3D|CORE™
all around composites

MANUAL

INSTRUCTIONS, RECOMMENDATIONS AND TIPS FOR THE PROCESSING OF 3DICORE™ XPS

IN THE STRUCTURES

3DICORE™ HEXAGON - HX
3DICORE™ RHOMBUS - RB
3DICORE™ DELTA - DT

3DICORE GMBH & CO. KG
OSTSTRASSE 74
32051 HERFORD
GERMANY
WWW.3D-CORE.COM
PHONE: 0049 5221 93 63 90
E-MAIL: INFO@3D-CORE.COM

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3DICORE GMBH & CO. KG
OSTSTRASSE 74
32051 HERFORD
GERMANY
WWW.3D-CORE.COM
PHONE: 0049 5221 93 63 90
E-MAIL: INFO@3D-CORE.COM

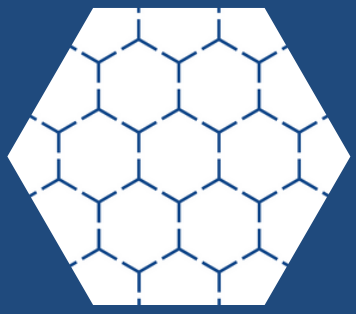
IN GENERAL

This short manual is intended to support you in the processing of 3D|CORE™ XPS. The processing instructions, recommendations and tips are intended to help you easily and quickly obtain optimum components and avoid mistakes.

1 BASICS

1.1 Foam system

3D|CORE™ XPS is a cost-effective foam system for sandwich structures made of extruded polystyrene with a density of approximately 45 kg/m³. 3D|CORE™ XPS is available in 3 structure types:



3DICORE™ HEXAGON (HX)

3DICORE™ RHOMBUS (RB)

3DICORE™ DELTA (DT)

All structures are based on the shape of a hexagon. The structures filled with epoxy resin in the foam result in a very economical hybrid core system with excellent technical properties. This hybrid core can be used as an economical alternative to high-performance foam cores.

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1.2 Sustainability

3D|CORE™ XPS requires little energy in processing. Combined with the low energy consumption in foam production and the low weight of the components made from it, the overall system has a positive CO2 balance.

1.3 Storage conditions

XPS foam should be stored at temperatures between 10°C and 30°C. The humidity at room temperature in a closed storage area should be below 80%. Co-storage with solvents is not recommended as the foam may absorb volatile organic solvents. Long-term storage may result in a 3% to 5% change in dimensions. A shelf life of one year is guaranteed for the foam when properly stored.

1.4 Working environment

Make sure that your production is a closed area and that negative environmental influences do not affect the process.

Make sure that the area is cleaned with an industrial vacuum cleaner with filters according to EN 1822-1: 2009 filter class E12 (EPA) before starting the process. This corresponds to a filter with a separation rate of at least 95%. Please note that even the smallest organic or inorganic dust particles in the mold or on the fibre, can negatively affect the subsequent components.

Make sure that all surfaces are free of silicones, grease, oil or cosmetic components such as creams. Hair shampoos available on the market may contain silicones. Silicones act like release agents and can, for example, negatively influence or even prevent subsequent painting.

Therefore, have your employees wear headgear and fresh work gloves before touching the foam core and fibre.

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1.5 Occupational safety and health protection

When cutting, grinding, milling or drilling during your manufacturing process, employees should wear an FP 3 type respirator and disposable protective suits with headgear.

Make sure that the exhaust air from the vacuum pump is ducted outside the building. This will ensure that your employees are not exposed to the exhaust air of the epoxy resin.

If possible, avoid using open processes such as hand lay-up or wet press fabrication. If this is the case due to repair and modification work, personnel must wear nitrile protective gloves, FP A1 (activated carbon) respirators and protective suits.

Give instructions that eating and drinking are absolutely forbidden during the production.

These simple rules will help you protect your employees.

1.6 Humidity

Absorbed moisture on the foam surface may cause a chemical reaction of the resin or release agent to occur. Before processing, we recommend that 3D|CORE™ XPS be stored in the uniformly tempered working space for about 36 hours beforehand. Moisture can also lead to delamination of fibre, core and coating. Therefore, we recommend this procedure for all materials to be used in production. Please also observe the recommended processing temperature of your resin system, otherwise the curing time of the resin may change.

