin can be cured at temperature 120-125°C for 20 minutes, or eg. 80°C for 240 min. Laminate is fixed with pressure 0.075-0.09 MPa during curing. Two processes occur during temperature rise of the foil:

1. The viscosity of Letoxit® Foil decreases with increasing temperature and the dry reinforcement is being impregnated
2. Epoxy resin starts to cure (effect of hardeners) after temperature rise

Therefore it is necessary to ensure sufficient time for impregnation of dry reinforcement during curing at increased temperature before Letoxit® Foil reaches the gel point when material is not able to flow and thus impregnate the dry reinforcement. For that reason the following temperatures are determined:

- *Impregnation temperature*, which is the lowest temperature when the viscosity of Letoxit® Foil is low enough to impregnate the dry reinforcement. In the case of Letoxit® Foil LFX 162, the impregnation temperature is 80°C. Impregnation is easier at higher temperatures, but the time for resin flow is shorter.
- *Curing temperature*, which is the temperature when resin is cured at certain time.

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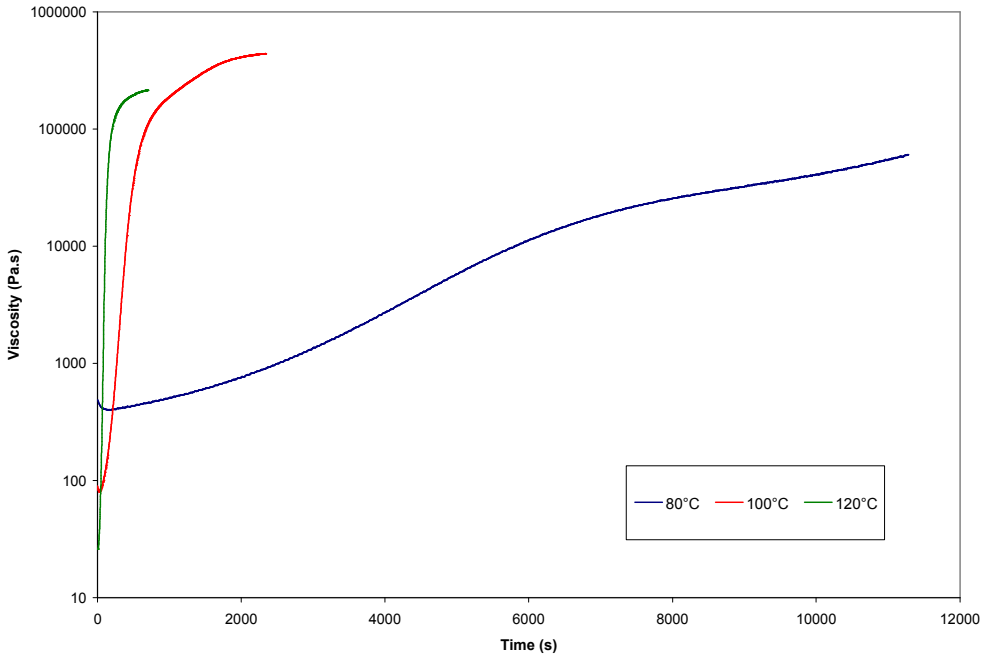

Fig.1: Dependence of viscosity on time at various temperatures

Curing time is counted from the moment when the temperature within the produced laminate reaches curing temperature. No volatile compounds are released from laminate during preparation or curing. Laminated can be also cured at lower temperature but the curing time have to be prolonged, see Fig. 2.

