HexTOOL® M81
User Guide

HEXCEL®

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1 - INTRODUCTION

Tooling is an integral part of the manufacturing process of a composite component process. Tooling is key factor in the cost and quality of the composite component produced. Tools must provide temperature resistance, a low co efficient of thermal expansion to match that of the composite materials, vacuum integrity, thermal conductivity and machinability.

HexTOOL® M81 is a new composite solution for building tools. This new concept for composite molds is an alternative to conventional composite and metal tools

The key advantages of HexTOOL® M81 are:

- Ability to make tools without distortion permitting the manufacture of tools with complex shapes and tight tolerances (able to obtain metal surface profile tolerances)
- Reparability and potential for modification of tool dimension following engineering changes
- Elevated Tg and service temperature (average Tg onset DMA 220°C/430°F) allowing use for components cure from 120°C to 180°C (250°F to 360°F)
- Formulated to withstand more than 100 part cure cycles
- Rapid material deposition as HexTOOL® is much thicker than standard composite tooling prepregs and do not require accurate lay up schedule thanks to our quasi isotropic property
- 21 days out life compare to just few days for tooling prepregs
- Coefficient of thermal expansion to match carbon epoxy parts

2 - HexTOOL® M81 PRODUCT DEFINITION AND PROPERTIES

2.1: Product Format & Definition

- 2000gsm (0.41lbs/foot^2) carbon fiber reinforced mat
- Composed of 8 x 50mm (0.315x 1.97inch) prepreg bundles presented in a quasi isotropic orientation
- High strength carbon fiber with a nominal fiber volume of 55%
- Epoxy based matrix at 38% resin content (by weight)
- Storage life of 12 months at -18°C (0°F) or below
- Autoclave cured at 125°C(260°F) under 7bar (100psi) pressure
- Out of autoclave post-cure at 205°C (400°F)
- Nominal cured ply thickness of 1.28mm (0.05inch)

2.2: Main Properties

2.2.1: Physical Properties

Property	Units	Condition	Method	Value
Glass Transition Temperature	°C(°F)	Dry	DMA	220 (430)
Coefficient of Thermal Expansion*	GPa (msi)	X-Y plane	ASTM E831	5 (0.72)

Table 1 – Physical properties of cured HexTOOL® M81
*C.T.E. data generated over the range 23°C – 150°C (70° - 300°F)

Material	Units	Rockwell B Hardness Value *	
HexTOOL® M81	HRB	-	81
Epoxy tooling prepregs	HRB	-	from 24 to 55
Aluminium alloy 2024	HRB	Treatment 0	45
		Treatment T4	75
		Treatment T6	78

* Hardness properties are for reference only and not to be considered certification values.

Table 2 – Rockwell B Hardness comparison table of tooling materials

2.2.2: Mechanical Properties*

Property	Units	Condition	Temp °C (°F)	Method	Value
Tensile Strength	MPa (ksi)	Dry	RT	EN2561	175 (25.37)
			120 (250)		170 (24.65)
Tensile Modulus	GPa (msi)	Dry	RT	EN2561	43 (6.23)
			120 (250)		40 (5.8)
Compression Strength	MPa (ksi)	Dry	RT	EN2850B	250 (36.25)
			120 (250)		250 (36.25)
Compression Modulus	GPa (msi)	Dry	RT	EN2850B	32 (4.64)
			120 (250)		30 (4.35)
Short Beam Shear Strength	MPa (ksi)	Dry	RT	EN2563	45 (6.52)
			120 (250)		35 (5.07)

* Mechanical properties obtained on 4mm (0.16inch) thick laminates after machining bag side

Table 3 – Mechanical properties of cured HexTOOL® M81
Data provided is for reference only to aid in tool design

3 - HexTOOL® PROCESSING

3.1 : Tool manufacturing procedure:

Step 1 : Design and manufacturing of the master model taking into account bag side or tool side machining
Step 2 : HexTOOL® M81 lay-up and bagging
Step 3 : HexTOOL® M81 cure and post-cure
Step 4 : Tool machining and finishing

3.2: Part Model (Master Mold)

The part model may be produced from any material that can withstand a pressure of 7bar (100psi) at a temperature of 125°C (260°F) keeping air tightness. Examples of various products are detailed in the table below:

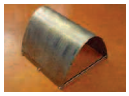
Type	Epoxy tooling board	Wood			Light concrete	Tooling paste on honeycomb	Steel Construction
Supplier	RAMPF	Massive or MDF	RETIstab		XELLA	Huntsman	Various
Grade	WB-0700		RS20 (massive)	CP RS20 (Plywood)	Ytong		
Density (g/cc)	0,7	0,9 to 1,2	0,42	0,48	0,35 to 0,65	0,5 (combined with Nomex	material 7,8→ approx 0,5 in volume
CTE x 10^6 / °C	40	na	3 to 5		8	High (40)	12
Pros	standard model maker techno	Inexpensive, available, easy machining	Light, moderate cost, available in customer dimensions		Inexpensive, light; available	Light/ model accuracy/ surface aspect	Well known, inexpensive
Cons	High CTE	low temp resistance, distortion, vapors	Surface preparation and demoulding, water pick-up		matching, surface preparation	machined aluminium honeycomb core	simple shapes
							

Table 4 – Examples of part model (master mold) materials

Dimensional accuracy is not required from the part model, as the final dimensions are achieved by machining.

