AQUACORE™

Ready to use, heat resistant 1-component moulding compound, water soluble

*Aquacore is a new **high-temperature, water soluble** fugitive core material.*

Aquacore is supplied as a moist powder which is machined, molded or hand shaped to the desired geometry and dried at 93 °C (200 °F). Aquacore is compatible with all commercial resins and prepreg compounds with cure temperatures below 193 °C (380 °F). It can be dissolved away from the cured composite quickly using tap water, and the effluent is nontoxic.

The wash-away feature minimizes the possibility of damaging fine details.

Benefits
- *washes out in cold tap water in minutes*
- *makes complex part manufacturing simple*
- *environmentally friendly, no special disposal*
- *compatible with all commercial resins and prepreg compounds*
- *nontoxic and odorless*
- *easily repaired and re-formed*
- *remove mandrel from previously inaccessible hidden areas*
- *saves time*
- *reduces labor*
- *saves money*
- *strong and lightweight*

Instructions for using Aquacore™

If Aquacore™ has notably separated, we recommend placing the product in a shallow trough or bucket and kneading it by hand until thoroughly mixed.

Aquacore™ is porous and may need to be sealed. Aquaseal™, a water-soluble and thermally stable sealer, is recommended for sealing the mandrel.

No special disposal procedures need to be followed for the washed mandrel material, as it is completely environmentally friendly.

Aquacore™ is compatible with the curing temperatures of all commercial pre-preg resins.

***1.** Prepare mould. We recommend a Lecithin based mould release (e.g. rape oil) or teflon. Apply the rape oil with a brush.*

***2.** Form material into the desired shape by packing into a mould or shaping it by hand. Compress it well.*

***3.** Remove material from mould carefully. If you have problems to get the material out of the mold, before you put it in the oven. You can put the material with the mold in the freezer, to get the material very hard (frozen) and after it is freezed you can remove the mold without problems. The frozen material will then put in an oven and dried without the mold.*

***4.** Dry material in a convection oven at 125 °C (257 °F). Fundamental Heating- / Cooling rate 3 °C /min.*

> ***a.** The material can also be dried at temperatures below 125 °C (257 °F). However, Aquacore™ is very thermally stable and can withstand temperatures in excess of 195 °C (383 °F).*

A

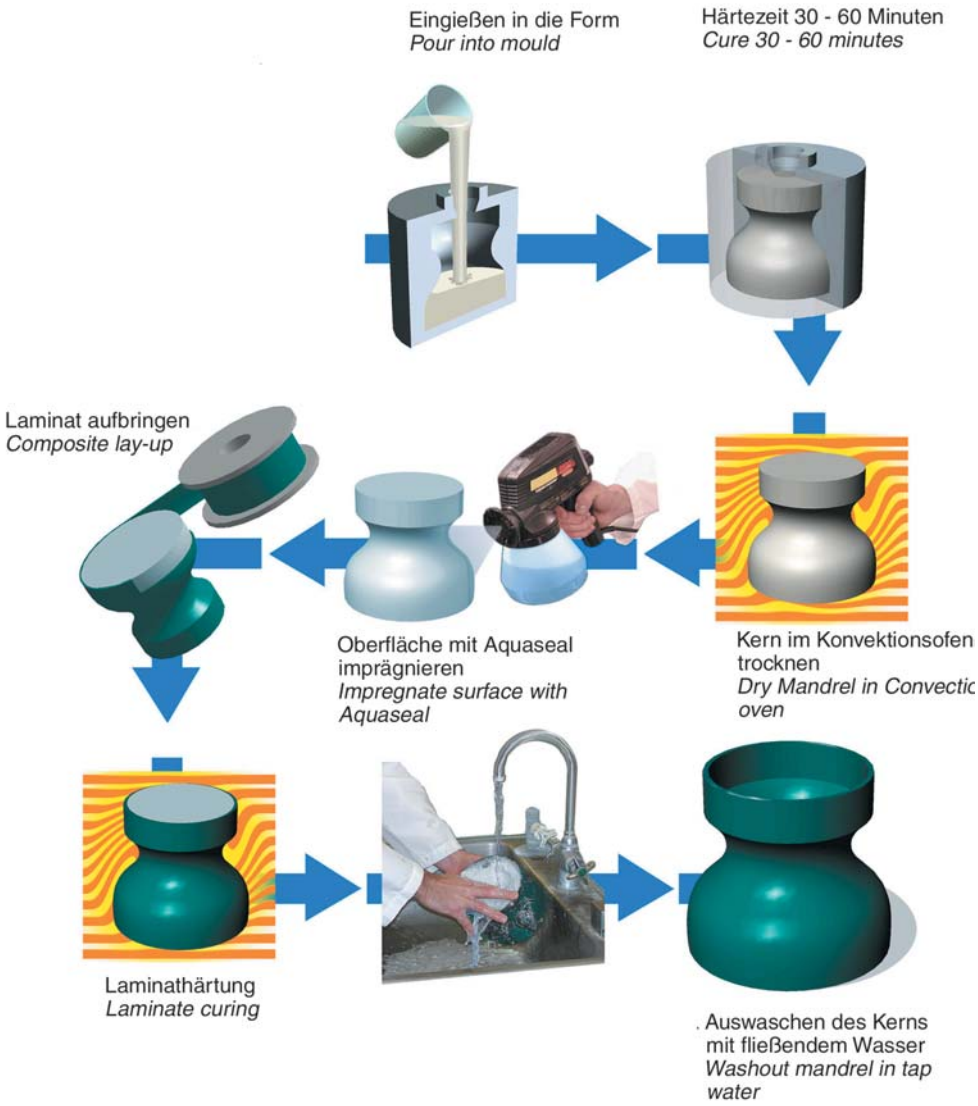
R&G Faserverbundwerkstoffe GmbH · Im Meissel 7 + 13 · D-71111 Waldenbuch
Tel. +49 (0) 7157 5304-60 • Fax +49 (0) 7157 5304-70 • e-Mail: info@r-g.de • www.r-g.de