2 TECHNICAL RULES AND RECOMMENDATIONS

2.1 Resin systems

XPS foams are only suitable for epoxy resins and some polyurethane resins. Vinylester and polyester resins are expressly not suitable due to their styrene content. A number of common epoxy resins have been successfully tested. We will be happy to recommend a suitable epoxy resin. Polyurethane resins are currently being tested by us for future RTM components.

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2.2 Compatibility of the materials used

You should always carry out a small test to check whether all the components used in the composite and the required production materials are compatible with each other. This means that the foam core material, the fibre sizing of the fabric, the release agent of the mold, the sealing tape, and also the vacuum bagging film must be compatible with the resin system. We will be happy to manufacture and test the corresponding test specimens for you in our technical center.

2.3 Outgassing and voids

Blowholes (voids) can significantly deteriorate the technical properties of a component. To avoid this, vacuum pretreatment of the foams can be very helpful. The combination of a vacuum bag, a negative pressure by means of a vacuum pump of -0.5 bar and a maximum temperature of 35°C for 24 to 36 hours is a simple and affordable method for deaerating the foams. Afterwards, let the foam cool down to room temperature again.

2.4 Exothermic reaction - self heating of the resin

Avoid exothermic reactions of the resin by preventing larger accumulations of resin in your component. This is very easy with 3D|CORE™, as the structure in the foam forms a fine channel system in which the resin is only contained in a small, non-critical quantity. By injecting/aspirating the calculated amount of resin, a stable vacuum of -0.5 bar and processing at room temperature (max. 23°C), the entire system remains within a safe range.

2.5 Preparation of the foam surface

For standard foam cores, surface treatment is recommended to improve secondary bonding. The recommended grooves of 2x3 mm every 50mm over a length of 1000mm result in a remarkable resin absorption in the part.
With 3D|CORE™, there is no need to pre-treat the surface with grooves or perforations to improve secondary bonding. The patented 3D|CORE™ structures create high peel strength and ensure an ideal bond with the face sheets. No air is trapped in the component and resin flow is optimized. This saves time and weight.

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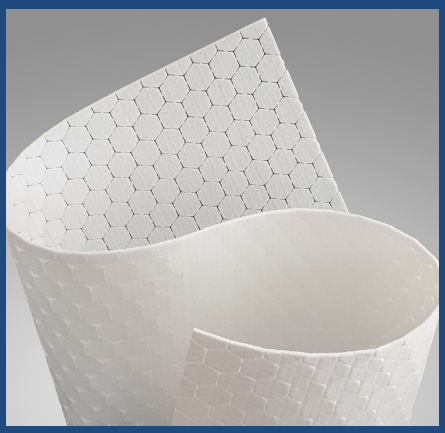
3 MECHANICAL PROCESSING OF THE CORE MATERIAL

3.1 Forming



Due to the small bridges between the individual honeycomb foam bodies, 3D|CORE™ is an extremely flexible core material. Neither heat, nor weight, nor vacuum forming are required to adapt the foam core to the respective shape. This saves time and energy. Although 3D|CORE™ already fits tightly to the respective mold during insertion, you can additionally use a spray adhesive suitable for your epoxy resin to ensure that the core remains in the desired position of the mold.

3.2 Cutting and chamfering

The best tool for cutting XPS foam by hand is a knife blade ground on one side, a so-called cutter. For the production of shanks/bevels, we recommend the use of a cutter and a beveled steel ruler with a 45° bevel as a guide. These tools are ideal for straight cuts and precise bevels.

3.3 CNC – Cutting

To achieve perfect results when cutting by machine on a cutting table, we recommend using a CNC cutter with an oscillating knife.

3.4 CNC - Kits

The easiest, fastest and most economical way to realize your project is to order the required 3D|CORE™ ASSEMBLY KITS from us. All you need to do is send us your three-dimensional technical drawing and our engineering team will use it to create the processing, as well as a two-dimensional file for cutting. This file is reviewed online with your engineers, discussed and optimized if necessary.

