

Handling Guide & Instructions:

Z01 UD Prepreg

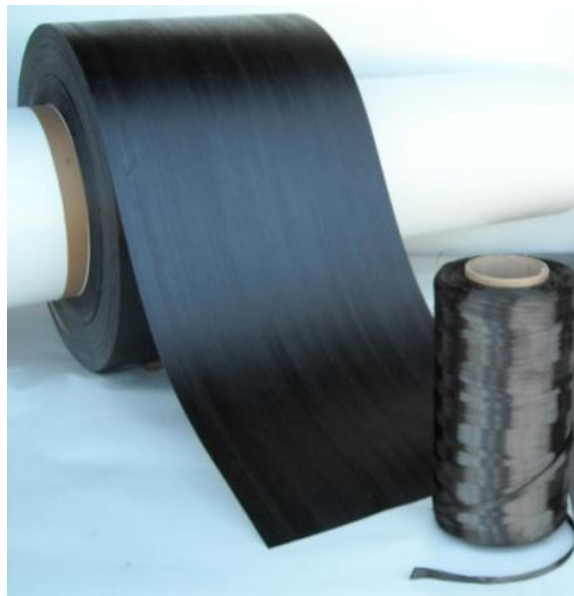
Product Description

Z01 is an epoxy resin formulation designed for making unidirectional prepreg with Panex®35 carbon fiber. Z01 Prepreg is particularly suited for use in large composite structures such as wind turbine blades. It has medium tack for easy processing and medium flow in cure to facilitate consolidation. Z01 composites display excellent mechanical properties, particularly in compression and fatigue.

Thick UD Laminate Quality

Z01 heavy areal weight prepreg allows the customer to build up part thickness rapidly and reduce time on tool. This prepreg has proven to achieve excellent laminate quality with low void content, without the need for debulking. Zoltek's Panex® 35 commercial carbon fiber is used with this material to suit the application. The Z01 Prepreg resin system allows for a quicker cure with a mild exotherm allowing faster production rates.

In order to maximize the potential of Z01 Prepreg for use within components, please contact your Zoltek representative. Contact details are on the back of this Product Handling Guide.



Resin System

Z01's out time is over five weeks at room temperature (23°C/73°F) yet it can be cured at relatively low temperatures (85°C). High-performance, low-void composite parts up to 88mm (3.25in) in thickness have been produced with only vacuum-bag pressure during cure and without intermediate debulking.

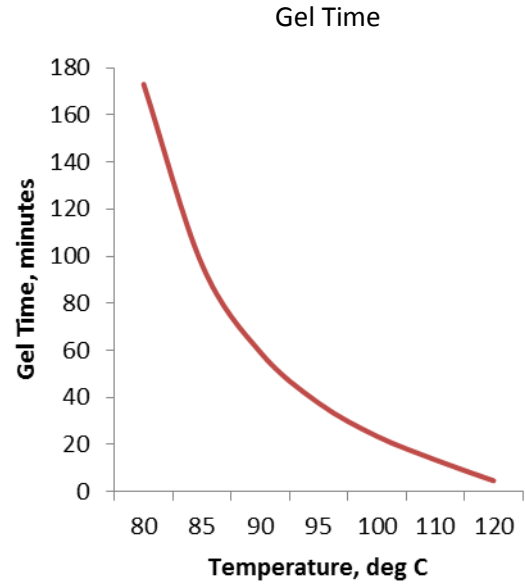
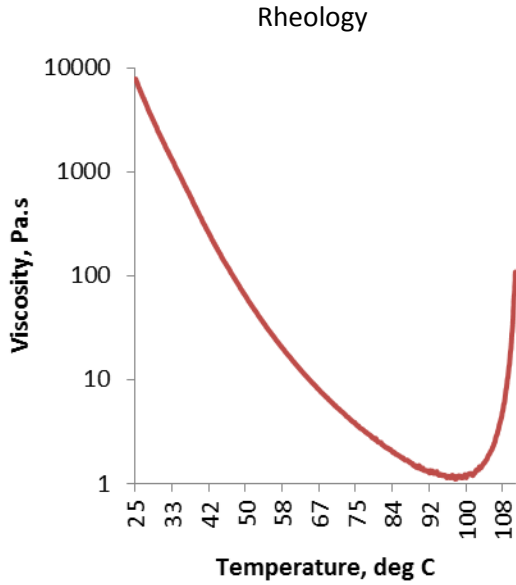
Resin Matrix Properties

