



HexPly® M21

180°C (350°F) curing epoxy matrix



Product Data Sheet

Description

HexPly® M21 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).

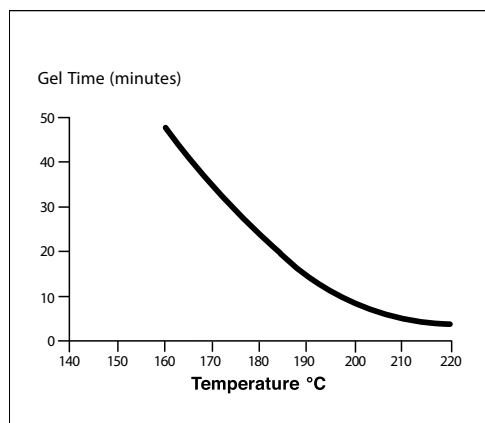
Benefits and Features

- 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





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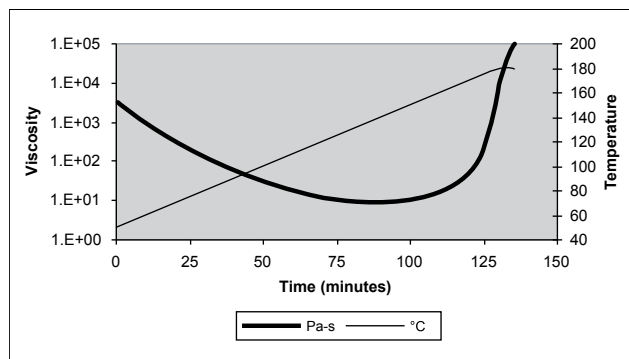
Product Data Sheet

Cure Cycle Viscosity Profiles

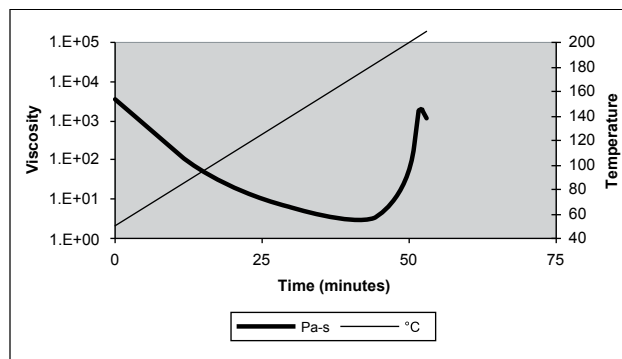
All experiments were made on an ARES-RDA Rheometer and correspond to the recommended cure cycles overleaf.