b. *Drying times for Aquacore™ vary according to the part geometry and surface area. For example, a cylinder measuring 2 inches in diameter and 6 inches in length will require approximately 1.5 hours of drying time at 125 °C (257 °F) or approximately 2 hours at 95 °C (203 °F). Objects much larger in diameter are also dried at the same temperatures.*
Drying times will increase at approximately 1 hour per inch in diameter at 125 °C (257 °F) and at 1.5 hours per inch in diameter at 95 °C (203 °F).

c. *To avoid cracking, we recommend turning the oven off with the mandrel inside and letting the mandrel cool in the oven. This prevents thermal shock.*

5. *Once dried, seal the mandrel with Aquaseal™ according Instructions for using Aquaseal™. After dried, apply Release Agent or Release Wax on the Aquacore™. After lay up composite material around Aquacore™ and cure according to the specifications of the material.*

6. *After cure, simply wash with tap water to remove the mandrel particulate.*



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Aquacore

Aquacore is a new high-temperature, water soluble fugitive core material. Aquacore is supplied as a moist powder which is machined, molded or hand shaped to the desired geometry and dried at 93°C (200°F). With a specific gravity of 0.45 wet, it is lightweight, easily machined, and thermally stable.

Aquacore is compatible with most commercial epoxy and cyanate resin ester systems with cure temperatures below 193°C (380° F). It can be dissolved away from the cured composite quickly using tap water, and the effluent is nontoxic.

Unlike conventional mandrel materials, which must be tediously removed from composite lay-ups, Aquacore mandrel is readily soluble in cold tap water and can easily be washed away from the finished part.

Aquacore saves time, labor and the wash-away feature minimizes the possibility of damaging fine details.

Benefits

- Washes out in cold tap water in minutes
- Environmentally friendly, no special disposal procedures required
- Nontoxic and odorless
- Remove mandrel from previously inaccessible hidden areas
- Easily dried in a convection oven
- Strong and lightweight
- Makes complex part manufacturing simple
- Compatible with all commercial resins and prepreg compounds
- Easily repaired and re-formed
- Saves time
- Reduces labor
- Saves money

Aquacore is available in 5 to 55 gallon containers. Aquacore is also available in machinable, pre-formed, dried blocks in virtually any size.

We recommend Aquaseal to seal the tool and prevent resin migration.

Call or fax Aero Consultants AG for assistance with your specific manufacturing requirements.

Aero Consultants AG
P.O. Box 35
CH-8606 Nänikon/Uster
Switzerland
Email:
Internet:
Tel +41 (0) 44 905 28 00
Fax +41 (0) 44 941 31 37
info@aero-consultants.ch
www.aero-consultants.ch

Aero Consultants (UK) Ltd.
13/14 Clifton Road
GB-Huntingdon, Cambs PE29 7EJ
United Kingdom
Email:
Internet:
Tel +44 (0) 1480 432 111
Fax +44 (0) 1480 412 910
info@aero-consultants.co.uk
www.aero-consultants.ch

Instructions for using Aquacore

The watersoluble mandrel material, Aquacore™, has been formulated with a minimum amount of water to enable it to be easily formed into complex shapes. Aquacore™ comes ready to use, no additional water is needed for production.
If Aquacore™ has notably separated, we recommend placing the product in a shallow trough or bucket and kneading it by hand until thoroughly mixed.
Aquacore™ is porous and may need to be sealed. Aquaseal™, a water-soluble and thermally stable sealer, is recommended for sealing the mandrel. No special disposal procedures need to be followed for the washed mandrel material, as it is completely environmentally friendly. Aquacore™ is compatible with the curing temperatures of all commercial pre-preg resins.

NOTE: If the Aquacore™ has been sitting for a length of time, mix well before using.

1. Prepare mould. We recommend a Lecithin based mould release (e.g. rape oil) and apply the rape oil with a brush or use a Teflon foil or tape. *Never use release wax!*

2. Form material into the desired shape by packing into a mould or shaping it by hand. Compress it well.

3. Remove material from mould carefully. If you have problems to demold the material, before you put it in the oven. You can put the material with the mold in the freezer, to get the material very hard (frozen) and after it is frozen you can remove the mold without problems. The frozen material will then put in an oven and dried without the mold.

