E6-215

Low temperature curing tooling epoxy prepreg

High service temperature

TECHNICAL DATA SHEET

E6-215 MATRIX is a thermosetting epoxy matrix designed for low temperature cure, with process temperatures ranging from 45°C to 55°C.

After initial curing, E6 tooling laminates can be postcured, to allow final service temperature up to 190°C.

E6 prepregs have at least 72 hours out life at 21°C.

PRODUCT VARIANTS

E6-215: Hotmelt version, unpigmented

SHELF LIFE

OUT LIFE[2]
72 hours @ 21 °C

STORAGE LIFE
6 months @ -18 °C

TYPICAL APPLICATIONS

TOOLING

FEATURES

- INITIAL AUTOCLAVE CURE BETWEEN 45 AND 55 °C
- SHORT POSTCURING CYCLE OPTION
- MAXIMUM Tg OF 240 °C
- CARBON FABRIC WEIGHTS BETWEEN 193 AND 995 g/m²
- TOOLING OPTIONS OF 1-8-1, 1-6-1 AND 1-5-1 QUASI-ISOTROPIC CONSTRUCTIONS
- LOW VOLATILE CONTENT

1 Where the intended end application is for a cosmetic product, customers are advised to consult a Microtex Composites sales representative for specific advice on fibre selection when placing an order for material.

2 Out life is the maximum time allowed before cure after a single frozen storage cycle in the original prepreg bag unopened stored at -18°C or below for a period not exceeding the above mentioned frozen storage life.

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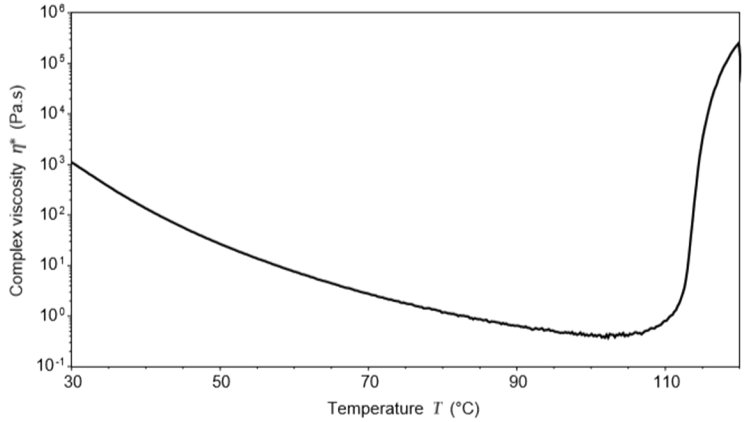
MATRIX PROPERTIES

Cured resin density @ RT: (average value) 1.20 g/cm^3.

Resin viscosity: ramp rate = 2 °C/min, v = 10 rad/sec.



TOOL OR MASTER MODEL REQUIREMENTS

The terms “model”, will be used throughout this document to describe the item or shape onto or into which the pre-preg is to be laid up.
E6 prepregs can be cured against most non porous materials (e.g. aluminium, closed cell syntactic foams) and some porous materials (e.g. wood, plaster) providing that a suitable epoxy sealant is applied in the latter case.
The model must be constructed in such a manner as to possess perfect vacuum integrity and to withstand the pressure applied during cure. In some cases, E6 prepregs may be cured under oven/vacuum bag moulding conditions, the vacuum required varying from few hundreds mmHg to full vacuum. In other cases, the materials may be cured under autoclave pressure, typically 6 bar (600kPa). Whatever the cure cycle to be used, it is strongly recommended that the tool or model be subjected to a representative cure cycle, including representative bagging arrangement, prior to commencing lay-up.
The curing reaction of E6 prepregs can be inhibited when the material is moulded in contact with certain materials. Cure inhibition results in a sticky, uncured resin surface, which can be thin but sufficient to impair the cosmetic quality of the surface finish of the part or tool. Materials that are known to cause such a reaction are:
Urethane or phenolic based foams as used in some common tooling
Polyurethane based lacquers and sealants
Some phenolic resins
Some polyester resins
Acid catalysed resins and sealers
Some acrylic paints
Epoxy tooling board can lead to rough surface and cure inhibition without the proper master model preparation.

The preferred method of preventing cure inhibition when moulding E6 prepregs against such materials is the application of an approved barrier coating.

The Experience lead that the epoxy master model resin should be adequately sealed with an appropriate product and application tecnique. With urethane or phenolic modelling board, a surface gel-coat should be used as a suitable barrier material.

Whichever product is used, the application instructions as given in the appropriate Microtex Data Sheet must be carefully observed as slight deviations from these instructions can render the barrier coating ineffective.

