# HexPly® M21

## 180°C (350°F) curing epoxy matrix

Product Data Sheet

### Description

HexPly® 21 is a high performance, very tough epoxy matrix for use in primary aerospace structures. It exhibits excellent damage tolerance, especially at high energy impacts.

HexPly® M21 is a toughened epoxy resin system supplied with unidirectional or woven carbon or glass fibers.

HexPly® M21 was developed as a controlled flow system to operate in environments up at 121°C (250°F).

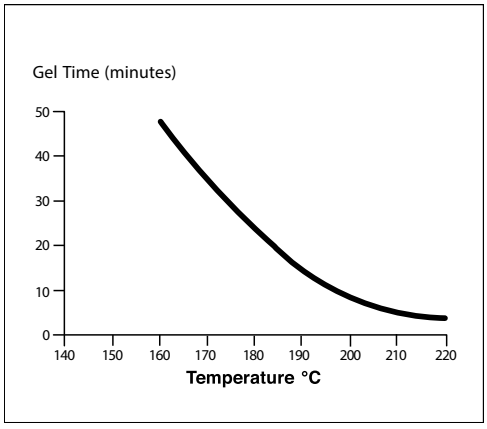
### Benefits and Features

- Excellent toughness, in particular at high energy impact.
- High residual compression strength after impact.
- Effective translation of fibre properties, especially with intermediate modulus carbon fiber.
- Good hot-wet properties up to 150°C (302°F).
- Low exotherm behavior allowing simple cures of thick structures up to 48mm (1.89”).
- Good tack life.

HexPly® M21 is best suited to press or autoclave cure to obtain optimum mechanical performance from the cured composite.

### Resin Matrix Properties

*Gel Time*

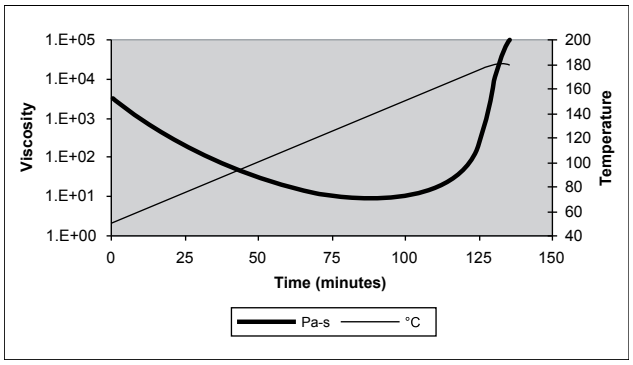


## Cure Cycle Viscosity Profiles

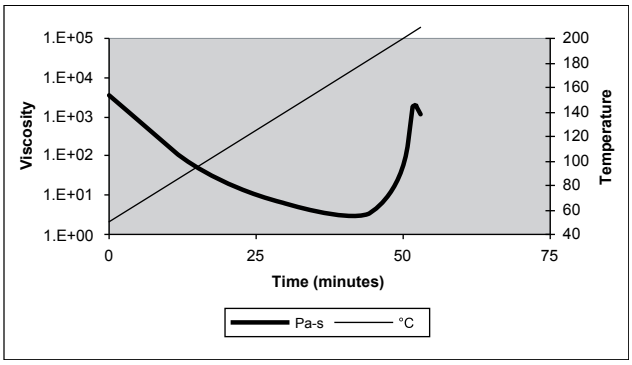
All experiments were made on an ARES-RDA Rheometer and correspond to the recommended cure cycles overleaf.