4. Dry material in a convection oven at 125°C (257°F). Fundamental Heating- / Cooling rate 3°C /min.

    a. The material can also be dried at temperatures below 125°C (257°F). However, Aquacore™ is very thermally stable and can withstand temperatures in excess of 195°C (383°F).

    b. Drying times for Aquacore™ vary according to the part geometry and surface area. For example, a cylinder measuring 2 inches in diameter and 6 inches in length will require approximately 1.5 hours of drying time at 125°C (257°F) or approximately 2 hours at 95°C (203°F). Objects much larger in diameter are also dried at the same temperatures. Drying times will increase at approximately 1 hour per inch in diameter at 125°C (257°F) and at 1.5 hours per inch in diameter at 95°C (203°F).

    c. To avoid cracking, we recommend turning the oven off with the mandrel inside and letting the mandrel cool in the oven. This prevents thermal shock.

5. Once dried, seal the mandrel with Aquaseal according Instructions for using Aquaseal. After dried, apply Release Agent or Release Wax on the Aquacore. After lay up composite material around Aquacore™ and cure according to the specifications of the material.

6. After cure, simply wash with tap water to remove the mandrel particulate.

Call or fax Aero Consultants AG for assistance with your specific manufacturing requirements.

Aero Consultants AG
P.O. Box 35
CH-8606 Nänikon/Uster
Switzerland
Email:
Internet:
Tel +41 (0) 44 905 28 00
Fax +41 (0) 44 941 31 37
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www.aero-consultants.ch

Aero Consultants (UK) Ltd.
13/14 Clifton Road
GB-Huntingdon, Cambs PE29 7EJ
United Kingdom
Email:
Internet:
Tel +44 (0) 1480 432 111
Fax +44 (0) 1480 412 910
info@aero-consultants.co.uk
www.aero-consultants.ch

Application with Aquacore 1024

EUROCOPTER

The World's First All-Composite Aircraft Door

The Airplane Components division of Eurocopter in Donauwörth, Germany, has just produced the first all-composite aircraft doors using a single-phase polymerization process. Their advantages include low weight and excellent resistance to fatigue and corrosion.

The all-composites aircraft door made by Eurocopter is called 'monolithic' because all its components (spars, frames, skin) are produced and joined in a single molding operation.

Eight companies from Germany, France, the United Kingdom and Italy came together in 2001 in a joint research project called FUBACOMP *(Full Barrel Composite Fuselage)* as part of a European research program aimed at assuring competitive and sustained growth. The objective of the project was to construct a complete section of a business-aircraft fuselage, including the cockpit, entirely in composites. Eurocopter Donauwörth is responsible for the doors and Eurocopter France for the door and window-frames. For starters, this technology is expected to produce extremely lightweight structures, with a weight saving for the doors of around 30% compared with conventional aluminum constructions.

"The details of this process require highly specific know-how, so we are well placed with our unrivaled technological expertise," says Michael Rehmet, director of the program at Donauwörth. A one-shot operation is sufficient to produce the complete door, from skin to spars and frames. The carbon fibers are immersed in a mold filled with resin before being cured. "We expect this new construction technique to produce exceptionally lightweight parts, but above all to bring advantages in terms of operating characteristics, such as improved resistance to fatigue and corrosion," added Wolfgang Buchs, head of the project.

"This is a true technology breakthrough after an intensive and successful development phase," said Bert Stegkemper, Senior Vice President of Eurocopter. "It proves once again that not only is Eurocopter the market leader in airplane door design but that we are able to reduce to a large extent the inherent complexity of this area of aeronautical engineering and achieve at the same time incredible weight reduction."

The three doors already completed are currently undergoing static and dynamic tests at Eurocopter Donauwörth, Institut für Materialforschung und Anwendungstechnik (IMA) in Dresden and Centre d'essais aéronautiques in Toulouse (CEAT). The tests are expected to run until mid-2005. This innovation will not benefit future aircraft only: the doors may also be used as alternatives in existing aircraft programs where weight is a critical factor.

BERNDT VON MITZLAFF

Aero Consultants LTD. AG
P.O. Box 35
CH-8606 Nänikon/Uster
Switzerland
Email:
Internet:
Tel +41 (0) 44 905 28 00
Fax +41 (0) 44 941 31 37
info@aero-consultants.ch
www.aero-consultants.ch

