



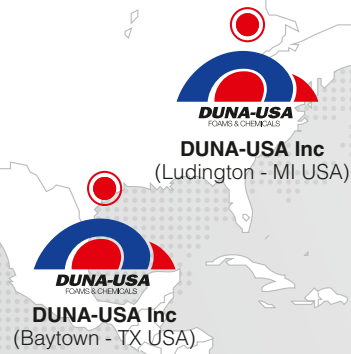
I N N O V A T I O N P R O V I D E R S  
**INNOVATION PROVIDERS**



**SOLUTIONS FOR CARBON  
FIBER TOOLING**  
COMPREHENSIVE GUIDELINES



# Dove siamo Where we are



HEADQUARTERS:  
DUNA - Corradini Spa (Soliera, Modena - Italy)



DUNA - USA INC (Baytown, Houston - USA)



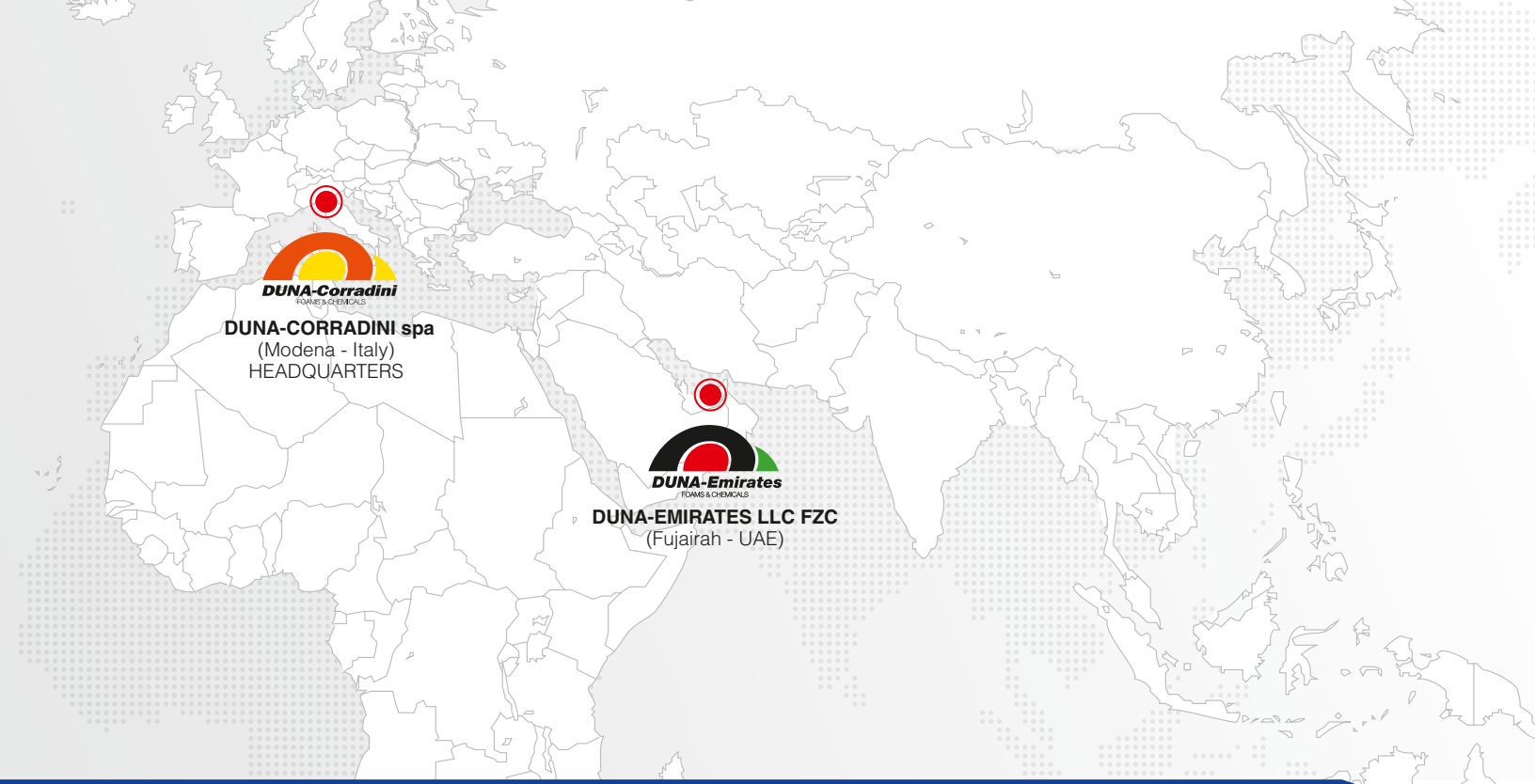
DUNA - USA INC (Ludington, Michigan - USA)



