HexPly® M91

180ºC (350ºF) curing epoxy matrix

HEXCEL®

Product Data Sheet

Description

HexPly® M91 is a high performance, very tough epoxy matrix for use in aerospace primary structures and engines.

HexPly® M91 is a toughened, controlled flow, epoxy resin system supplied with unidirectional fibers.

Benefits and Features

- Excellent toughness with very high residual compression strength after impact.
- Good translation of HexTow® fiber properties, both for intermediate modulus and high strength carbon fiber.
- Designed for automation and particularly suited for both automated tape laying (ATL) and advanced fiber placement (AFP).
- Good tack life and out-life, providing flexibility on the shop floor.
- Low exotherm behaviour allowing simple cures of thick monolithic structures up to 70mm (2.76")
- Dry Tg (DMA extrapolated onset E') of 185°C-190°C (365°F-374°F)
- Good hot-wet performance up to 120°C (250°F)

HexPly® M91 is best suited to autoclave cure to obtain optimum mechanical performance from the cured composite.

Material Presentation

Details of current presentations available for HexPly® M91 unidirectional prepreg.

Width mm	Tolerance mm	Width (inch)	Tolerance (inch)	Application	Poly/Colour
600	–	(23.6)	–	Hand	Optional
300	–	(11.8)	–	Hand	Optional
300	+0mm, -0.75mm	(11.8)	(+0", -0.030")	ATL	None
150	+0mm, -0.75mm	(5.9)	(+0", -0.030")	ATL	None
12.7	+/- 0.127mm	(0.5)	(+/- 0.005")	AFP	Blue plain
6.35	+/- 0.127mm	(0.25)	(+/- 0.005")	AFP	Blue plain
3.175	+/- 0.127mm	(0.125)	(+/- 0.005")	AFP	Blue plain

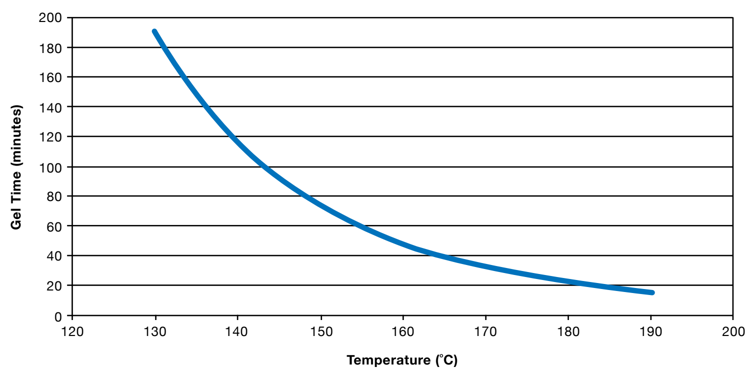
<u>Key</u>
Hand – Hand lay-up
ATL – Automated Tape Laying
AFP – Automated Fiber Placement

These products are available on cores with internal diameters of 254mm (10inch) and 292mm (11.5inch).

Resin Matrix Properties

Gel Time

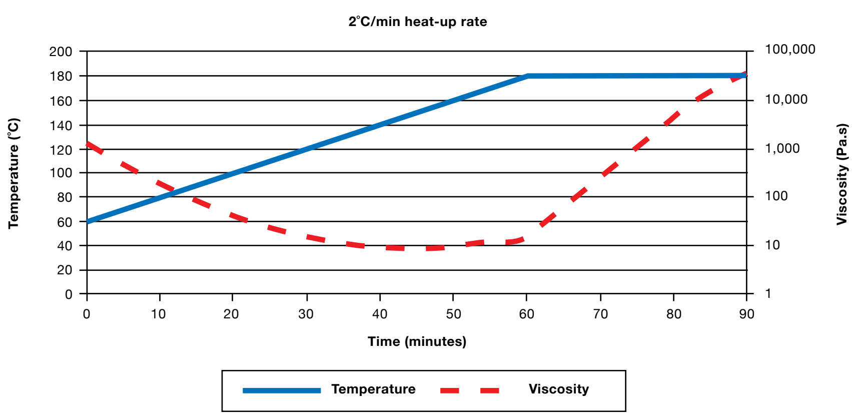
All experiments were made on a Bohlin Gemini Rheometer.