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

1°C/min (2°F/min) heat-up rate

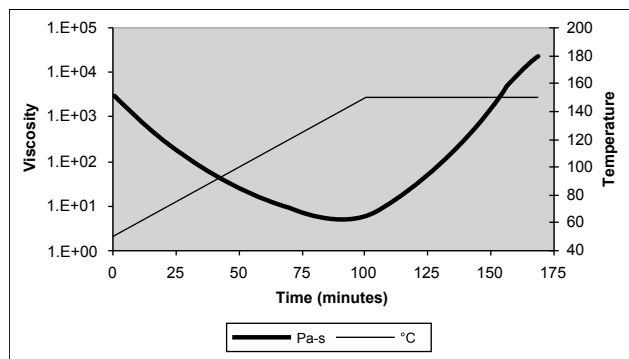


3°C/min (5°F/min) heat-up rate

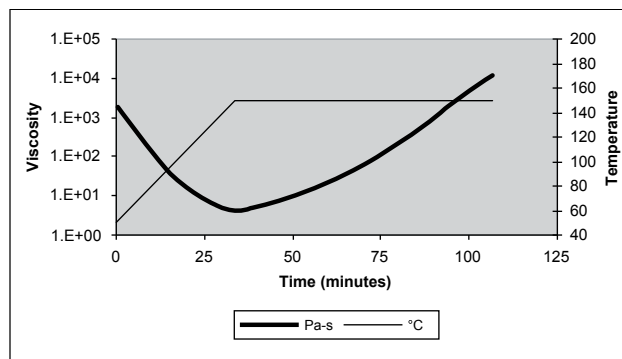


Typical Autoclave Cure Monolithic Par 15 - 48mm (0.6-1.89") thick

1°C/min (2°F/min) heat-up rate

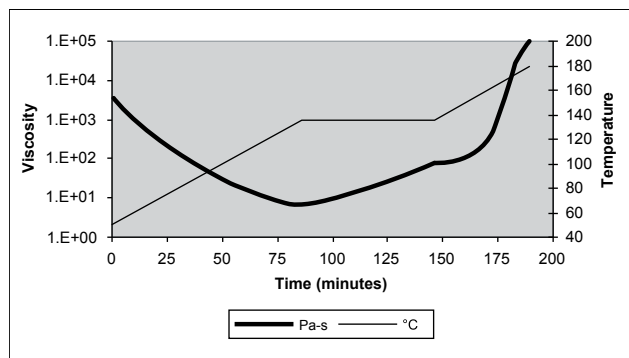


3°C/min (5°F/min) heat-up rate

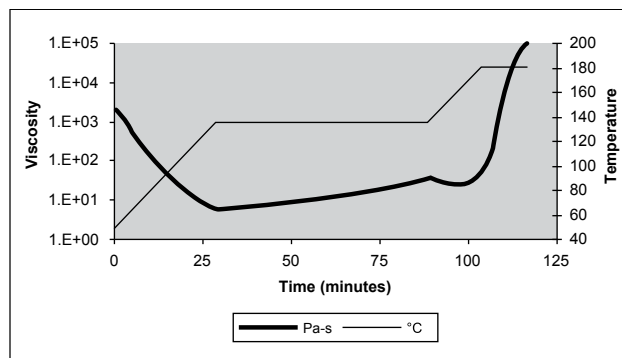


Typical Autoclave Cure Sandwich Parts

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.

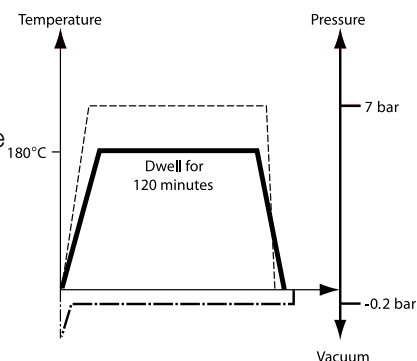


Prepreg Curing Conditions

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.

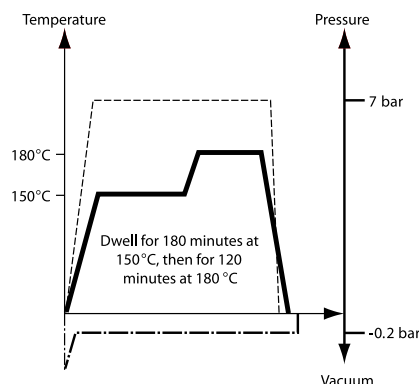
Typical Autoclave Cure Monolithic Part <15mm (0.6") thick (1)

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°F ±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°F ±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.



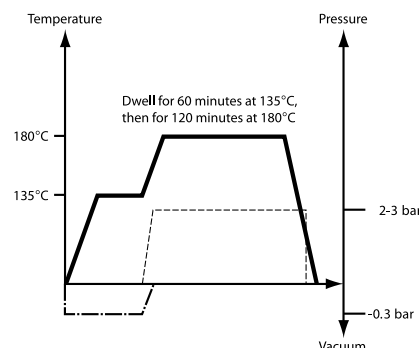
Typical Autoclave Cure Monolithic Part <15mm-48mm (0.6-1.89") thick (1)

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°F ±9°F) to achieve an actual component heat-up rate between 0.5-1°C/minute (1-2°F/ minute).
5. Hold at 150°C ±5°C (302°F ±9°F) for 180 minutes ±5 minutes.
6. Set heat-up rate from 150°C ±5°C (302°F ±9°F) to 180°C ±5°C (356°F ±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°F ±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°F ±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°F ±9°F) for 60 minutes ±5 minutes
5. After 60 minutes at 135°C (275°F), 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°F ±9°F) to 180°C ±5°C (356°F ±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°F ±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.