» *Uncured*

Thermal Properties (20°C-250°C @ 10°C/minute)	
Enthalpy (J/g)	245

Time to 95% Cure	
Minimum Cure Temperature	Time @ minimum cure temp (minutes)
80°C	400
90°C	170
100°C	70
110°C	45
120°C	25

Rheology	30-120°C @ 1°C/minute	30-120°C @ 2°C/minute
Temperature @minimum Viscosity (°C)	97	104



» Cured

Mechanical Properties	
Tensile Strength (MPa)	77
Tensile Modulus (GPa)	4.2
Tensile Strain (%)	2.5
Matrix Density (g/cm ³)	1.23

Thermal Properties (Cured between 90°C-120°C)	
DSC T _g (°C)	125-135

Panex® 35 Reinforcement Properties (typical values)

	SI Units	US Units
Tensile Strength	4200 MPa	610 ksi
Tensile Modulus	245 GPa	35.5 msi
Elongation	1.5%	
Density	1.81 g/cc	0.065 lb/in ³
Fiber Diameter	7.2 microns	0.283 mils
Carbon Content	95%	
Yield	270 m/kg	400 ft/lb

Prepreg Characteristics (typical values)

Z01 Prepreg	
Fiber areal weight (FAW):	150 - 600 g/m ²
Prepreg Density:	1.54 g/cm ³
Resin System:	Z01
Resin content by weight:	30-45%
Fiber content by volume:	45-70%
Nominal Cured Ply Thickness:	0.15 – 0.60 mm

Mechanical Properties

The following represents typical minimum values generated at Zoltek Laboratories:

Mechanical Properties (Vf = 56%)	
Tensile Strength	1750 MPa
Tensile Modulus	131 GPa
Compressive Strength	1250 MPa
Compressive Modulus	120 GPa
In-plane Shear Strength	59 MPa
In-plane Shear Modulus	4.8 GPa
ILSS	67 MPa

Material Receipt

Z01 UD prepreg is rolled onto cardboard cores of two different sizes:

1. 250mm (10in) inside diameter for lower fiber areal weights (150-350 gsm)
2. 300mm (12in) for higher fiber areal weights (greater than 350 gsm).

The core is at least 25mm (1in) wider than the prepreg on each side so that the roll can be supported by the core ends. Both the width of the prepreg and the roll size can be specified by the customer. Identifying labels are placed inside the core of each prepreg roll and on the box. Upon receipt, the material should be stored in its original packaging at 5°C (40°F) or lower. Conditioning to use temperature is required prior to the application of the prepreg. See below for recommended use temperatures.

Delivery Form

Delivery form:	Rolls
Release film:	According to customer preference, Zoltek prepreg is supplied with either paper or poly (polyethylene) film on one side only, paper on one side and poly on the other, or poly film on both sides.
Roll length:	Roll lengths up to 250 m (800 ft)
Inner core diameter:	25, 30 cm (10, 12 in)
Prepreg width:	Up to 1.25 m

Note: Special packaging is available upon request such as markings, labeling, roll size, packaging configuration and type, etc. Resin content and carbon fiber areal weight can be specified by the customer.

Shelf Life

@20°C:	2 months
@5°C:	6 months
@-18°C:	12 months

Prior to Use

The Z01 Prepreg must be slightly above room temperature (23-28°C / 74-83°F) prior to use. Remove the prepreg from cold storage sufficiently in advance of use for it to warm to room temperature. The actual time required will depend on the size of the roll and the warming conditions. To speed warm-up, remove the roll from its box or, at a minimum, open the box. However, do not remove the polyethylene bag until it is completely warm. Support the roll at all times by its core and not by the prepreg itself as this can deform the prepreg build-up and lead to problems during lay-up. The prepreg roll can be stood on end if a set of shipping cradles or other similar structures are placed under the prepreg to prevent telescoping.