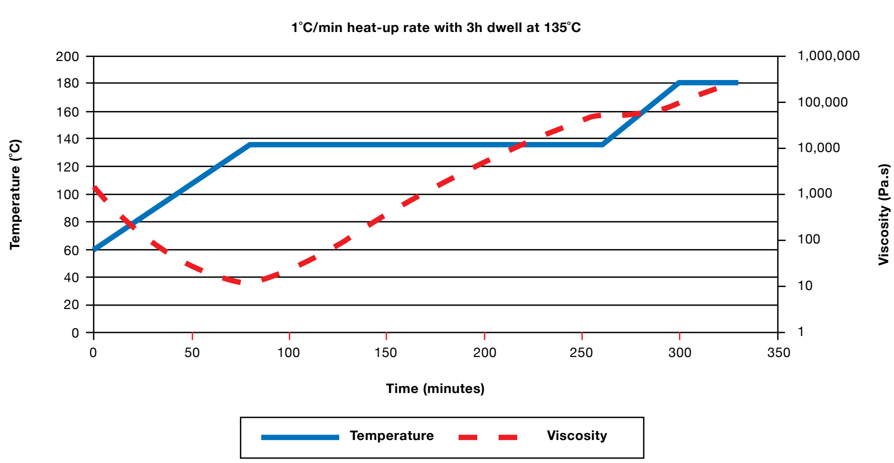
Cure Cycle Viscosity Profiles

All experiments were made on a Bohlin Gemini Rheometer and correspond to the recommended cure cycles below.

Typical Autoclave Cure – Monolithic Part < 15mm (0.6inch) thick



Typical Autoclave Cure – Monolithic Part 15mm-70mm (2.7inch) thick



Prepreg Lay-up

Hand Lay-up

To achieve the best laminate quality, the 1st ply should be vacuum debulked to the mold 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.

Automated Tape Laying (ATL)

Recommended parameters in order to achieve good quality ATL laminates are detailed below.

Ambient temperature:	20°C to 23°C (68°F to 75°F)
Humidity:	30% to 60%

For the first ply, heat may need to be applied by the ATL head.

Prepreg temperature at the head:	19°C to 25°C (66°F to 77°F)
Speed:	30 to 60m/min

Automated Fiber Placement (AFP)

Recommended parameters in order to achieve good quality AFP laminates are detailed below.

Creel temperature:	14ºC to 17ºC (57°F to 63°F)
Creel humidity:	~40%
Room temperature:	18 to 19°C (64°F to 66°F)
Prepreg surface temperature:	~28°C (~82°F)

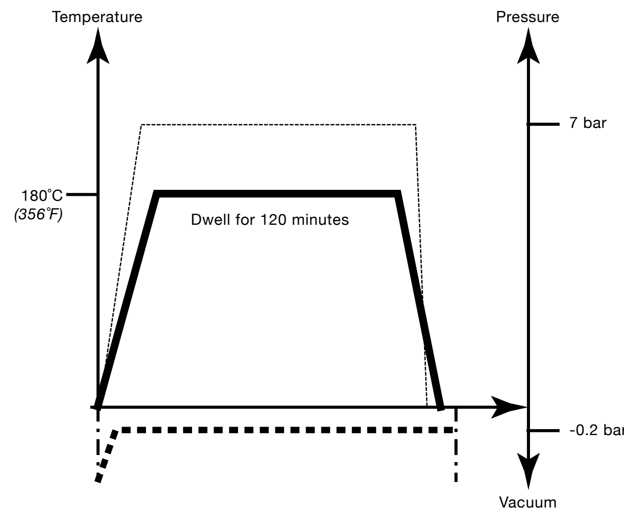
The above recommendations are intended as initial guidelines and may change for different machine types.

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.

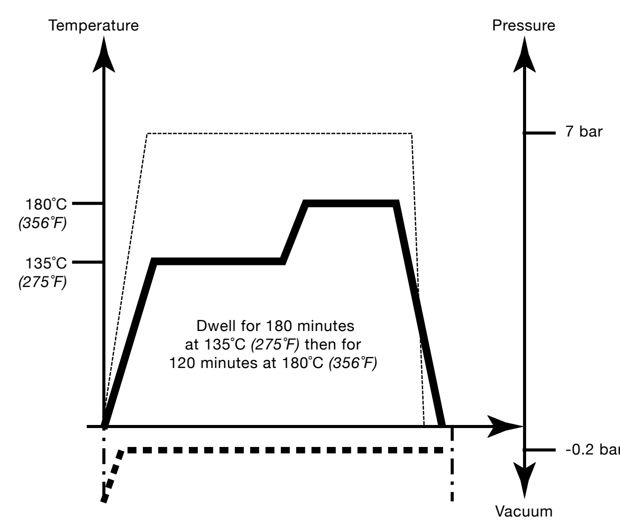
Typical Autoclave Cure Monolithic Part < 15mm thick (1)

1. Apply full vacuum (1bar).
2. Apply 7 bar gauge autoclave pressure.
3. Reduce vacuum to a safety value of -0.2bar 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 cool down rate of 2-5°C/ minute (4-9°F/minute).
7. Vent autoclave pressure when the component reaches 60°C (140°F) or below.