DUNA - Emirates LLC FZC (Fujairah, UAE)

**DUNA-USA IS PART OF A LARGER GROUP OF COMPANIES WHO DEVELOPS AND MARKETS POLYURETHANE FOAM IN BLOCKS, SHEETS, SPECIAL ITEMS, LIQUID SYSTEMS, AS WELL AS POLYURETHANE ADHESIVES AND EPOXY RESINS. HEADQUARTERS OF THE WHOLE GROUP IS DUNA-CORRADINI, LOCATED IN ITALY (MODENA).**

- We have been working in the fine chemicals since the establishment of the Gustavo Corradini company (1957)
- Our polyurethanes and epoxy resins serve industry and industrial applications. We devote important resources for the formulation and continuous improvement of materials, production processes machines and systems in order to improve application techniques.
- The chemical laboratory is the center where our knowledge and our technology meet customer needs, through the formulation and development of new tailor-made solutions.
- “Innovation providers”, our payoff, goes beyond mere research and development on polyurethanes. Innovation also means finding the most appropriate technology, creating the right polymer but also providing technical assistance and verifying product performance.



This manual aims to provide guidelines for the correct use of:

## BLACK CORINTHO®

High temperature resistant polyurethane board, designed for laminating carbon fibre composites and master model making.

### Features:

- Very low CTE, excellent dimensional stability
- Operating temperature: +400°F
- High thermal conductivity (= reduced autoclave times)
- Easy to work with, non-abrasive
- Available in 50 and 69 lb/ft<sup>3</sup> densities
- High quality surface finish

## INDEX

<b>1</b>	<b>Strategic bonding</b> .....	<b>Page 04</b>
<b>2</b>	<b>Bonding</b> .....	<b>Page 04</b>
<b>3</b>	<b>CNC machining</b> .....	<b>Page 06</b>
<b>4</b>	<b>Surface sealing</b> .....	<b>Page 07</b>
<b>5</b>	<b>Releasing agents</b> .....	<b>Page 09</b>
<b>6</b>	<b>Polymerization in autoclave</b> .....	<b>Page 09</b>
<b>7</b>	<b>Polymerization in oven</b> .....	<b>Page 10</b>
<b>8</b>	<b>Technical assistance</b> .....	<b>Page 11</b>
<b>9</b>	<b>Available formats and packaging</b> .....	<b>Page 11</b>

## DUNAPOX AD 135 and DUNAPOX SEA 125

- DUNAPOX AD 135, epoxy adhesive
- DUNAPOX SEA 125, epoxy sealer.

Two-components epoxy systems specially developed for gluing and sealing BLACK CORINTHO® boards.

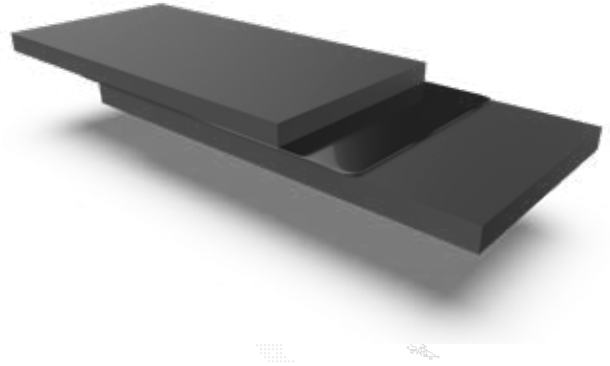
### Features:

- Two systems, one hardener
- Resistance to high temperatures
- Medium-slow hardening at room temperature
- Easily sandable
- The thixotropy of DUNAPOX AD 135 adhesive prevents dripping
- DUNAPOX SEA 125 sealer can be diluted with acetone to allow rapid spray application with any equipment

# 1. STRATEGIC BONDING

When the tool/mold that is to be built exceeds that of standard board size, bonding multiple boards together is possible and easy to do. Before beginning bonding operations, it is necessary to strategically position the bond joints, so they are always offset from each other.

The offset positioning ensures that no weaknesses are created in the structure that could break in case of stress and ensures maximum tightness.



# 2. BONDING

Bonding of BLACK CORINTHO® is best done using DUNAPOX BLACK AD 135 epoxy adhesive, which is a thixotropic resin specially formulated for use in both ovens and autoclaves in temperatures up to +400°F.

The DUNAPOX BLACK AD 135 will expand and contract with the tool under temperature without cracking or degradation.

Due to the slightly porous structure of BLACK CORINTHO® we do not recommend the use of fluid adhesives, which will absorb into the boards.

## Coverage rate of DUNAPOX BLACK AD 135: 0,06 lb/ft<sup>2</sup>

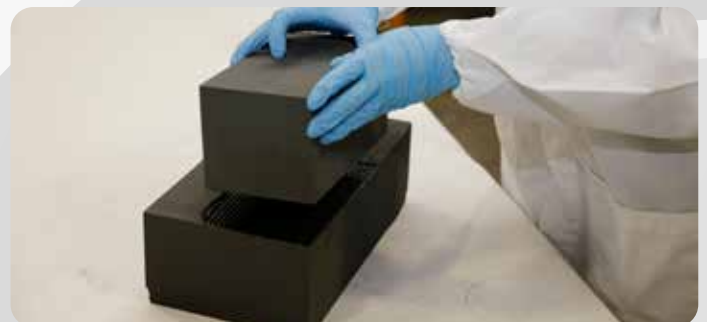
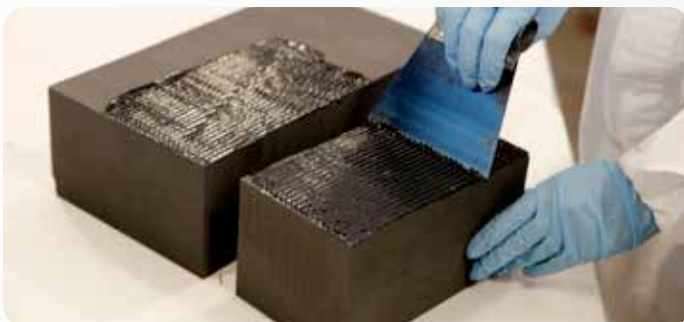
A minimum one gallon kit of DUNAPOX BLACK AD 135 (11 lbs of resin + 2,2 lbs of hardener) can cover up to 220 ft<sup>2</sup> (with a coverage of 0,06 lb/ft<sup>2</sup>).

With a board of BLACK CORINTHO® having an area of 8 ft<sup>2</sup>, by applying the glue on a single side, it is possible to cover up to 27 boards. However, it is our suggestion to distribute the adhesive on both surfaces to be bonded, taking care to use a sufficient amount of adhesive on each bond joint.

To work safely, therefore, we suggest that you consider being able to glue at least 10-12 sheets with each kit and always test the application before proceeding with large-scale operations.

- **Prepare the bonding surfaces correctly:** the surfaces should be clean, dry, free of dust, perfectly flat and square. Remove all traces of dust and smooth out any thickness irregularities.
- **Distribute the adhesive with a notched trowel,** making sure to cover the entire surface.
- **Join the surfaces closely, applying uniform pressure,** the excess adhesive will be inclined to flow out of the perimeter once the boards have been bonded. The bonded parts must be kept in close contact until the adhesive polymerizes.
- **Wait 24-48 hours** after gluing, letting the adhesive cure **at room temperature,** prior to proceeding to machining operations.