Handling and Lay-up

It is best to unroll the prepreg horizontally. Keep it as straight and flat as possible to minimize distortion. Leave the carrier film on the prepreg as long as possible to reduce distortion and contamination. (Note that Z01 UD prepreg can be supplied with paper or polyethylene film on one side (top or bottom), polyethylene film on both sides, or paper on one side and polyethylene on the other.)

Manual Application - During lay-up, place the prepreg into position with an “up-down” motion only. Maintain sufficient tension as it is laid in place to keep the fibers straight and to avoid distortion, waves or bubbles in the laminate. Press the ply in place only lightly, initially, and check to ensure that it is in the correct position; if it is not, lift it directly upward from the underlying surface with a peeling motion and re-lay it. Do not try to shift a misplaced ply sideways without lifting it up as the tackiness of the prepregs will cause it to distort. Once correctly located, the prepreg can be pressed, compacted or rolled firmly (when the top carrier is still in place, it will not move).

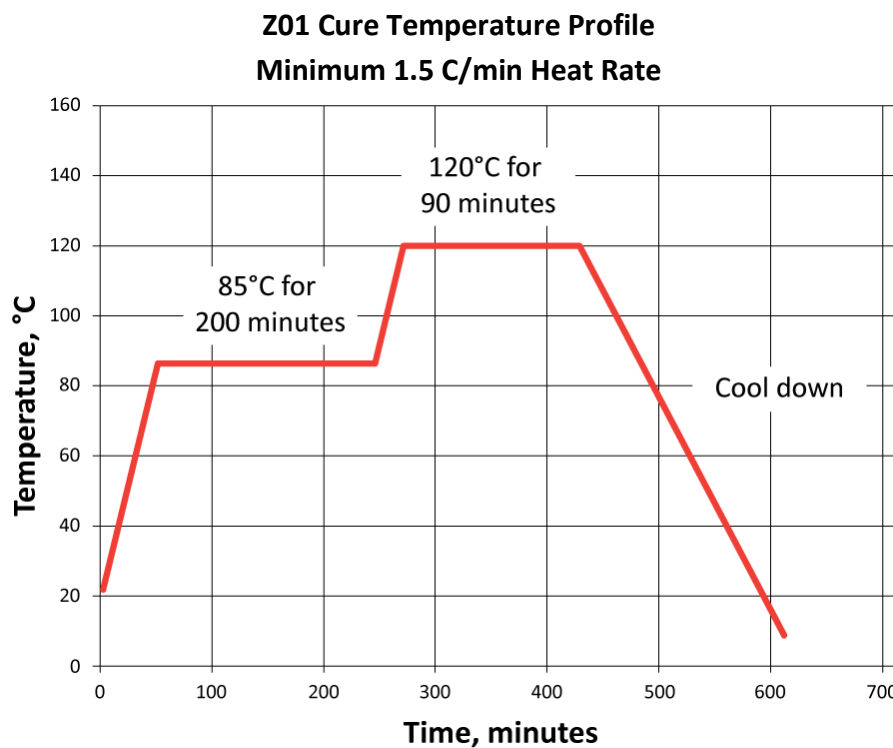
Prepreg Dispensing Cart – Some customers prefer an integrated dispenser to lay the prepreg onto their mold tool. Part quality, repeatability and manufacturing efficiency are all maximized with this approach. Zoltek works with the customer’s tool designers to develop an integrated dispenser specifically designed for that mold. The resulting Prepreg Dispensing Tool (PDT), sometimes called a prepreg cart, is delivered to the customer along with specific usage instructions to effectively apply the prepreg with minimal handling. For large, modestly shaped parts, such as a wind blade spar cap, it is best to use a dispensing cart. Mold temperatures should be kept at 26°C to 30°C (79°F to 86°F) during the application of the material. The mold temperature should not be allowed to reduce during the laydown process. The prepreg material should be conditioned to a uniform temperature of 23°C to 28°C (74°F – 83°F). For large rolls this equilibration usually happens within 24 hours. If wrinkles are noticed during laydown (a function of degree of mold contour), increase the material temperature to 28°C (83°F) for the application. Zoltek can assist customers in selecting the proper mold and material temperatures for best results.