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3.5 Milling

Since 3D|CORE™ with its fine structures is not a homogeneous material, please test the possible feed rate of your milling machine in advance. Furthermore, this process generates a lot of dust.

3.6 Sawing

Sawing with standard saw blades is possible without any problems, but a lot of dust is generated here as well. To cut dust-free, 3D|CORE™ XPS can alternatively be cut very well with a hot wire. The resulting smoke, however, must be collected and disposed of, which incurs additional costs. Note that when cutting with hot wire, about 0.6-0.8mm of the XPS foam on each side of the cutting channel on the workpiece/component will shrink or vaporize due to the heat. You should take this into account in the design.

4 JOINING

In general, you must check that the joining method you use does not clog the channels of the structures in the foam core and thus impede the flow of resin during infusion.
A simple and safe method is to create a symmetrical joining zone between the hexagons (see Figure 4.1.-4.4. on the following page). Here, the 3D|CORE™ honeycomb foam bodies can be arranged as a linear or hexagonal joining zone.

4.1 Bonding

Bonding the individual 3D|CORE™ XPS sheets together is a very simple method of joining them. There are many different systems available on the market, e.g. adhesive spray, hot glue, 2K PUR adhesive, etc.
We always recommend testing the adhesive system on a small sample of material before starting work. Here you add small adhesive dots in the middle of the foam bodies. Then you can push them together and leave a maximum of 1mm space between the foam bodies. Simply use some spacers made of 0.8mm sheet steel for this purpose.

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4.2 Welding

Welding with a welding bar at around 120°C is possible. You must bear in mind that you will lose 1mm on each side of the joining area as a result of the welding process. To obtain a consistent structure and technical properties, you should add this 1mm per side in the cut area when dimensioning your foam sheet.

4.3 Stapling

Stapling, also known as "tacking", is the safest way to join 3D|CORE™ modules. Arrange the joining parts symmetrically to the counterpart. There are two possibilities, which are shown in Figures 4.1.-4.4.
Take a stapler and thermoplastic staples (clips). When stapling together, always make sure that the channels remain open. This is the only way to guarantee an ideal flow of the resin and a uniform structure within the sandwich body.

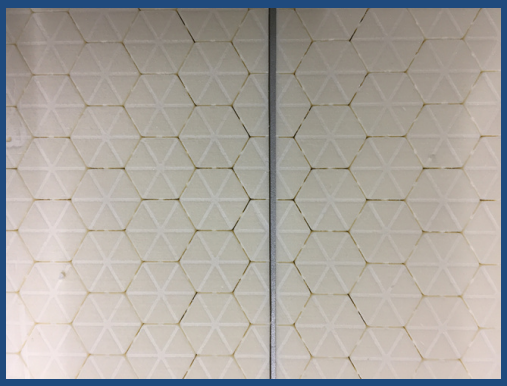

Fig. 4.1 Linear arrangement

Fig. 4.2 Stapling linear

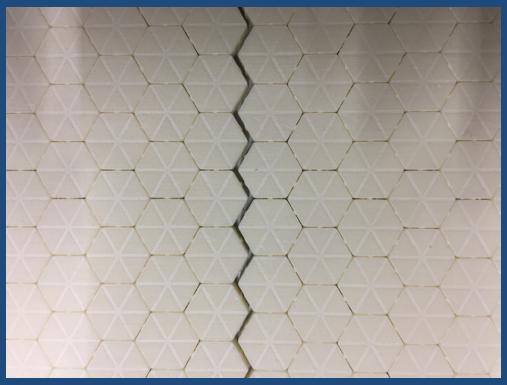

Fig. 4.3 Hexagonal arrangement

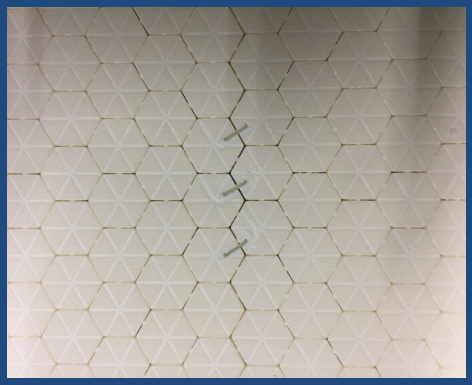

Fig. 4.4 Stapling hexagonally

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OSTSTRASSE 74
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PHONE: 0049 5221 93 63 90
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5 PRODUCTION OF COMPOSITES WITH AN 3D|CORE™ XPS CORE

3D|CORE™ XPS is a heat-sensitive polymer foam.