It is not generally recommended to conduct a post-cure to reduce adhesive cure time, due to the numerous variables present in each project (tool size and geometry, heat source effectiveness). In addition, on monolithic tools, adhesive at the core/inner areas will receive heat at a much different time than outer-areas, resulting in varying degrees of cured adhesive during post-cure.



You can use different techniques to glue parts and apply adequate pressure; each technique has its advantages and disadvantages:

## ***Vacuum bag***

The use of a vacuum bag is for most, the most versatile and effective: it works with both tops and with large or small complex shapes, it also offers accurate control of applied pressure.



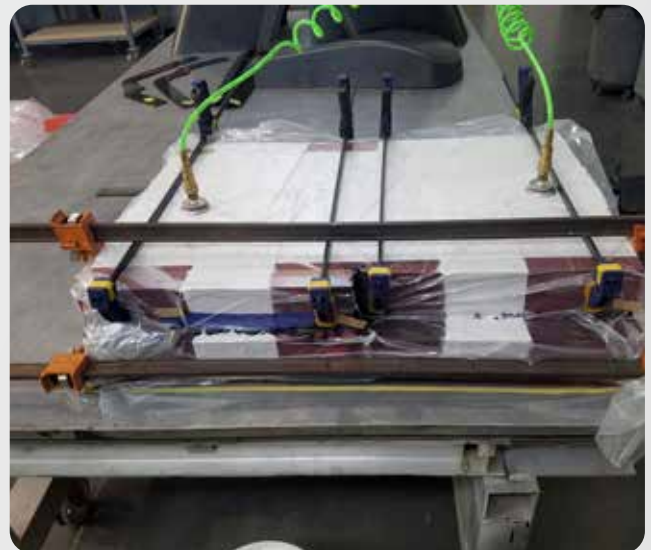
## ***Pressing***

The use of a hydraulic / oleodynamic press can be effective for gluing overlapping boards; a containment jig can be useful to keep parts in position while closing the press plates.



## ***Clamping with clamps***

The use of clamps is quick and easy, but works best with small parts, since it may be difficult to control the uniformity of the pressure applied to a large piece, by exerting localized pressure on the clamp in only one point. If using clamps, it is important to ensure that the pressure is evenly distributed, through the use of blocks, etc.



After gluing, it is advisable to wait for the adhesive to cure completely for at least 24 hours at room temperature.

### 3. CNC MACHINING

Setting of the CNC machine is always a balance between several factors; modifying one parameter may lead to having to change the others as well

Processing specifications	Reference	(UM)	Formula
Number of laps	n	rpm	$n = \frac{Vc \cdot 1000}{3,14 \cdot \text{Diameter}}$
Cutting speed – tool in straight line	F	inches/min	$F = fz \cdot z \cdot n$
Depth of cut	ap	inches/min	
Cutting speed	Vc	inches/min	$Vc = \frac{D \cdot n \cdot 3,14}{1000}$
Number of teeth of the cutting tool	z		
Progress per tooth	fz	inches	$fz = \frac{F}{z \cdot n}$
Percentage of material removed in relation to the diameter of the cutting tool (STEPOVER)*	ae		

\* Note: some materials allow you to increase this number without problems; with others, if you increase the percentage of removed material, it is necessary to reduce the cutting speed (Vc). Although there are exceptions, as a general rule Ae should never exceed 2/3 of the diameter.

### Roughing parameters

We provide here as a suggestion recommended parameters for the roughing operation of BLACK CORINTHO® boards.

The range of variation of the finishing degrees, on the other hand, is too wide to be shown in a simple parametric table and we recommend carrying out testing to achieve the degree of finishing related to your specific needs.