Microtex should be contacted regarding the availability of chemical surface pretreatments which have in many cases been effective in eliminating or reducing the effects of inhibition reactions.

In all cases where there exists no prior experience of moulding E6 prepregs against specific tool or model materials, Microtex Microtex should be consulted and if necessary a suitable trial conducted.

TOOLING COSTRUCTION

Tooling prepregs are offered as fabric surface plies and bulk plies. The surface plies are of a lighter weight fabric, and this assists with laminating details and corners. On the cured tooling, the surface ply provides a pit-free finish and an even surface. The bulk plies are of heavier fabrics and used to form the majority of the tooling laminate thickness.

A typical tooling laminate is 5 to 6 mm in thickness, which confers rigidity to the final tool.

It is usual to lay-up tooling prepregs in a nominal quasi-isotropic construction, to provide the same coefficient of thermal expansion in all directions for the cured tool. This can be achieved by a 1-8-1 construction (surface ply-bulk plies-surface ply).

A typical lay-up is:

0° 0°, -45°, +45°, 90°, 90°, +45°, -45°, 0° 0°

With E6 carbon fabric tooling prepregs, there are now four options for the bulk plies. The original 600 gsm 2x2 Twill (GG600T) for a 1-8-1 construction, and now an 800 gsm 2x2 twill (GG800T) or 995 gsm 2x2 twill (GG995T).

As the twill weave is balanced in warp and weft, the GG800T can be laminated in a simpler quasi-isotropic 1-6-1 construction:

0° 0/90, ±45, 0/90, 0/90, ±45, 0/90 0°

Likewise, the GG995T can be used according to this option for 1-5-1 construction:
0° 0/45, 0,/45, 0 0°

TOOLING LAY-UP

- Thaw the frozen prepreg in the sealed bag at room temperature. Cut pieces of surface and bulk ply prepreg appropriate to the shape and dimensions of the tool. Ensure a suitable release agent is applied to the epoxy master model. For additional information, please contact the Microtex Technical Department (see "Tooling prepreg Processing Guide" file).
- Lay-up the surface fabric plies, in a nominated 0° direction, to cover the entire master model. For corners and fine detail, it is usual to use compliant ±45° strips of surface ply prepreg first to avoid bridging. All pieces of surface ply prepreg need to be overlapped by 2 to 5 mm.
- De-bulk after the lamination of the first and the second ply under a vacuum bag for approximately 15 minutes. All de-bulks should be performed using a perforated release film between prepreg and breather (suggested perforation pattern P3; Polyester NW Breather: 150 to 200 g/m2); ensuring no bridging in the bag .
- The stacking for the following bulk plies of the heavier fabric should be quasi-isotropic with a symmetrical and balanced sequence. All pieces of bulk ply prepreg can be overlapped slightly. It is best to avoid overlaps occurring at the same point with adjacent ply layers, they should be staggered away from each other.
    - De-bulk after surface ply
    - De-bulk after first bulk ply, then de-bulk every 1 to 2 plies .
- The last ply will be surface fabric prepreg orientated in the nominated 0° direction, to complete the nominated symmetrical construction.
- Perform a final vacuum de-bulk immediately before bagging the laminate for initial cure.
- For the final bagging arrangement, the following steps should be observed:
    - place at least one thermocouple between the surface ply and the first bulk ply, near the thickest part of the master model.
    - solid (non-porous) release film must be used between prepreg and breather.
    - the polyester breather should wrap the laminate ensuring no bridging; for larger tools use VV770 (50 to 100mm Dry fabric) stripes in order to realise a 400x400mm mesh on the breather surface for better air extraction.
    - a minimum of two vacuum ports as the following table:

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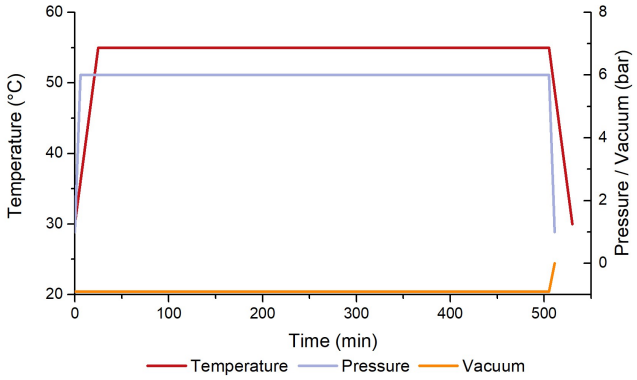
Vacuum ports number vs laminate surface	
Until 2 m²	2
Until 3 m²	3
Over 3 m²	One additional port every m²

vacuum ports should be located away from the top of the laminate ensuring they are connected with the breather path.