Aero Consultants (UK) Ltd.
13/14 Clifton Road
GB-Huntingdon, Cambs PE29 7EJ
United Kingdom
Email:
Internet:
Tel +44 (0) 1480 432 111
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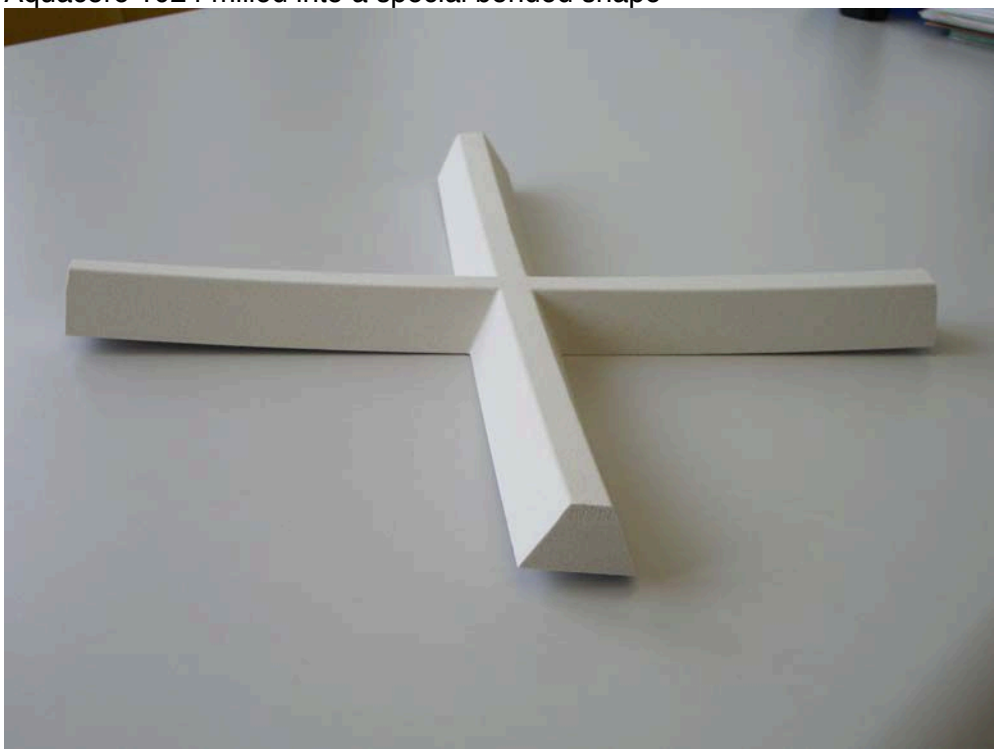
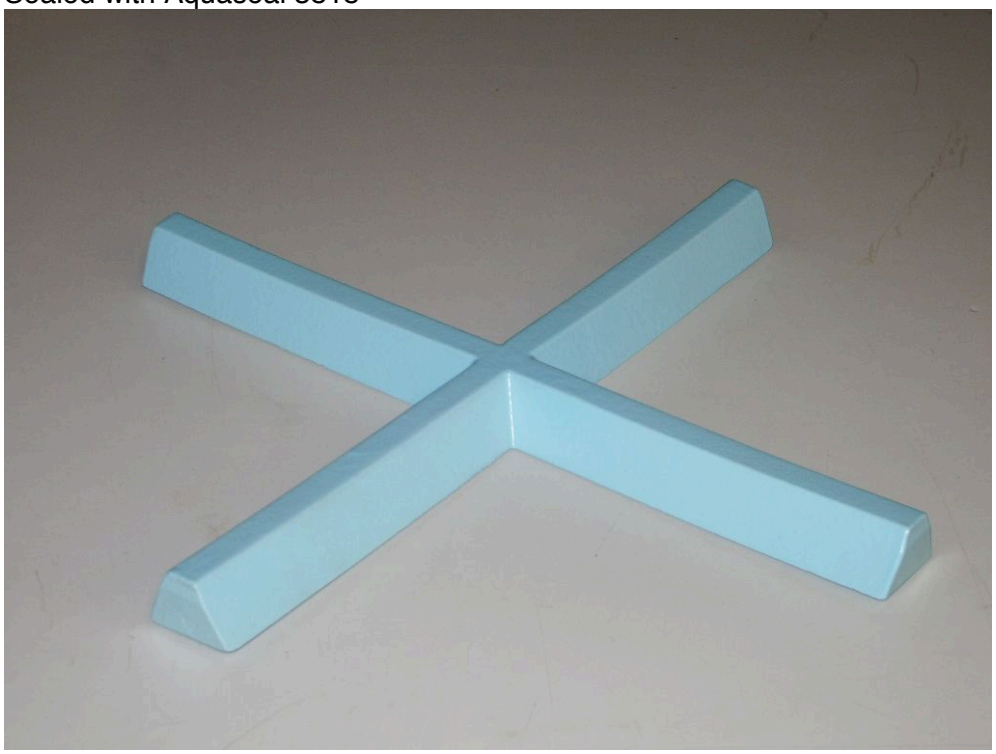
Autoclave Application with Aquacore 1024