Cure

In most cases, Z01 Prepreg can be cured with:

1. a simple cure profile consisting of a steady ramp up to the cure temperature,
2. a hold at that temperature for the specified time,
3. a steady cool-down ramp.

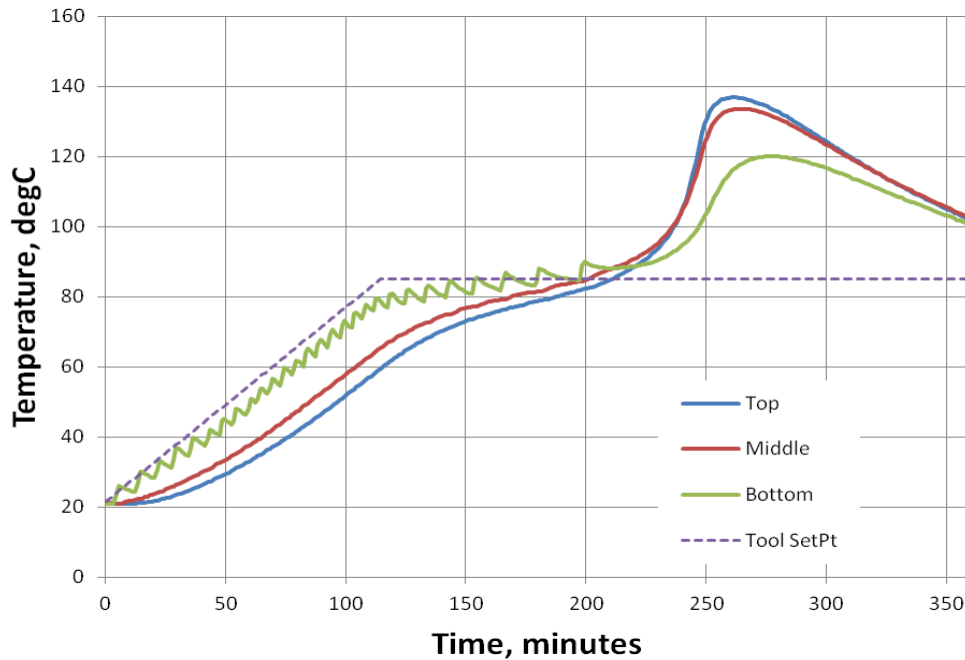
Ramp rates are typically from 1.5-3°C/min (2.5-5°F/min). Z01 Prepreg will cure at 80°C (175°F) (part temperature) for eight hours or at 120°C (250°F) for 90 minutes or at various temperatures and times in between. A suggested cure cycle is illustrated below:



The optimum cure conditions for each part will depend on the part thickness, part mass, tool mass, heating method and capability, etc. Zoltek can recommend cure profiles for specific parts, molds and shop environments.

Exothermic reaction is a consideration for thick laminates. Slower ramp rates are required to assure that the material has time to melt and flow, enabling the vacuum to remove the air from the laminate. For example the cure of a 54-ply laminate is shown below. Thermocouples were inserted at the bottom of the laminate (next to the tool), in the middle and on the top. Once the exotherm has peaked, it is sometimes desirable to raise the tool to a higher temperature for post-curing. Post curing assures that all of the segments of the blade have a prescribed minimum T_g.

Thick Laminate Thermal Profile



Tool temperature during layup is an issue that warrants consideration because of differential thermal expansion between tool and the prepreg. Most importantly, it is not recommended that the tool temperature cools during the time of the prepreg application as this could result in ply wrinkling. If anything, the tool should be gradually warming if not maintained at constant temperature. Zoltek can recommend methods to attain desired results.

Certification

A Certificate of Conformance is included with each shipment; either a standard Zoltek Certificate of Conformance or certification to a customer specification and/or other special requirements, as requested by the customer.

About Zoltek

Zoltek's mission is to lead the commercialization of carbon fiber; providing low-cost, high-performance composite reinforcements for use in primary building materials in everyday products.

We will meet this objective through technology and innovation, high product performance, price stability, and capacity expansion.

Please direct all inquiries, sales orders, or sample requests to your respective sales office below.

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