3.3: HexTOOL® M81 Tool Manufacturing Process

3.3.1: Lay-up & Bagging

After removal from refrigerator storage, HexTOOL® M81 should be allowed to reach room temperature before opening of the protective polyethylene bag (minimum of 12 hours for a 30kg/60lb roll).

Cut material plies as required. Cutting may be achieved using sharp razor knives, pneumatic or electrical rotating cutters. Equipment examined includes:

- FEIN SuperCut Electric Cutter
- TMI Ultrasonic Branson Trim Knife
- Eastman Buzzaird Pneumatic Rotary Knife

For simple and numerous ply shapes a die cutter is most convenient.

Prepare the part model surface using an appropriate release agent (e. g., Frekote® 700-NC or Cirex 043).

Lay-up the HexTOOL® M81 plies directly over the part model. Debulking after the first ply is recommended to ensure conformity with the part model. Thereafter, depending on part size and complexity, debulking is recommended after every 2 to 5 plies. Build up plies as required to the desired thickness.

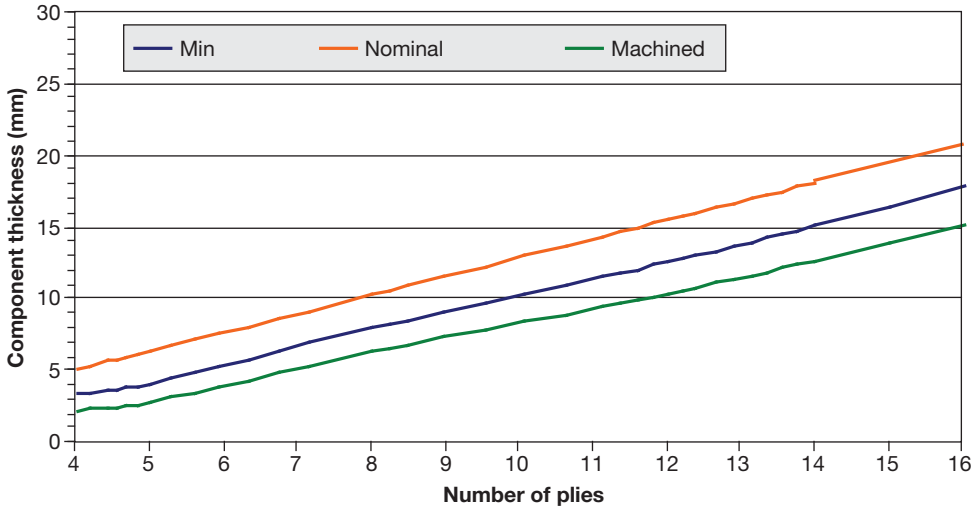


Figure 1 – Plot of Component thickness vs. Number of M81 plies

The plot above highlights the number of HexTOOL® M81 plies required to obtain a desired component thickness following machining of the bag side. This data was generated for simple laminates. For more complex geometries, additional plies may be required.

The following bagging materials are required:

- Sealant tape to withstand autoclave temperatures of 125°C (260°F)
- Porous PTFE glass peel ply fabric
- Non-perforated release films
- Breather material
- Epoxy resistant vacuum bag

A typical bagging assembly is outlined in Figure 2. Specific bagging schemes depend on the size and complexity of the lay-up. Please contact local Hexcel Technical Support for consultation.

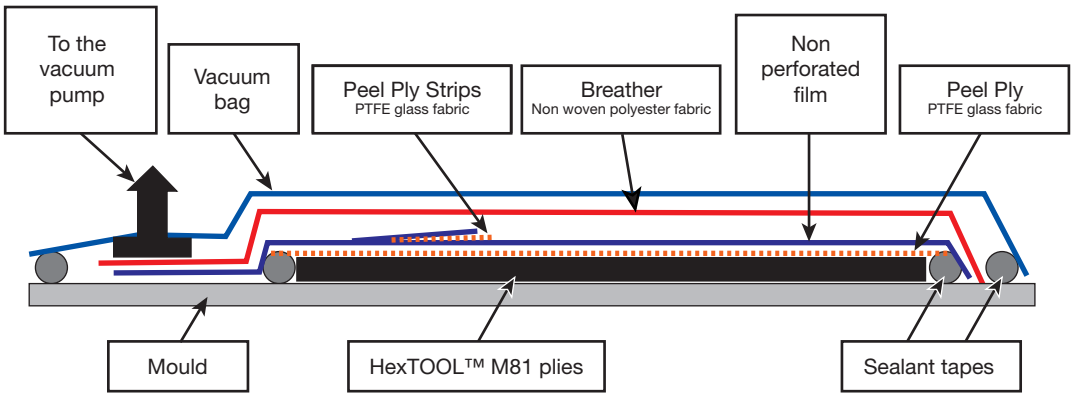


Figure 2 – Bagging scheme for HexTOOL® M81 cure

To ensure a successful cure, and to improve the breathing, some strips of PTFE glass fabric may have to be added between the peel ply and the breather.