Aquacore 1024 milled into a special bonded shape



Sealed with Aquaseal 3818



Aero Consultants LTD. AG
P.O. Box 35
CH-8606 Nänikon/Uster
Switzerland
Email:
Internet:
Tel +41 (0) 44 905 28 00
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13/14 Clifton Road
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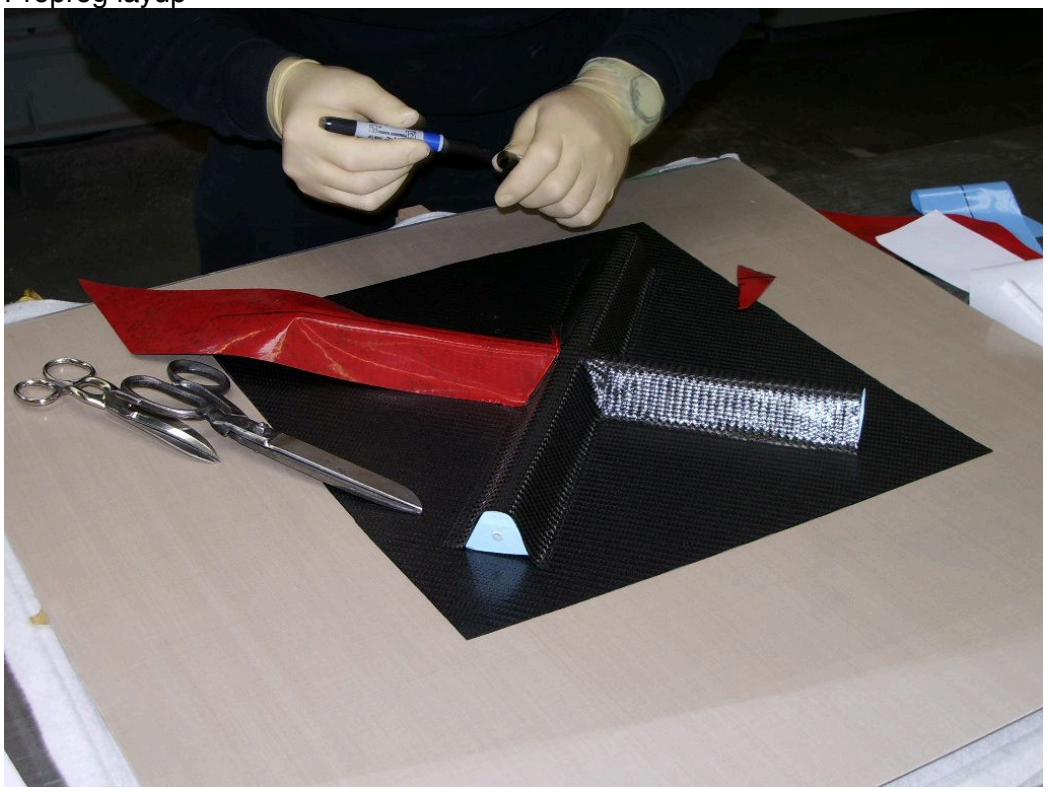
Prepreg layup



Vacuum pulling

Aero Consultants LTD. AG
P.O. Box 35
CH-8606 Nänikon/Uster
Switzerland
Email:
Internet:
Tel +41 (0) 44 905 28 00
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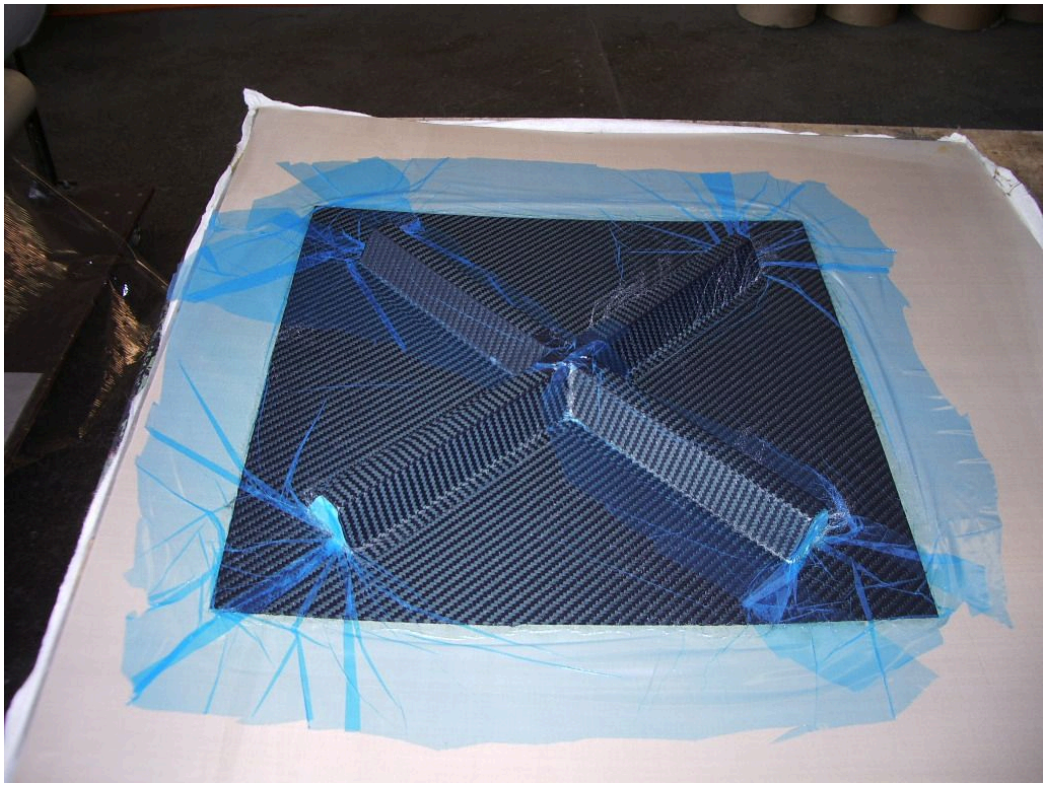
Autoclave Cycle at 120°C, 4bars of pressure, duration 2h