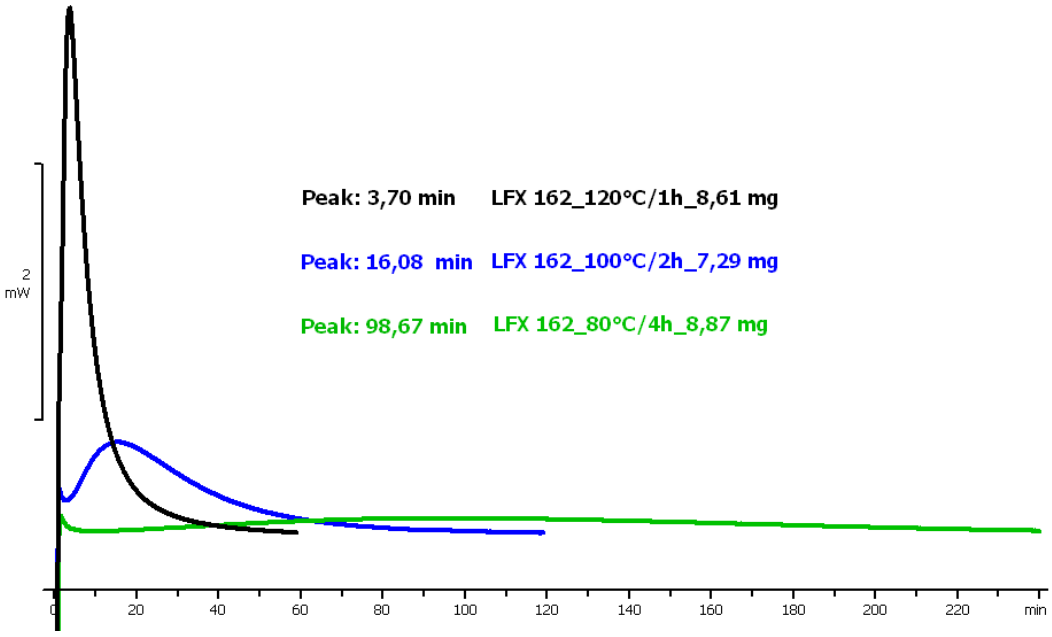

Fig. 2: Dependence of reaction rates on time at constant curing temperatures 80, 100 and 120°C, measured at DSC.

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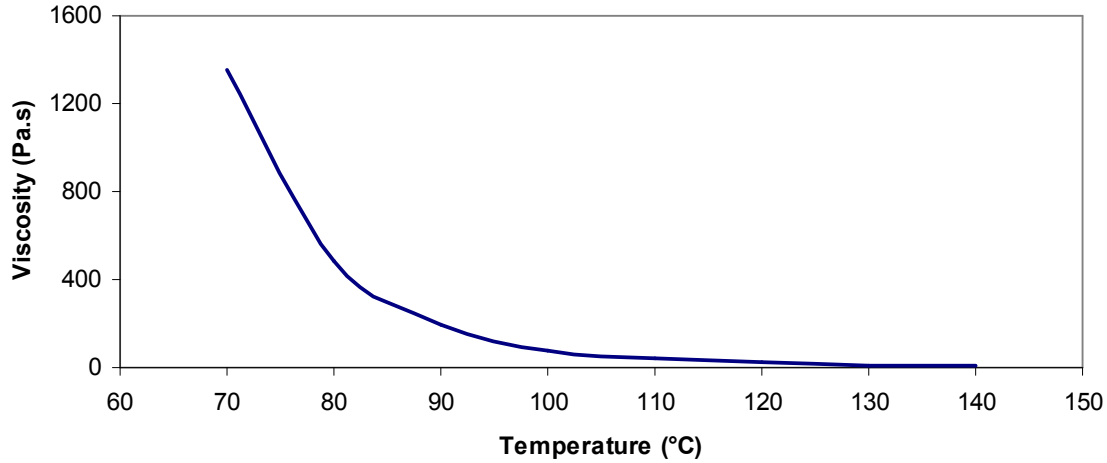

Fig. 3: Dependence of viscosity on temperature

It is necessary to keep the composition at the curing temperature for at least the minimal curing time. It is necessary to verify that the curing temperature is reached within whole cross-section of the cured composition. Temperature inside the cured composition can be measured with e.g. thermocouple, see Fig. 4.