- wrap the layup with a bagging film compliant with the process specification, ensuring no bridging in the bag.
- a vacuum integrity check should be undertaken on the final bag before placing in the autoclave for curing (the procedure includes the application of a full vacuum and then a disconnection of the vacuum source). A pressure loss greater than 70 mbar in 15 minutes, need a recheck of the bag for removing the leaks.

CURING CONDITIONS

Autoclave Cure[3,4]			
Time (min)	Temp. (°C)	Time (min)	Pressure (bar)
0	30	0	1
25	55	6	6
505	55	505	6
530	30	511	1



3 Temperature must be measured by the lagging thermocouple attached to the part.
4 Vacuum bag pressure: 0.9 bar.

POST-CURING CONDITIONS

A slow controlled temperature ramp rate, not exceeding 0.33°C/min (20°C/Hour) is essential to develop the resin Tg. The slow postcure also ensures the tool retains the correct profile and dimensions.

	Option I	**Option II**
Start temperature	Initial tooling cure temperature, minus 10°C	Initial tooling cure temperature, minus 10°C
Oven ramp rate	0.33 °C/min (20 °C/h)	0.33 °C/min (20 °C/h)
Postcure Dwell Conditions	4 h @ 180 °C (+5/-0 °C)	8 h @ 195 °C (+5/-0 °C)

Microtex also explored on small laminates the opportunity to harden the material at lower temperatures as low as 55 °C:

Initial minimum cure times[5]	
Temperature [°C]	Time [h]
45	24
50	16

CURING CYCLES AND Tg's

Cure cycle	**Tg (DMA) Onset (°C)**	**Tg (DMA) tanδ (°C)**
8 h @ 55 °C	55	70
Postcure opt. I	201	225
Postcure opt. II	215	243

[5] This is the minimum recommended dwell time; large heat capacity (e.g. aluminum or steel) or high insulated master model (e.g. epoxy or MDF) need longer dwell time up to two or three times more than the minimum recommended.

MECHANICAL PROPERTIES AFTER THERMAL CYCLING

Thermal Cure Cycles @ 135°C	**GG200T-45[6] (Postcure opt.I)**
	0° Interlaminar shear strength (ILSS) [MPa] ASTM D2344
Postcured	49
50 Cycles[8]	49
100 Cycles[8]	48

Thermal Cure Cycles @ 180-195°C	**GG600T-34[7] (Postcure opt.II)**
	0° Interlaminar shear strength (ILSS) [MPa] ASTM D2344
Postcured	45
40 Stress cycles[9]	38
After stress cycles at different temperatures[10]	38

C.T.E.

Fabric	GG200P
Ply Orientation	Quasi-isotropic
Cure Cycle	8 h @ 55 °C + 4 h @ 180 °C
Alpha [µm/m·°C]	2.520

6 Carbon fabric 200 gsm twill 2/2 3K, RC 45%.
7 Carbon fabric 600 gsm twill 2/2 12K, RC 34%.
8 Each cycle: 90 min @ 135 °C (heat ramp 2 °C/min 40-135 °C – isotherm 90 min @ 135 °C – cool ramp 5°C/min 135-50°C).
9 Each cycle: 8 h @ 180 °C (heat ramp 2 °C/min 40-180 °C – isotherm 8 h @ 180 °C – cool ramp 5 °C/min 180-120 °C – isotherm 1 hour @ 120 °C - heat ramp 2 °C/min 120-180 °C) .
10 320 h @ 180 °C + 50 h @ 195 °C .

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AVAILABILITY

Carbon Tooling Surface Plies

Fabric	Weave Style	Fibre Aeral Weight	Fibre Type	Nominal Ply Thickness
GG193P	Plain	193 g/m²	Flat HS Carbon	0.23 mm
GG200T	2x2 Twill	200 g/m²	3K HS Carbon	0.24 mm
GG245T	2x2 Twill	245 g/m²	3K HS Carbon	0.29 mm

Carbon Tooling Bulk Plies

Fabric	Weave Style	Fibre Aeral Weight	Fibre Type	Nominal Ply Thickness
GG600T	2x2 Twill	600 g/m²	12K HS Carbon	0.63 mm
GG800T	2x2 Twill	800 g/m²	24K HS Carbon	0.84 mm
GG995T	2x2 Twill	995 g/m²	24K HS Carbon	1.00 mm

Other fabrics prepreg versions can be made available on request.

STORAGE CONDITIONS

This prepreg should be stored as received in a cool dry place or in a refrigerator.
After removal from refrigerated storage, prepreg should be allowed to reach room temperature before opening the polyethylene bag, thus preventing condensation.

PRECAUTIONS FOR USE

The usual precautions when handling uncured resins and fibrous materials should be observed, and a Safety Data Sheet is available for this product.

SDS Reference Codes: E6-215: SDS-435