Cross section with release film



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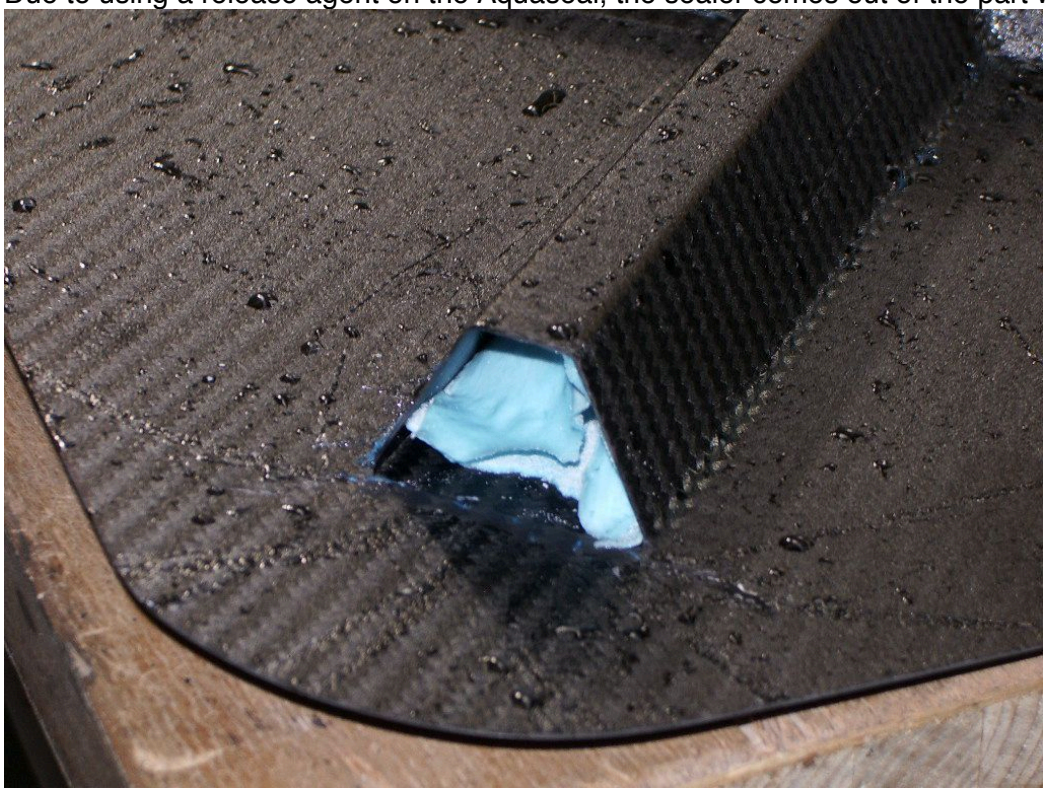
Washout the Aquacore 1024

Due to using a release agent on the Aquaseal, the sealer comes out of the part without problems



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Email:
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info@aero-consultants.co.uk
www.aero-consultants.ch

Finished part

Finished part

Aero Consultants LTD. AG
P.O. Box 35
CH-8606 Nänikon/Uster
Switzerland
Email:
Internet:
Tel +41 (0) 44 905 28 00
Fax +41 (0) 44 941 31 37
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Email:
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Fax +44 (0) 1480 412 910
info@aero-consultants.co.uk
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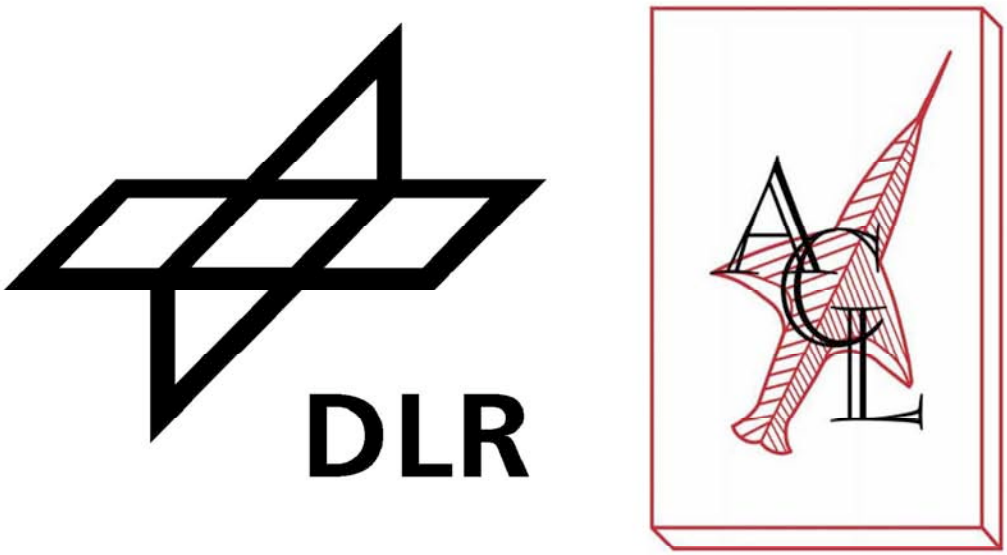
Report

Microwave Drying of Aquacore, Aquapour and Aquaseal



Institute for Composite Structures and Adaptive Systems
DLR Braunschweig

Braunschweig, June 2005

Faserverbundleichtbau und Adaptronik

Contents

1 Overview

This report discusses the findings of our analysis of the forming materials Aquapour and Aquacore as well as the releasing agent Aquaseal, produced by Aero Consultants Ltd. AG. The drying behaviour of said materials in a microwave oven was examined, especially with respect to possible acceleration of the drying process in comparison to conventional ovens.