### *Typical Autoclave Cure Monolithic Par <15mm (0.6") thick*

*1°C/min (2°F/min) heat-up rate*

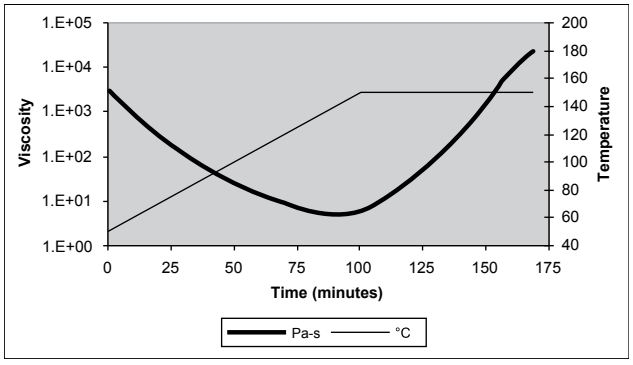



*3°C/min (5°F/min) heat-up rate*

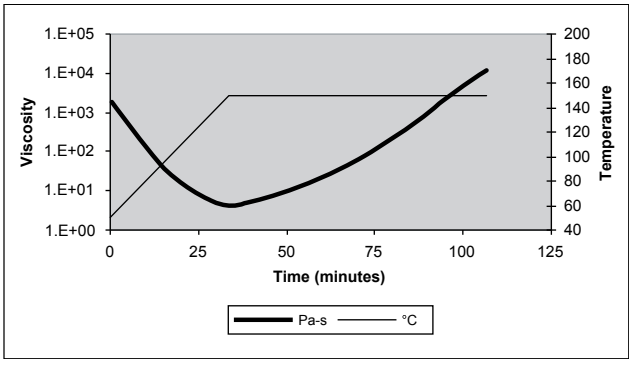



### *Typical Autoclave Cure Monolithic Par 15 - 48mm (0.6-1.89") thick*

*1°C/min (2°F/min) heat-up rate*

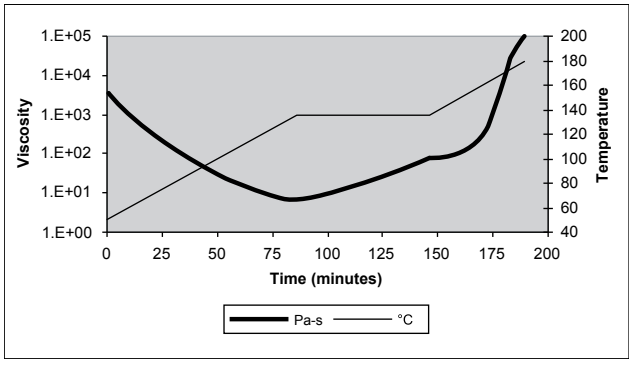



*3°C/min (5°F/min) heat-up rate*

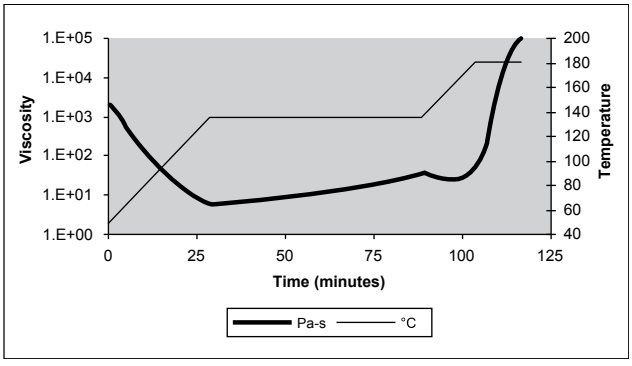



### *Typical Autoclave Cure Sandwich Parts*

*1°C/min (2°F/min) heat-up rate*




*3°C/min (5°F/min) heat-up rate*




## Prepreg Lay-up

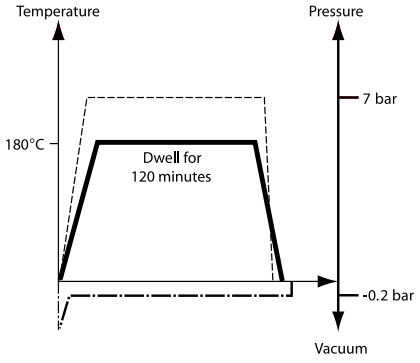
To achieve the best laminate quality, the 1st ply should be vacuum debulked to the mould at room temperature. Vacuum debulking of subsequent plies may be necessary to ensure removal of air trapped during the lay-up process. The frequency of debulking depends on part size and complexity.