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Product Data Sheet

Cured Unidirectional Prepreg Properties

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

Physical Properties	Units	M21/34%/UD194/ IM7-12K
Fiber	g/m ²	IM7
Weave/UD		UD
Fiber Mass		194
Nominal Prepreg Mass	g/m ²	294
Theoretical Calculated	mm	0.184
Cured Ply Thickness	(inch)	(0.0072)
Theoretical Calculated	%	59.2
Fiber Volume		
Resin Density	g/cm ³ (lbs/ft ³)	1.28 (79.9)
Fiber Density	g/cm ³ (lbs/ft ³)	1.78 (111.1)
Theoretical Calculated	g/cm ³	1.58
Laminate Density	(lbs/ft ³)	(98.6)

M21/34%/ UD194/ AS7-12K	M21/34%/ UD194/ IMA-12K
AS7	IMA
UD	UD
194	194
294	294
0.184 (0.0072)	0.184 (0.0072)
58.9	59.2
1.28 (79.9)	
1.79 (111.1)	1.79 (111.1)
1.58 (98,6)	1.58 (98,6)

Mechanical Properties	Units	Temp °C (°F)	M21/34%/UD194/ IM7-12K
Test Standards			US Standards
Glass Transition Temperature	°C (°F)		195 (383)
Method			ASTM E1640
Tension Strength	MPa (ksi)	23 (73)	2860 (415)
Tension Modulus	GPa (msi)	23 (73)	160 (23.2)
Method			ASTM D3039 (1)
Compression Strength	MPa (ksi)	23 (73)	1790 (260)
Compression Modulus	GPa (msi)	23 (73)	148 (21.4)
Method			ASTM D695 (2)
ILSS	MPa (ksi)	23 (73)	110 (15.9)
Method			ASTM 2344
In-plane Shear Strength	MPa (ksi)	23 (73)	-
In-plane Shear Modulus	GPa (msi)	23 (73)	4.6 (0.67)
Method			ASTM D3039 (3)
Open Hole Tension	MPa (ksi)	23 (73)	495 (72)
Method - (25/50/25) (gross section)			ASTM 5766 (5)
Open Hole Compression	MPa (ksi)	23 (73)	303 (44)
Method - (25/50/25) (gross section)			ASTM D6484
CAI @ 30.5J	MPa (ksi)	23 (73)	298 (43)
CAI @ 30.0J	MPa (ksi)	23 (73)	-
Method - (25/50/25)			ASTM D7136-D137

M21/34%/ UD194/ AS7-12K	M21/34%/ UD194/ IMA-12K
European Standards	
195 (383)	
EN 6032 - DMA extrapolated onset E'	
2350 (341)	3050 (442)
148 (21.5)	178 (25.8)
EN 2561 B	
1560 (226)	1500 (218)
123 (17.8)	146 (21.2)
EN 2850 B	
114 (16.5)	97 (14.1)
EN 2563	
109 (15.8)	94 (13.6)
5.2 (0.75)	5.2 (0.75)
EN 6031	
365 (53)	510 (74)
EN6035 (4)	
315 (46)	305 (44)
EN 6063 (6)	
-	-
238 (34.5)	219 (31.8)
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)



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Product Data Sheet

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		AS4C	AS4C	E-Glass	E-Glass	E-Glass
Weave/UD	g/m²	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.



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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, from date of manufacture, when stored continuously, in a sealed moisture-proof bag, at -18 °C (0 °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 | ● HexFlow® RTM resins | ● Engineered core |
| ● HexForce® reinforcements | ● HexBond™ adhesives | ● Engineered products |
| ● HiMax® multiaxial reinforcements | ● HexTool® tooling materials | ● Polyspeed® laminates & pultruded profiles |
| ● HexPly® prepregs | ● HexWeb® honeycombs | ● HexAM® additive manufacturing |
| ● HexMC®-i molding compounds | ● Acousti-Cap® sound attenuating honeycomb | |

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<https://www.hexcel.com/contact>

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