Percentage of removed material (in relationship to the tool volume)	Vc (m/min)				fz
	10%	20%	50%	100%	
BLACK CORINTHO® 800	550	450	350	250	0,15-0,25
BLACK CORINTHO® 1100	350	250	150	50	0,15-0,25

Solid Carbide cutting tools  
ROUGHING



STRATEGIC BONDING  
BONDING  
CNC MACHINING  
SURFACE SEALING  
RELEASING AGENTS  
POLYMERIZATION IN AUTOCLAVE  
POLYMERIZATION IN OVEN  
TECHNICAL ASSISTANCE  
AVAILABLE FORMATS AND PACKAGING

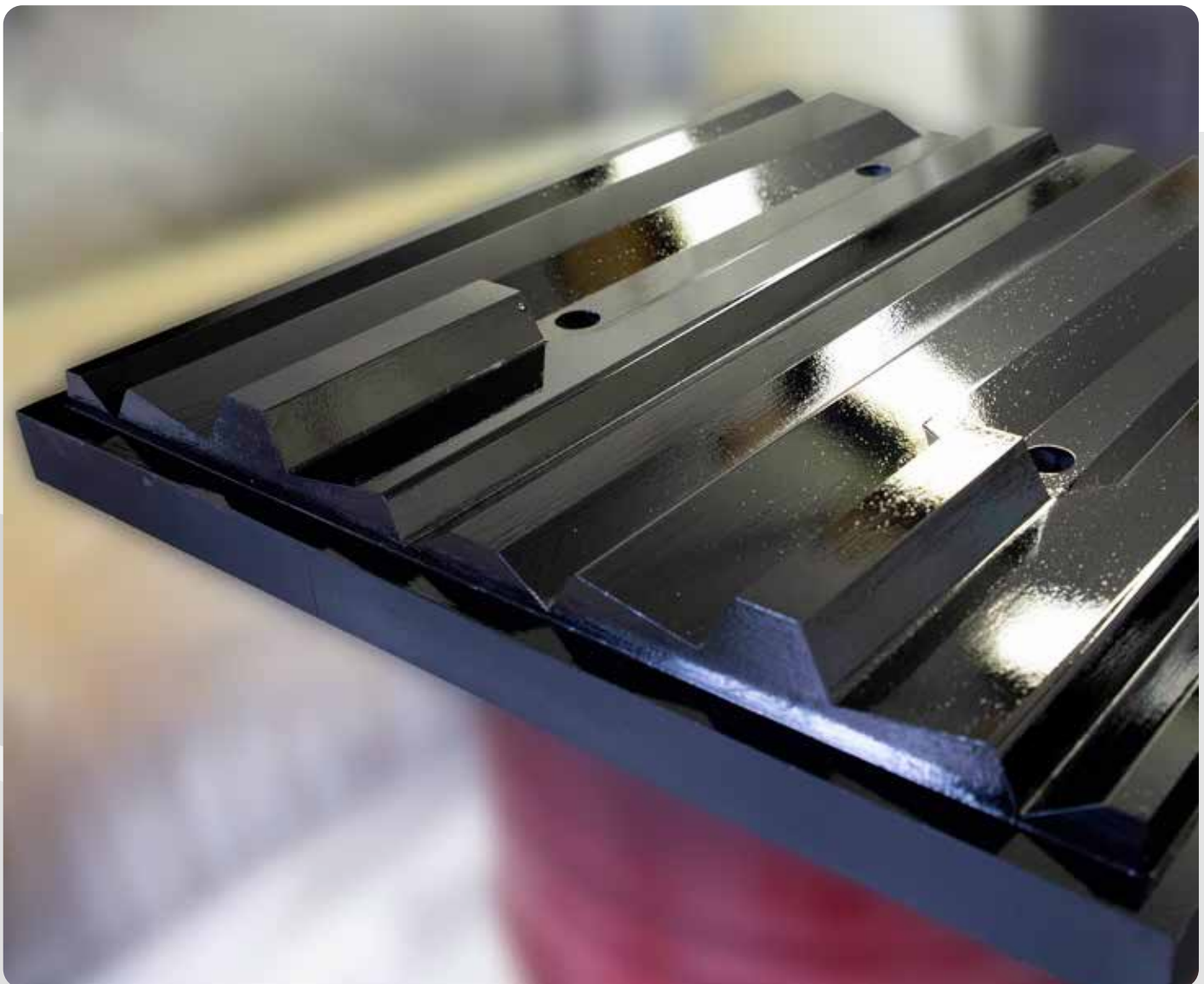
## 4. SURFACE SEALING

BLACK CORINTHO® boards are slightly porous and must be surface-sealed to obtain vacuum integrity. DUNA-USA manufactures the high temperature epoxy sealant DUNAPOX BLACK SEA 125, designed to withstand temperature of up to 400°F in an oven or autoclave, without degrading or cracking under temperature. DUNAPOX BLACK SEA 125 also provides a protective layer with a surface hardness of 85 Shore-D.

### Sealing with DUNAPOX BLACK SEA 125:

Before adding the hardener, DUNA-USA recommends homogenizing the resin through the use of a propeller mixer. The mixing ratio by weight between resin/hardener of 100/20 must be strictly respected. DUNAPOX BLACK SEA 125 can be applied with a spatula, brush or spray. The surface must always be clean and free of dust.

The **spray** application is very quick and leaves no marks on the surface, thus allowing faster sanding operations. When spraying DUNAPOX BLACK SEA 125, it may be useful to dilute it with 8-10% by weight with acetone, in order to make it easily applicable with most equipment. We always recommend testing before beginning your project, to determine the best process for your application.



## Coverage rate of DUNAPOX BLACK SEA 125: Maximum 0.06 lb/ft<sup>2</sup> Thickness: 0,12-0,13 mm

DUNA-USA recommends applying two separate coats of DUNAPOX BLACK SEA 125, followed by optional layer(s) of a mold prep and primer to obtain a smoother and shinier surface. Do not apply too much material per layer, otherwise the liquid resin will slip.



### Surface sealing cycle

DUNA-USA and several customers have conducted successful laminations by treating the surface of BLACK CORINTHO<sup>®</sup> with the following procedure:

- 2 layers of DUNAPOX BLACK SEA 125
- For a “carbon look” finish: 5 layers of a mold prep and primer
- Release agent

Any imperfections in the mold before sealing can be filled with minimal quantities of DUNAPOX BLACK AD 135 adhesive, sufficient to fill the gap. After the adhesive has hardened, sand to obtain uniformity.

1. Apply the first layer of DUNAPOX BLACK SEA in quantity of 0.023 lb/ft<sup>3</sup>.
2. Post-cure for 2h at 160°F or for 8h at room temperature. This will obtain a tack-free surface.
3. Wet-sand.
4. Thoroughly clean the surface.
5. Apply a second layer of DUNAPOX BLACK SEA 125
6. Proceed with a two-phase hardening: 2h at 160°F, followed by 6h at 250°F. Allow the material to cool from room temperature.
7. Wet sand again with sandpaper at first 500 grit and then with finer sandpaper (grit to be decided according to the desired degree of finish).

*NOTE:* to remove any drops or excess sealant, you can use a higher-grit sandpaper (for example 250) to remove the build-up and then proceed with sanding.

**IMPORTANT:** If an oven is used for the post curing process, the oven must have forced air recirculation and the BLACK CORINTHO<sup>®</sup> must be heated evenly to maintain dimensional stability. It may be necessary to place the entire piece on support blocks to ensure uniform heating in the lower part. Non homogeneous heating causes deformation, bowing and/or curvatures.



## 5. RELEASE AGENT

It is extremely important to ensure that the release agent used on the mold is compatible with the prepreg and with the temperatures used.

## 6. POLYMERIZATION IN AUTOCLAVE

DUNA-USA recommends following a heating and/or cooling ramp **not exceeding 4°F/minute**. The larger the item, the more moderate the heating and cooling ramps must be.

BLACK CORINTHO® has been tested at pressures of 6 bar on repeated autoclave cycles without any degradation or breakage. When the temperature exceeds 250-300°F, it is strongly recommended to work in an inert atmosphere, using nitrogen.