## Prepreg Curing Conditions

Defined heat-up rates will vary depending on the autoclave dimensions, the mass of tooling used and the size of the component to be manufactured.

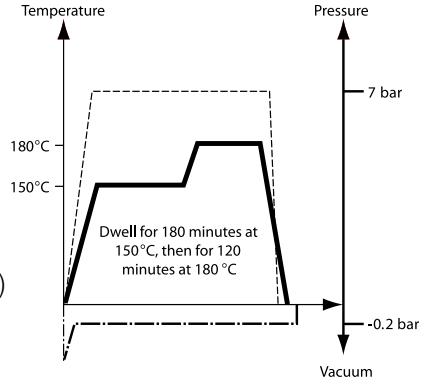
### *Typical Autoclave Cure Monolithic Part <15mm (0.6") thick (1)*

1. Apply full vacuum (1 bar).
2. Apply 7 bar gauge autoclave pressure.
3. Reduce vacuum to a safety value of -0.2 bar when the autoclave pressure reaches ~ 1 bar gauge
4. Set heat-up rate from room temperature to 180°C ±5°C (356°C ±9°F) to achieve an actual component heat-up rate between 1-2°C/minute (2-4°F/ minute).
5. Hold at 180°C ±5°C (356°C ±9°F) for 120 minutes ±5 minutes.
6. Cool component at an actual cooldown rate of 2-5°C/minute (4-9°F/minute).
7. Vent autoclave pressure when the component reaches 60°C (140°F) or below.



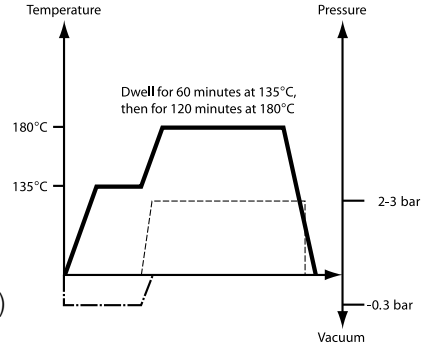

### *Typical Autoclave Cure Monolithic Part <15mm-48mm (0.6-1.89") thick (1)*

1. Apply full vacuum (1 bar).
2. Apply 7 bar gauge autoclave pressure.
3. Reduce vacuum to a safety value of -0.2 bar when the autoclave pressure reaches ~ 1 bar gauge
4. Set heat-up rate from room temperature to 150°C ±5°C (302°C ±9°F) to achieve and actual component heat-up rate between 0.5-1°C/minute (1-2°F/ minute).
5. Hold at 150°C ±5°C (302°C ±9°F) for 180 minutes ±5 minutes.
6. Set heat-up rate from 150°C ±5°C (302°C ±9°F) to 180°C ±5°C (356°C ±9°F) to achieve an actual heat-up rate between 0.5-1°C/minute (1-2°F/minute).
7. Hold at 180°C ±5°C (356°C ±9°F) for 120 minutes ±5 minutes.
8. Cool component at an actual cooldown rate of 2-5°C/minute (4-9°F/minute).
9. Vent autoclave pressure when the component reaches 60°C (140°F) or below.