In the manufacture of fibre composite components with a foam core, they are wetted with a resin-hardener mixture (matrix) until they are completely impregnated with the matrix.
Most resin impregnation processes involve the risk of accumulation of a larger quantity of the liquid of the resin-hardener mixture. When the resin and hardener start to react, an uncontrolled exothermic reaction of the resin may occur if the so-called "critical amount" is exceeded at any point in the mold or die and/or the outside temperature is too high. Please follow the recommendations of the resin manufacturer.
This also means that "open systems" such as hand laminating, wet embossing and similar processes where you cannot control the amount of resin well are not suitable for XPS foam.

3D|CORE™ XPS foam and epoxy resin should only be used in a closed process. These include VI (Vacuum Infusion), VARTM (Vacuum Assisted Resin Transfer Molding), and vacuum assisted resin injection.

5.1 VI - Vacuum Infusion

The cut fibres (mats, fabrics, etc.) and the 3D|CORE™ foam cores are inserted into the mold as a sandwich (fibre, core, fibre) and then sealed airtight with the appropriate vacuum bag. Use a suitable piping system to introduce the resin and to evacuate the air. If you are not using a self-sealing vacuum exhaust hose system, please never forget the resin trap in front of the vacuum pump.

In the areas of the part where 3D|CORE™ is not used and a full laminate is intended, please use aids such as flow and deaeration aids. This is the only way to avoid dry spots in these areas due to the so-called fiber brake.

Make sure that the mold and the vacuum bag are properly sealed with sealing tape. Start your vacuum pump and build up a vacuum of -0.5 bar. Then stop your vacuum pump and check the vacuum with a pressure gauge. Make sure that the vacuum remains stable for more than one hour.

If you have enough time in production, we recommend to deaerate the mold and the inserted materials overnight with the vacuum applied, i.e. with the vacuum pump running.

Pre-mix the resin and hardener exactly as recommended for slow curing (pot life). Observe the recommended maximum volume per batch (amount in a container), the lifetime of the resin and the ambient temperature to avoid an exothermic reaction. Self-heating of the resin can lead to spontaneous combustion and thus to a fire in production.

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OSTSTRASSE 74
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When everything is prepared, open the valve of the container with the prepared resin mixture inside. The vacuum now sucks the resin into the mold to wet the foam and sandwich structure. When the laminate has cured and you do not notice any elastic areas when you press on the part with your finger, the part can be demolded.
For larger components, we recommend using mixing equipment consisting of a mixer unit and a pump unit.

Tip:
If critical temperatures are measured despite all preparations (plus 40°C for 3D|CORE™ XPS), you can cool down the hotspots in the mold with cold water from a hose as an additional safety measure.

VACUUM INFUSION CHECKLIST - PLEASE NOTE THE FOLLOWING POINTS:

- Check that all the materials used (resin, hardener, fibres, sizing of the fibres and the release agent) are matched to each other
- Check that the fibres and the 3D|CORE™ foam core are sufficiently dry
- Calculate the required resin volume in advance
- Contact our engineering team for more information if you have any questions
- Use a low viscosity VI epoxy resin or VI polyurethane resin system
- Avoid temperatures above 40°C during vacuum infusion
- Apply a vacuum of -0.7 bar maximum
- Do not use higher temperatures for post-curing (tempering) until the resin is fully cured

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5.2 VARTM - Vacuum Assisted Resin Transfer Molding

Instead of one or more plastic containers for the resin mixture, take an RTM mixing and pumping unit to continuously produce the right resin mixture in the right amount. The rest of the process is similar to classic vacuum infusion (see above). Advantages of this process are the controllability, as well as the possibility to add resin immediately if you find that the calculated amount is not sufficient.