The DUNA-Group has a full composites laboratory with autoclave and recommends consulting with us prior to beginning your project. For large scale projects, it may be possible for DUNA to advise on cure profile through in-house testing.



STRATEGIC  
BONDING

BONDING

CNC MACHINING

SURFACE  
SEALING

RELEASING  
AGENTS

POLYMERIZATION  
IN AUTOCLAVE

POLYMERIZATION  
IN OVEN

TECHNICAL  
ASSISTANCE

AVAILABLE FORMATS  
AND PACKAGING

## 7. POLYMERIZATION IN OVEN

BLACK CORINTHO® can be used in combination with prepregs for high temperature oven curing. It is extremely important that BLACK CORINTHO® is heated evenly to avoid deformation. DUNA-USA recommends placing the piece on supports to allow adequate air flow and correct heat propagation even on the bottom of the piece. When the hardening temperature exceeds 250-300°F, it is highly recommended to work in an inert atmosphere using nitrogen.

### Special considerations

#### Dimensional variations

BLACK CORINTHO® boards undergo a modest shrinkage if heated and kept at a high temperature for a prolonged period of time; in particular, a prolonged heating cycle at 356°F can cause a shrinkage of the table by 0,1%. It is important to note that within 12-24 hours after the heating cycle, the board will almost completely regain its original size.

#### CTE variation

CTE values vary slightly based on selected temperature ranges; the average values are those reported on the technical data sheets:

			BLACK CORINTHO® 800	BLACK CORINTHO® 1100
Coefficient of linear thermal expansion CTE (86°F/158°F)	EN 13471/ASTM E228	1/F·10 <sup>-6</sup>	3*	6*
Coefficient of linear thermal expansion CTE (86°F /248°F)	EN 13471/ASTM E228	1/F·10 <sup>-6</sup>	5*	7*
Coefficient of linear thermal expansion CTE (86°F /356°F)	EN 13471/ASTM E228	1/F·10 <sup>-6</sup>	12*	11*

\*Measurement conducted at the Thermal Analysis Laboratory c/o “Enzo Ferrari” Engineering Department (University of Modena and Reggio Emilia).

BLACK CORINTHO® has been successfully tested with the following prepreg systems:

- Epoxies
- Bismaleimide (BMI)
- Cyanate Ester
- Benzoxazine

Although BLACK CORINTHO® sealed with DUNAPOX BLACK SEA 125 has been found to be compatible with most of the carbon fibre available, it is advisable to perform a test to ensure compatibility, before proceeding with large scale operations.

## 8. TECHNICAL ASSISTANCE

Our R&D laboratory is perfectly qualified and equipped to provide advice and possibly conduct tests on specific projects. Do not hesitate to contact us!

## 9. AVAILABLE FORMATS AND PACKAGING

### **BLACK CORINTHO® Boards**

Cardboard packaging on wooden pallets.

Size (in)		BLACK CORINTHO® 800	BLACK CORINTHO® 1100
59" x 19.6" x 1.95"	Nr of boards	20	20
	Weight of pallet	620 kg	850 kg
	Volume	26.5 ft <sup>3</sup>	26.5 ft <sup>3</sup>
59" x 19.6" x 3.95"	Nr of boards	10	10
	Weight of pallet	620 kg	850 kg
	Volume	26.5 ft <sup>3</sup>	26.5 ft <sup>3</sup>

### **DUNAPOX AD 135 - One gallon kit:**

Resin DUNAPOX BLACK AD 135: 11.0 lbs can  
Hardener DUNAPOX H 156: 2.2 lbs can  
Coverage: 220 ft<sup>2</sup> (with a quantity of 0.06 lb/ft<sup>2</sup>)

### **DUNAPOX SEA 125 - One gallon kit:**

Resin DUNAPOX BLACK SEA 125: 11.0 lbs can  
Hardener DUNAPOX H 156: 2.2 lbs can  
Coverage: 581 ft<sup>2</sup> (with a quantity of 0.02 lb/ft<sup>2</sup>)



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