### *Typical Autoclave Cure Sandwich Structure - Honeycomb or Foam (1)*

1. Apply -0.3 bar maximum vacuum.
2. Do not apply autoclave pressure.
3. Set heat-up rate from room temperature to 135°C ±5°C (275°C ±9°F) to achieve an actual heat-up rate between 1-2°C/minute (2-4°F/minute).
4. Hold at 135°C ±5°C (275°C ±9°F) for 60 minutes ±5 minutes
5. After 60 minutes at 135°C (275°C), apply 2-3 bar gauge autoclave pressure (dependent on core density).
6. Remove vacuum when the autoclave pressure reaches ~1 bar gauge.
7. Set heat-up rate from 135°C ±5°C (275°C ±9°F) to 180°C ±5°C (356°C ±9°F) to achieve an actual heat-up rate between 1-2°C/minute (2-4°F/minute).
8. Hold at 180°C ±5°C (356°C ±9°F) for 120 minutes ±5 minutes.
9. Cool component at an actual cooldown rate of 2-5°C/minute (4-9°F/minute).
10. Vent autoclave pressure when the component reaches 60°C (140°F) or below.




*(1) As the cure cycle tolerance are related to the material, the temperature profile of the whole part must be kept within these tolerances. Thermocouples have to be applied to the component to guarantee that the temperature recording is representative of the actual experienced cure cycle of the component.*

## Cured Unidirectional Prepreg Properties

*Nomenclature: resin/resin content by weight (%)/fiber weight (gsm)/fiber type*

| Physical Properties | Units | M21/34%/UD194/ IM7-12K | M21/34%/ UD194/ AS7-12K | M21/34%/ UD194/ IMA-12K |
|---|---|---|---|---|
| Fiber | g/m² | IM7 | AS7 | IMA |
| Weave/UD | | UD | UD | UD |
| Fiber Mass | | 194 | 194 | 194 |
| Nominal Prepreg Mass | g/m² | 294 | 294 | 294 |
| Theoretical Calculated Cured Ply Thickness | mm (inch) | 0.184 (0.0072) | 0.184 (0.0072) | 0.184 (0.0072) |
| Theoretical Calculated Fiber Volume | % | 59.2 | 58.9 | 59.2 |
| Resin Density | g/cm³ (lbs/ft³) | 1.28 (79.9) | 1.28 (79.9) | |
| Fiber Density | g/cm³ (lbs/ft³) | 1.78 (111.1) | 1.79 (111.1) | 1.79 (111.1) |
| Theoretical Calculated Laminate Density | g/cm³ (lbs/ft³) | 1.58 (98.6) | 1.58 (98,6) | 1.58 (98,6) |

| Mechanical Properties | Units | Temp °C (°F) | M21/34%/UD194/ IM7-12K | M21/34%/ UD194/ AS7-12K | M21/34%/ UD194/ IMA-12K |
|---|---|---|---|---|---|
| Test Standards | | | US Standards | European Standards | |
| Glass Transition Temperature | °C (°F) | | 195 (383) | 195 (383) | |
| Method | | | ASTM E1640 | EN 6032 - DMA extrapolated onset E' | |
| Tension Strength | MPa (ksi) | 23 (73) | 2860 (415) | 2350 (341) | 3050 (442) |
| Tension Modulus | GPa (msi) | 23 (73) | 160 (23.2) | 148 (21.5) | 178 (25.8) |
| Method | | | ASTM D3039 (1) | EN 2561 B | |
| Compression Strength | MPa (ksi) | 23 (73) | 1790 (260) | 1560 (226) | 1500 (218) |
| Compression Modulus | GPa (msi) | 23 (73) | 148 (21.4) | 123 (17.8) | 146 (21.2) |
| Method | | | ASTM D695 (2) | EN 2850 B | |
| ILSS | MPa (ksi) | 23 (73) | 110 (15.9) | 114 (16.5) | 97 (14.1) |
| Method | | | ASTM 2344 | EN 2563 | |
| In-plane Shear Strength | MPa (ksi) | 23 (73) | - | 109 (15.8) | 94 (13.6) |
| In-plane Shear Modulus | GPa (msi) | 23 (73) | 4.6 (0.67) | 5.2 (0.75) | 5.2 (0.75) |
| Method | | | ASTM D3039 (3) | EN 6031 | |
| Open Hole Tension | MPa (ksi) | 23 (73) | 495 (72) | 365 (53) | 510 (74) |
| Method - (25/50/25) (gross section) | | | ASTM 5766 (5) | EN6035 (4) | |
| Open Hole Compression | MPa (ksi) | 23 (73) | 303 (44) | 315 (46) | 305 (44) |
| Method - (25/50/25) (gross section) | | | ASTM D6484 | EN 6063 (6) | |
| CAI @ 30.5J | MPa (ksi) | 23 (73) | 298 (43) | - | - |
| CAI @ 30.0J | MPa (ksi) | 23 (73) | - | 238 (34.5) | 219 (31.8) |
| Method - (25/50/25) | | | ASTM D7136-D137 | EN6038 | |