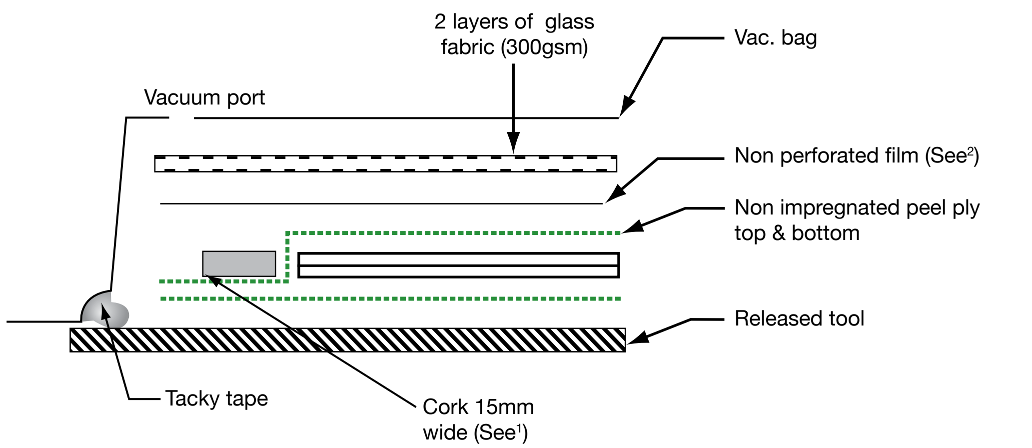
Typical Autoclave Cure Monolithic Part 15 - 70mm thick (1)

1. Apply full vacuum (1bar).
2. Apply 7 bar gauge autoclave pressure.
3. Reduce vacuum to a safety value of -0.2bar when the autoclave pressure reaches ~ 1 bar gauge.
4. Set heat-up rate from room temperature to 135°C ± 5°C (275°F ± 9°F) to achieve an actual heat-up rate between 0.5-1°C/minute (1-2°F/minute).
5. Hold at 135°C ± 5°C (275°F ± 9°F) for 180 minutes ± 5 minutes.
6. 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 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 cool down rate of 2-5°C/ minute (4-9°F/minute).
9. Vent autoclave pressure when the component reaches 60°C (140°F) or below.

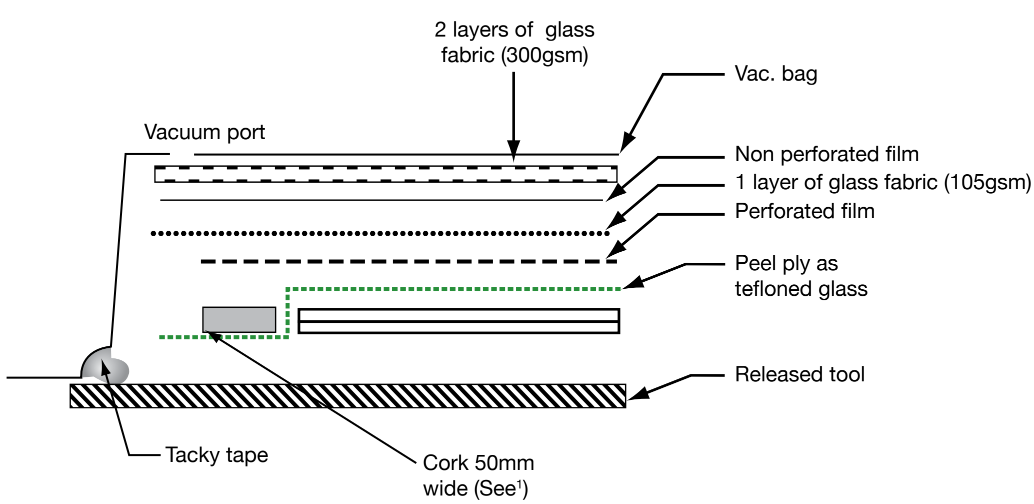


(1): As the cure cycle tolerances are related to the material, the temperature profile of the whole part must be kept within these tolerances. Thermocouples have to be applied to the component to guarantee that the temperature recording is representative of the actual experienced cure cycle of the component.