3.3.2: Cure

Specific cure cycles [temperature, pressure (amount and time of application)] depend on autoclave type and dimensions, the extent and type of tooling used and the size and complexity of the layup. Please contact local Hexcel Technical Support for consultation prior to cycle definition.

The following cycles are typical for HexTOOL® M81 :

Autoclave Cycle

- Apply full vacuum (>0.85bar/12.3psi)
- Heat up to 125°C (260°F) using a ramp between 0.5° and 1°C/min (1° and 2°F/min)
- Apply 7bar (100psi) gauge pressure when temperature reaches 50°C (120°F)
- Hold at 125°C(260°F) for 360 minutes
- Cool down using a 0.5°C/°1F min ramp to 60°C (140°F)
- At 60°C(140°F) release pressure and vacuum

Free Standing Post Cure Cycle

- Heat up to 140°C(280°F) using a ramp between 0.5° and 2°C/min (1° and 4°F/min)
- Heat up to 205°C (400°F) using a ramp between 0.25° and 1°C/min (0.5° - 2°F/min)
- Hold at 205°C(400°F) for 2 hours
- Cool down using a 0.5°C/1°F min ramp to 150°C (300°F)
- Cool down using a 1°C/2°F min ramp to 60°C (140°F)

3.3.3: Machining & Finishing

Machining

The cured HexTOOL® M81 near net shape component is accurately machined to the defined tool dimensions using standard carbon composite machining equipment. Typically, the machining process incorporates two steps:

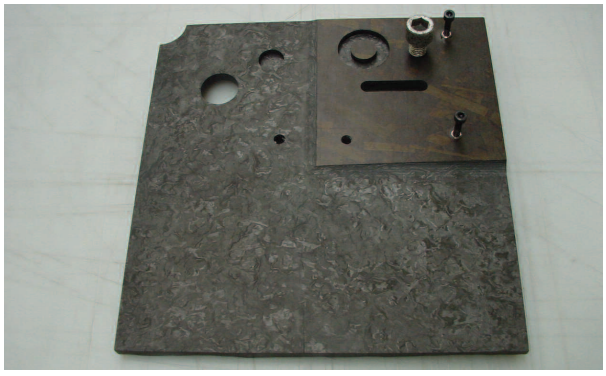
Step 1: rough machining to achieve a dimensional tolerance of +0.1 to +0.5mm (+0.004 to 0.02inch)

Step 2: smooth machining to obtain a dimensional tolerance of +/-50 m.

Specific machining parameters will vary with manufacturers equipment and guidelines.

The extent of machining and finishing is dependant on the surface aspect required.

All kinds of shapes and part details can be machined. Holes or threaded holes, to hold the tool to its support structure, can be machined as well. Inserts can be put into machined holes where screws are needed.



Finishing

The surface quality after machining of HexTOOL® M81 molds can be improved by sanding with sandpaper (from grit 150 to 600). Wet sanding with sand paper grit 1000 to 1200 can be performed in order to improve the surface roughness (e. g. Ra ~0.8).

Next step is the sealing of the tool (e. g., Chemtrend MPP112 or Airetec Cirex021) and then the application of the release agent (e. g., Frekote® 700-NC or Cirex 043) and the mold is ready for part curing.

3.4: Modify a HexTOOL® M81 Mold

For slight tools geometry changes, it is possible to reload a tool area by curing some fresh material over it. The procedure is to locally remachine the HexTOOL® M81 mold and prepare the surface by sanding to get a good bonding of the added material. The mold is then reloaded with fresh HexTOOL® M81 and cured using standard cure cycle with local or complete vacuum bag. The final 'new mold geometry' is obtained by machining and finishing.

3.5: Repairing a HexTOOL® M81 Mold surface

For reparation of small defects on HexTOOL® M81 mold surface, a high temperature filled epoxy paste can be used to fill the defects (e. g., Cass Polymer/Adtech ESG-215T, Airtech Infusion Coat, Airtech TMS F5001). After freestanding cure, the finishing has to be done by sanding and then by application of sealer and release agent over the surface of the tool.

For bigger defects reparation, the use of additional HexTOOL® M81 material can be compulsory. The procedure is outlined in the following steps:

1. Remove damaged area by machining a suitable cavity
2. Prepare surface for bonding
3. Cut plies to suitable dimensions
4. Lay-up plies over cavity
5. Bag, standard autoclave cure cycle & post-cure (local bag or complete bag)
6. Machine repair to desired surface
7. Finishing

Important

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