*(1) Specimen dimensions: 12.7mm wide and 127mm free length (0.5" wide and 5" free length)*
*(2) Specimen dimensions: 80x12.7mm (3.1"x0.5")*
*(3) Specimen dimensions: 12.7mm wide and 127mm free length (+45/-45)s (0.5" wide and 5" free length)*
*(4) Specimen dimensions: 280x32 mm (11"x1.3")*
*(5) Specimen dimensions: 305x38mm and 6.35mm hole diameter (12"x1.5" and 0.25" hole diameter)*
*(6) Specimen dimensions: 132x32mm and 32 mm free length (5.2"x1.3" and 1.3" free length)*

## Cured Woven Prepreg Properties

*Nomenclature: resin/resin content by weight (%)/reinforcement reference/width (mm)*

| Physical Properties | Units | M21/40%/285T2/ AS4C-6K | M21/35%/370H5/ AS4C-6K | M21/37%/7581 | M21/45%/120 | M21/56%/1080 |
|---|---|---|---|---|---|---|
| Fiber | g/m² | AS4C | AS4C | E-Glass | E-Glass | E-Glass |
| Weave/UD | | 2x2 twill | 5HS | 8HS | 4HS | PW |
| Fiber Mass | | 285 | 370 | 300 | 105 | 48 |
| Prepreg Mass | g/m² | 475 | 569 | 476 | 193 | 109 |
| Theoretical Calculated Cured Ply Thickness | mm (inch) | 0.285 (0.0112) | 0.343 (0.013) | 0.235 (0.009) | 0.106 (0.004) | 0.066 (0.0026) |
| Theoretical Calculated Fiber Volume | % | 55.8 | 60.2 | 50.0 | 38.4 | 28.2 |
| Resin Density | g/cm³ (lbs/ft³) | 1.28 (79.9) | | | | |
| Fiber Density | g/cm³ (lbs/ft³) | 1.78 (111.1) | 1.78 (111.1) | 2.56 (159.8) | 2.56 (159.8) | 2.56 (159.8) |
| Theoretical Calculated Laminate Density | g/cm³ (lbs/ft³) | 1.56 (97.7) | 1.59 (99.1) | 1.92 (119.9) | 1.77 (110.5) | 1.64 (102.4) |