VARTM CHECKLIST - PLEASE NOTE THE FOLLOWING POINTS:

- Check that all the materials used (resin, hardener, fibres, sizing of the fibres and the release agent) are matched to each other
- Check that the fibres and the 3D|CORE™ foam core are sufficiently dry
- Separate the mold with the appropriate release agent
- Calculate the required resin volume in advance
- Contact our engineering team for more information if you have any questions
- Use a low viscosity VI epoxy resin or VI polyurethane resin system
- Avoid temperatures above 40°C during the process
- Apply a maximum vacuum of -0.7 bar and a maximum injection pressure of 1 bar
- Do not use higher temperatures for post-curing (tempering) until the resin is fully cured
- Do not add any additional resin-hardener mixture to the mold if it is already filled

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5.3 RTM – Resin Transfer Moulding

In this process, you use a two-part mold that is tightly sealed during injection. This saves you time and material (for example, no vacuum bag is required).

Both mold halves are separated with a suitable release agent. The preform cut to size for the component (preform made of fibre and foam core) is placed in the mold and the mold is closed. The mold is then vented via the built-in vacuum elements. After venting, the RTM mixing unit pumps the pre-calculated resin volume into the mold at high speed and under pressure. The structure in the 3D|CORE™ core absorbs the pressure. Due to the lack of back pressure, the foam core is not compressed. The resin impregnates the materials completely and much faster than with the VI or VARTM process.

Before you start producing a component, we recommend that you carry out preliminary tests. Here, you gradually increase the injection pressure of the resin to find out at what point the pressure compresses the foam core. We will be happy to carry out these tests for you in our technical center. Subsequent, careful heating of the mold accelerates the curing of the resin and thus the process. These heating parameters must be determined in advance for the respective resin system.

RTM CHECKLIST - PLEASE NOTE THE FOLLOWING POINTS:

- Check that all materials used (resin, hardener, fibres, sizing of the fibres and the release agent) are matched to each other
- Check that the fibres and the 3D|CORE™ foam core are sufficiently dry.
- Separate the mould with the appropriate release agent
- Calculate the required resin volume in advance
- Contact our engineering team for more information if you have any questions
- Use a low viscosity VI epoxy or VI polyurethane resin system
- Avoid temperatures above 40°C during the process
- Do not exceed the maximum vacuum of -0.7 bar to avoid compressing the foam core
- Do not use higher temperatures for post-curing (tempering) until the resin is fully cured
- Never work with additional holding pressure when the mould is filled.
  This can destroy the component.

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OSTSTRASSE 74
32051 HERFORD
GERMANY
WWW.3D-CORE.COM
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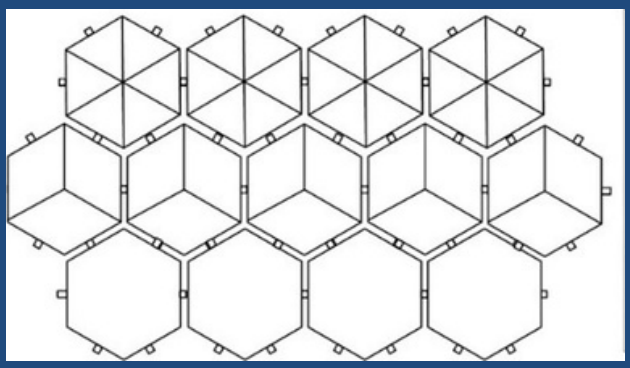
6 SPECIAL SOLUTION - ADAPTION TO DIFFERENT TECHNICAL REQUIREMENTS AND DIFFERENT LOADS

3D|CORE™ offers you the possibility to combine the different structure types for the local reinforcement of your component.
This allows you to adapt your structure to the required technical properties without changing the wall thickness of your sandwich.
This saves weight because the entire load application area does not have to be designed as a complete fibre laminate (full laminate).



7 CALCULATION OF THE RESIN VOLUME

Calculation basis for the resin volume of 3D|CORE™ XPS in HX, RB, DT	
Resin uptake of the surface per side	200g/m²
3D|CORE™ XPS HX HEXAGON	50 - 60 g/m²/mm
3D|CORE™ XPS RB RHOMBUS	100 - 110 g/m²/mm
3D|CORE™ XPS DT DELTA	150 - 160 g/m²/mm

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