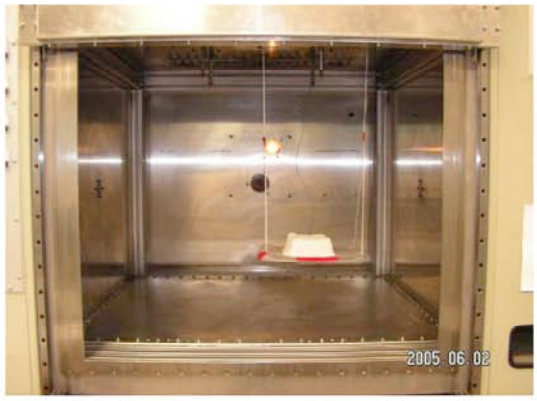


Abbildung 1: Gesamter Mikrowellenraum

2 Experiment Setup

The Institute of Composite Structures and Adaptive Systems uses a custom-built microwave oven equipped with four magnetrons. Each magnetron can be separately controlled to supply up to 2000W of microwave power at a frequency of 2.45GHz to a 1m^3 cavity. In order to examine the drying process it is necessary to continuously weigh the specimen.

Since it was not possible to install a scale within the microwave field a scale was placed above the microwave cavity, and cords of polypropylene (PP) routed through openings in the cavity wall were used to connect it to a polypropylene plate supporting the specimen (Fig. 2). To enable water to evaporate from the underside of the specimen, holes were drilled into the plate. Fig. 1 shows the microwave cavity with the specimen placed on the plate.

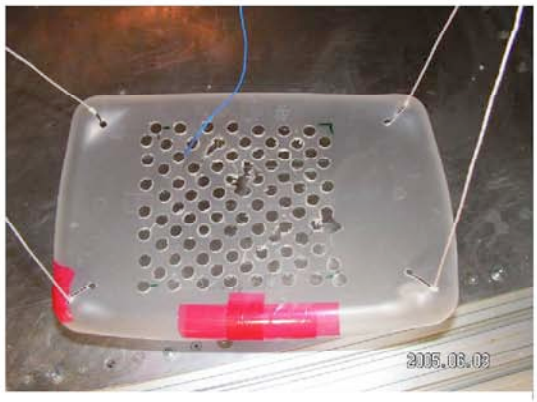


Abbildung 2: Gelochte Platte

3 Experiments

3.1 Aquacore and Aquapour

Figure 3: material in forms

Aquacore and Aquapur are both delivered in form of a powder which was then shaped into a specimen. The shape was provided by small PP containers which were filled with Aquacore or a mixture of water and Aquapour. The dimensions of the specimens were about 4.5cm x 12.5cm x 12.5cm, resulting in a volume of about 700ml.
Aquacore is inserted into the PP mould without any further preparation. The whole process of forming is completed within 15 minutes.
Aquapour is mixed with 45% by weight of water and left to sit for one hour before it is demoulded.
The specimens are then placed on the plate inside the microwave cavity. The emitted microwave power is kept constant throughout the experiment. During its course temperature and weight of the specimen are recorded at regular intervals. When the weight of the specimen remains constant, the experiment is terminated.
The temperature is measured by means of thermocouples inserted 1cm into the specimen.

3.2 Aquaseal

The releasing agent Aquaseal is delivered in liquid form. In order to examine the drying of Aquaseal the specimen, formed from Aquapour or Aquacore, it is weighed, covered in Aquaseal using a compressed-air spray gun and subsequently weighed again and placed inside the microwave oven. During the drying process the weight of the specimen is recorded at regular intervals until no further decrease in weight is noted.

Figure 4: applying Aquaseal

4 Results

4.1 Aquacore

4.1.1 400W/m³

The first experiment was conducted at a power density of 400W/m³, the measurements taken are displayed in Diagram 1. The weight settles after about 90 minutes, no defects were found on visual inspection.