| Mechanical Properties | Units | Temp °C (°F) | M21/40%/285T2/ AS4C-6K | M21/35%/370H5/ AS4C-6K | M21/37%/7581 | M21/45%/120 |
|---|---|---|---|---|---|---|
| Glass Transition Temperature | °C (°F) | | 195 (383) | | | |
| Method | | | EN 6032 - DMA extrapolated onset E' | | | |
| Tension Strength | MPa (ksi) | 23 (73) | 885 (128) | 880 (128) | 444 (64) | 320 (weft) (46) |
| Tension Modulus | GPa (msi) | 23 (73) | 67.6 (9.8) | 73.9 (10.7) | 25.5 (3.7) | 24.8 (weft) (3.6) |
| Method | | | EN 2597 B | | EN 2747 | |
| Compression Strength | MPa (ksi) | 23 (73) | 835 (121) | 820 (119) | 692 (weft) (100) | 674 (weft) (98) |
| Compression Modulus | GPa (msi) | 23 (73) | 59.7 (8.6) | 63.9 (9.3) | - | - |
| Method | | | EN 2850 B | | | |
| ILSS | MPa (ksi) | 23 (73) | 70 (10.1) | 70 (10.1) | 75 (10.8) | 60 (8.7) |
| Method | | | EN 2563 | | EN 2377 | |
| In-plane Shear Strength | MPa (ksi) | 23 (73) | 97 (14) | 94 (14) | 99 (14) | - |
| In-plane Shear Modulus | GPa (msi) | 23 (73) | 4.2 (0.61) | 4.8 (0.70) | 4.4 (0.64) | - |
| Method | | | EN 6031 | | | |
| Open Hole Tension | MPa (ksi) | 23 (73) | 340 (49) | 375 (54) | - | - |
| Method - (25/50/25) (gross section) | | | EN6035 (1) | | | |
| Open Hole Compression | MPa (ksi) | 23 (73) | 330 (48) | 345 (50) | - | - |
| Method - (25/50/25) (gross section) | | | EN 6063 (2) | | | |
| CAI @ 30.0J | MPa (ksi) | 23 (73) | 276 (40) | 270 (39) | - | - |
| Method - (25/50/25) | | | EN6038 | | | |

*(1) Specimen dimensions: 280x32mm (11"x1.3")*
*(2) Specimen dimensions: 132x32mm and 32mm free length (5.2"x1.3" and 1.3" free length)*

*Results for UD and Woven prepregs after an autoclave cure at 180°C (356°F) for 120 minutes.*
*Data normalised to Vf = 59% (0.184mm (0.0072") ply) for UD*
*Data normalised to Vf=56% (0.285mm (0.0112") ply) for 285T2 and Vf=60.5% (0.343mm (0.013") ply) for 370H5, to Vf = 50% for 7581*
*No normalization for ILSS and IPS (shear properties)*
*Woven samples tested in the warp direction.*
*Nominal cured ply thickness quoted is based on zero bleed and is determined using the fiber weight, resin content and resin & fiber density. Data quoted is for comparison only.*

**Prepreg Storage Life**

Tack Life: 10 to 15 days at 23°C (73°F) dependent on lay-up process (hand lay-up, ATL, AFP)

Out Life: 30 days at 23°C (73°F)

Shelf Life: 12 months at -18°C (0°F) (*from date of manufacture

***Definitions:***

Tack Life: The time, at room temperature, during which prepreg retains enough tack for easy component lay-up.

Out Life: The maximum accumulated time allowed at room temperature between removal from the freezer and cure.

Shelf Life: The maximum storage life for HexPly® M21 prepreg, upon receipt by the customer, when stored continuously, in a sealed moisture-proof bag, at -18 °C (o °F). To accurately establish the exact expiry date, consult the box label.

HexPly® M21 prepregs should be stored as received in a cool dry place or in a refrigerator. After removal from refrigerator storage, prepreg should be allowed to reach room temperature before opening the polythene bag, thus preventing condensation (A full reel in its packaging can take up to 48 hours).

**Precautions for Use**

The usual precautions when handling uncured synthetic resins and fibrous materials should be observe, and a Safety Data Sheet is available for this product. The use of clean, disposable, inert gloves provides protection for the operator and avoids contamination of material and components.

**For more information**

Hexcel is a leading worldwide supplier of composite materials to aerospace and industrial markets.
Our comprehensive range includes:

- HexTow® carbon fibers
- HexForce® reinforcements
- HexPly® prepregs
- HexMC® molding compounds
- HexFlow® RTM resins
- Redux® adhesives
- HexTool® tooling materials
- HexWeb® honeycombs
- Acousti-Cap® sound attenuating honeycomb
- Engineered core
- Engineered products

For US quotes, orders and product information call toll-free 1-800-688-7734. For other worldwide sales office telephone numbers and a full address list, please go to:

**http://www.hexcel.com/contact/salesoffice**



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