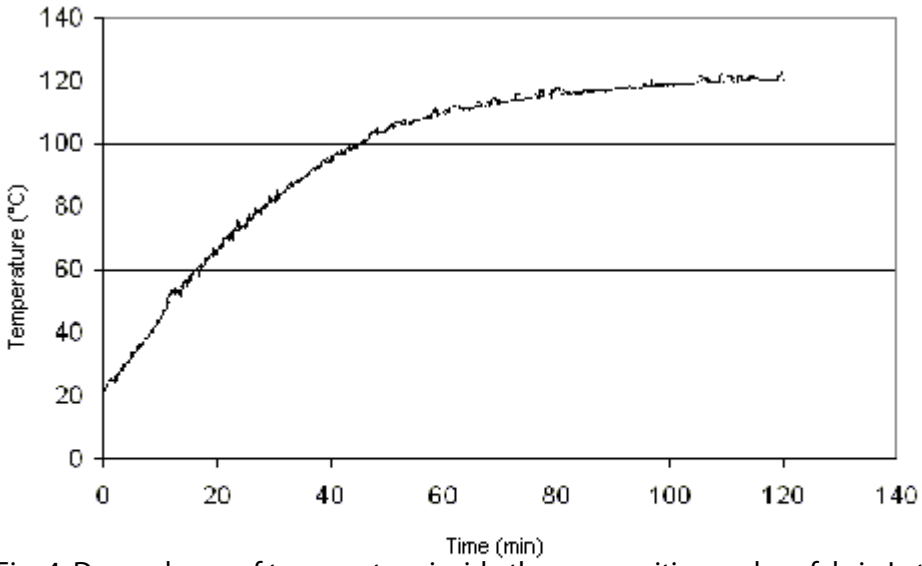

Fig. 4: Dependence of temperature inside the composition carbon fabric-Letoxit® Foil 2.3mm thick. The composition was cured under vacuum in a steel mold at 120°C laid in a drying kiln.

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Properties of Letoxit® Foil LFX 162

Density of uncured resin (g.cm^{-3})	1.20	1.20	1.20
Curing temperature (°C)	80	100	120
Minimal curing time (min)	240	90	30
Recommended curing time (min)	300	120	60
Peak of reaction (min)	98.7	16.1	3.7
Tg (°C)	67	94.5	96.6
Density of cured resin (g.cm-3)	1.30	1.30	1.30

Composite properties reinforced with glass *

Density (g.cm^{-3})	1.71
Resin content (%)	43.5
Maximal flexural stress (MPa)	540
Flexural modulus of elasticity (GPa)	18.9

* Properties of cured composite were measured after curing at given temperature and recommended curing time. Composite constitution: 12 layers of glass fabric - twill weave, 163 g/m2, and 5 layers of Letoxit® Foil LFX 162, 300 g/m2.

Composite properties reinforced with carbon *

Density (g.cm-3)	1.45
Resin content (%)	41
Maximal flexural stress (MPa)	820
Flexural modulus of elasticity (GPa)	47.5

* Properties of cured composite were measured after curing at given temperature and recommended curing time. Composite constitution: 12 layers of carbon fabric - twill weave, 211 g/m^2, and 10 layers of Letoxit® Foil LFX 162, 200 g/m^2.

The composition produced under the LF Technology can be cured to lower conversion degree, app. 70% and post-cured outside the mould. However, the composition that is not cured properly is very brittle.

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Packaging:

The resin is delivered in the form of foil, 250 mm or 1000 mm width, which is protected by a polyethylene foil from one side and isolating paper from the other side. It is winded up on the hollow with the total weight up to 10 kg (usually 5 kg rolls are supplied – according to the customer request).

Storage:

Without the change of properties, the resin can be stored for 1 month at +20°C, for 3 months at 5°C and up to 1 year for –18°C. The temperature +30°C mustn't be crossed during transport and storage.

Safety during processing:

see Safety sheet

Producer and Supplier:

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Letoxit® is a registered trademark of 5M s.r.o. company