Typical autoclave bagging configuration adopted for curing mechanical test laminates



Typical autoclave bagging configuration adopted for curing component



[1] Cork is butted up to the laminate with a height equal to that of the prepreg stack

[2] Non perforated film to extend over cork by 15mm (0.6inch)

Cured Unidirectional Prepreg Properties

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

Physical Properties	Units	M91/34%/UD194/ IM10-12K	M91/34%/UD194/ IM7-12K	M91/34%/UD194/ AS7-12K
Fiber Weave/UD Fiber Mass	g/m^2	IM10 UD 194	IM7 UD 194	AS7 UD 194
Nominal Prepreg Mass	g/m^2	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	%	58.9	59.2	58.7
Resin Density	g/cm^3 (lbs/ft^3)	1.28 (80.2)		
Fiber Density	g/cm^3 (lbs/ft^3)	1.79 (111.7)	1.78 (111.1)	1.80 (112.4)
Theoretical Calculated Laminate Density	g/cm^3 (lbs/ft^3)	1.58 (98.63)	1.57 (98.00)	1.58 (98.63)

HexTow® IM10 is a Hexcel intermediate modulus continuous carbon fiber 12K product with enhanced tensile strength properties.

HexTow® IM7 is a Hexcel intermediate modulus continuous carbon fiber 12K product.

HexTow® AS7 is a Hexcel high strength continuous carbon fiber 12K product.

Mechanical Properties	Units	Temp °C (°F)	M91/34%/UD194/ IM10-12K	M91/34%/UD194/ IM7-12K	M91/34%/UD194/ AS7-12K
Glass Transition Temperature	°C (°F)		185 - 190 (365 - 374)		
Method			EN 6032 – DMA extrapolated onset E'		
Tensile Strength	MPa (ksi)	23 (73)	3520 (510)	2980 (432)	2580 (374)
Tensile Modulus	GPa (msi)	23 (73)	176 (25.5)	165 (23.9)	142 (20.6)
Method			ASTM D3039 (1)		
Compression Strength	MPa (ksi)	23 (73)	1880 (273)	1860 (270)	1350 (196)
Compression Modulus	GPa (msi)	23 (73)	156 (22.6)	150 (22)	123 (17.8)
Method			ASTM D695 (2)		EN 2850A
ILSS	MPa (ksi)	23 (73)	105 (15)	110 (16)	115 (17)
Method			EN 2563		
Open Hole Tension	MPa (ksi)	23 (73)	610 (88)	505 (73)	
Method – (25/50/25) (gross section)			ASTM D5766 (3)		
Open Hole Compression	MPa (ksi)	23 (73)	315 (46)	315 (46)	315 (46)
Method – (25/50/25) (gross section)			ASTM D6484		
CAI @ 30.5J	MPa (ksi)	23 (73)	350 (51)	350 (51)	300 (44)
Method – (25/50/25)			ASTM D7136 & D7137		

(1) Specimen dimensions: 12.7mm (0.5") wide and 127mm (5.0") free length
(2) Specimen dimensions: 12.7x80mm (0.5"x3.1")
(3) Specimen dimensions: 305x38mm (12.0x1.5") and 6.35mm (0.25") hole diameter

Results for UD prepregs after an autoclave cure at 180°C (356°F) for 120 minutes.
Data normalised to Vf 59%, except for ILSS.

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

HexPly® M91 is fully compatible with:

- HexPly® M21 unidirectional carbon prepreg
- HexPly® M21 woven carbon prepreg
- HexPly® M21 woven glass prepreg
- HexPly® F161 or HexPly® M21 Peel Ply prepreg
- HexPly® M21 Bronze Mesh prepreg
- HexPly® M21 Copper Foils prepreg

Storage and Handling

Tack Life:	10 to 15 days at 23°C (73°F) dependent on lay-up process (Hand Lay-Up, ATL, AFP)
Out Life:	42 days at 23°C (73°F)
Shelf Life:	12 months at –18°C (0°F) (maximum, 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® M91 prepreg, from the 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® M91 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 roll in its packaging can take up to 48 hours).

The purpose of this data sheet is to provide information and direction on the use of HexPly® M91 prepreg. For further information and support for specific applications, please contact your local technical support engineer.

Precautions For Use

The usual precautions when handling uncured synthetic resins and fine fibrous materials should be observed, 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
- HiMax® multiaxial reinforcements
- HexPly® prepregs
- HexMC®-i molding compounds
- HexFlow® RTM resins
- HexBond™ adhesives
- HexTool® tooling materials
- HexWeb® honeycombs
- Acousti-Cap® sound attenuating honeycomb
- Engineered core
- Engineered products
- Polyspeed® laminates & pultruded profiles
- HexAM® additive manufacturing

For U.S. 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:

https://www.hexcel.com/contact

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