

Moisture Control and Venting GRAFOAM® Carbon Foam

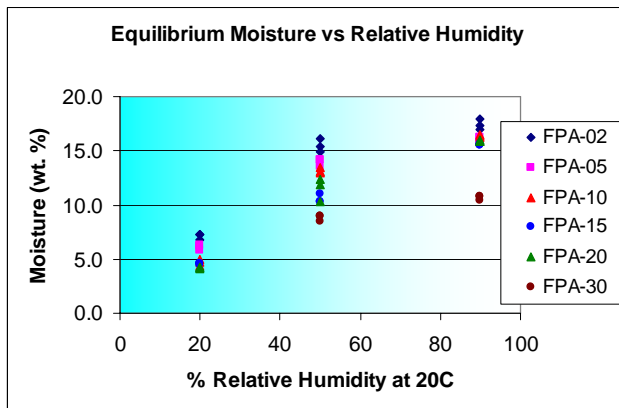
GRAFOAM® carbon foam is an excellent material for large composite tools due to its light weight, high strength to density ratio, and excellent CTE match to carbon fiber composite materials. This document provides guidelines for moisture control and venting of GRAFOAM® carbon foam tools which will be completely encased in a laminate skin.

Storage of Foam Prior to Encapsulation

Dry storage is recommended in order to avoid moisture pickup. If the foam has been subjected to water cutting or other contact with liquid water, it should be kept in heated storage to avoid freeze/thaw damage. Wrap dry foam in plastic wrap as shown in the image to avoid moisture pickup and other forms of contamination.



Moisture Pickup



The moisture pickup of carbon foam exposed to humid air depends on the temperature and relative humidity of the air. This graph shows the maximum amount of moisture regardless of how long the samples are exposed that each density of carbon foam could contain if allowed to come to full equilibrium with room temperature air at various levels of relative humidity.

Drying Carbon Foam

The machined foam core should be dried before beginning the encapsulation process and exposure to moisture should be controlled until the core is covered. The core should be encapsulated within 36 hours of drying. Recommended drying parameters are summarized in the chart at the right.

Drying Parameters		
Tool Thickness	Oven Temp.	Drying Time
< 20 cm (8 inches)	150°C (300°F)	12 hours
20-30 cm (8-12 inches)	150°C (300°F)	24 hours
> 30 cm (12 inches)	Measure with thermocouple, achieve > 120°C (250°F) for 24 hours	

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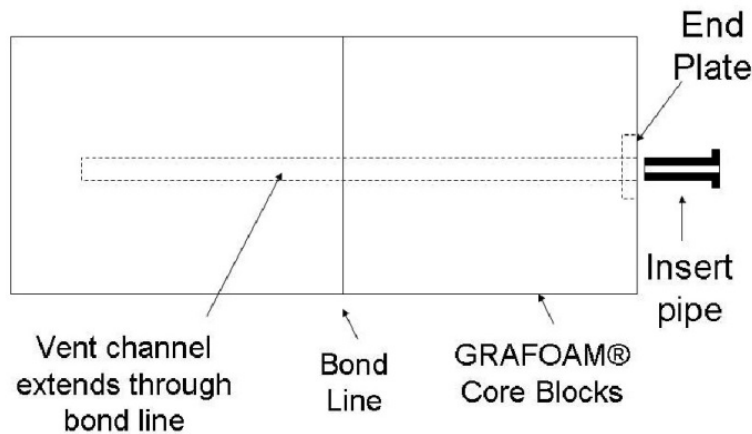
Vent Channels

The tool must incorporate a venting path to allow steam and/or resin curing off-gases to escape to the outside of a fully encapsulated carbon foam tool (usually into the vacuum bag). This can be accomplished by either boring or milling open channels within the tool. Once the encapsulated tool is produced, moisture uptake can easily be mitigated through controlled storage or by sealing the vent channel.

For foam densities less than 320 kg/m³ (20 lb/ft³), it is recommended that the vent area (calculated as diameter or height times the length of the channel, i.e. area projected on the x-y and x-z planes) be at least 1.8 m²/m³ (8 in²/ft³) of the carbon foam and that the flow path for moisture be no more than 60 cm (2.0 feet) from a vent channel. For 320 kg/m³ (20 lb/ft³) density foam and higher, the area should be 3.6 m²/m³ (16 in²/ft³) and the flow path less than 22.5 cm (9 inches). For small tools this usually means one hole thru the length of the tool. For larger tools, multiple vent channels can be connected together and emerge from the tool as a single port. This can usually be accomplished by milling slots on the sides on the blocks that are bonded together to make the core. GrafTech can supply fittings to provide an open vent channel to the outer vacuum bag as shown in the figure below. A 10-15 cm (4-6 inches) long insert pipe slips through a hole in the end plate. A tight fit between the end plate opening and the insert pipe is desirable to minimize resin seepage through the fittings toward the foam core. Vacuum bag tape should be used to seal the flange onto the inner solid film to block resin seepage.

Foam Density	Vent Area per Tool Volume	Max. Distance to a Vent Channel
160 kg/m ³ (10 lb/ft ³)	1.8 m ² /m ³ (8 in ² /ft ³)	60 cm (2 feet)
240 kg/m ³ (15 lb/ft ³)	1.8 m ² /m ³ (8 in ² /ft ³)	60 cm (2 feet)
320 kg/m ³ (20 lb/ft ³)	3.6 m ² /m ³ (16 in ² /ft ³)	22.5 cm (9 inches)

Top View



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Heating Rate to Cure the Tool's Working Surface

The pre-preg manufacturer's recommendations for heating schedule should be followed when curing the prepreg skin of the tool. It is important to remember that foam is a good insulator and changes in temperature at the center of the core will lag changes in the surface temperature. This may mean that residual moisture could still be contained in the core.

Post Cure

Usually the skin of the tool will be cured in a vacuum bag and later post cured to a higher temperature without a bag. It is recommended that the tool be held at post cure temperature long enough to ensure that the core is dry. The vent hole should be plugged with paste adhesives suitable for the service temperature as soon as possible after post cure. This can be done as soon as the tool has cooled below 90°C (200°F). If the vent port is not sealed, the tool should be stored with the vent hole covered. It is recommended to measure the dry weight of the tool to ensure that moisture can be eliminated before putting the tool back into service after long storage periods.

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