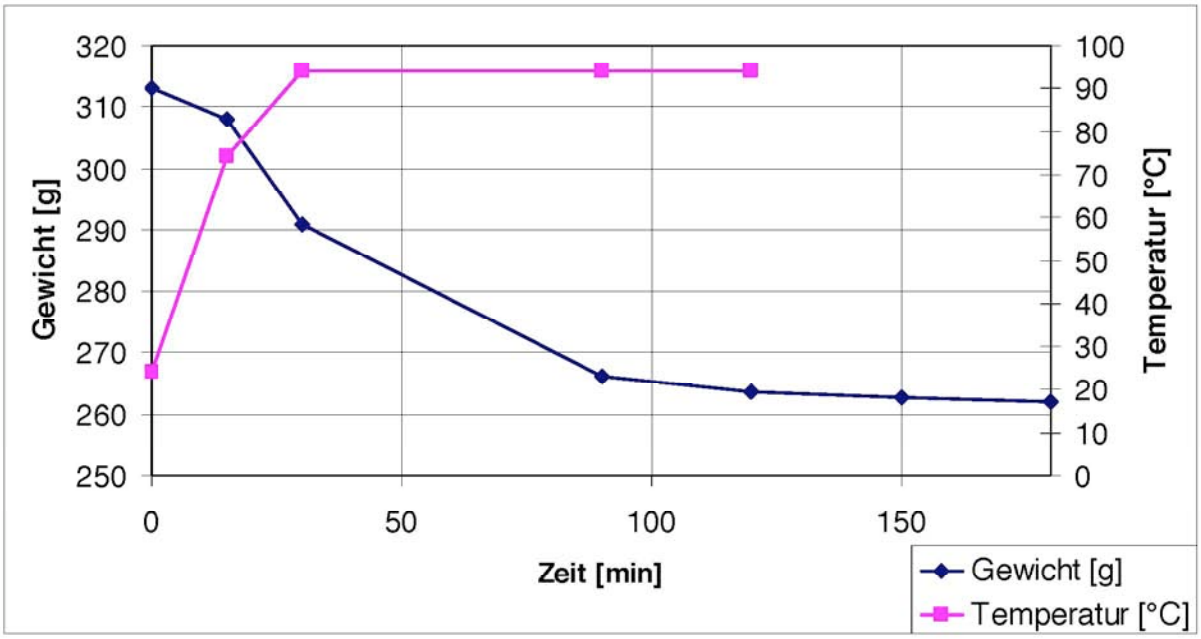


Diagram 1: Aquacore dried at 400W/m³

4.1.2 1000W/m³

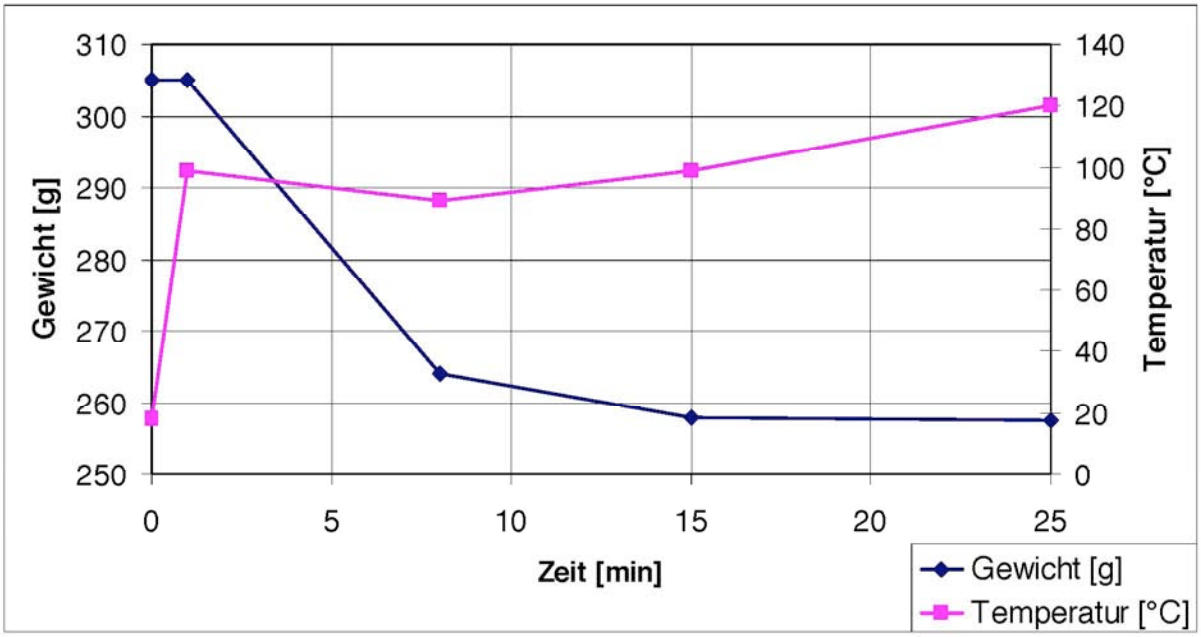


Diagram 2: Aquacore dried at 1000W/m³

At 1000W/m^3 the specimen had completely dried after 15 minutes. Measurements can be found in Diagram 2. No defects could be found on visual inspection.

4.1.3 2000W/m³

The measurements of Aquacore dried at 2000W/m³ can be found in Table 1 as well as Diagram 3. According to these the specimen dried within 7 minutes. The weight decreased exponentially while temperature increases at a rate of 120°C/min up to the boiling point of water and remains at this level for about 4 minutes. As the water content decreases the temperature rises further. Visual inspection reveals no grave defects, only the surface of the supporting plate has left a small imprint in the specimen. The dried specimen can be seen in Fig. 5.

Figure 5: Aquacore specimen at 2000W/m³

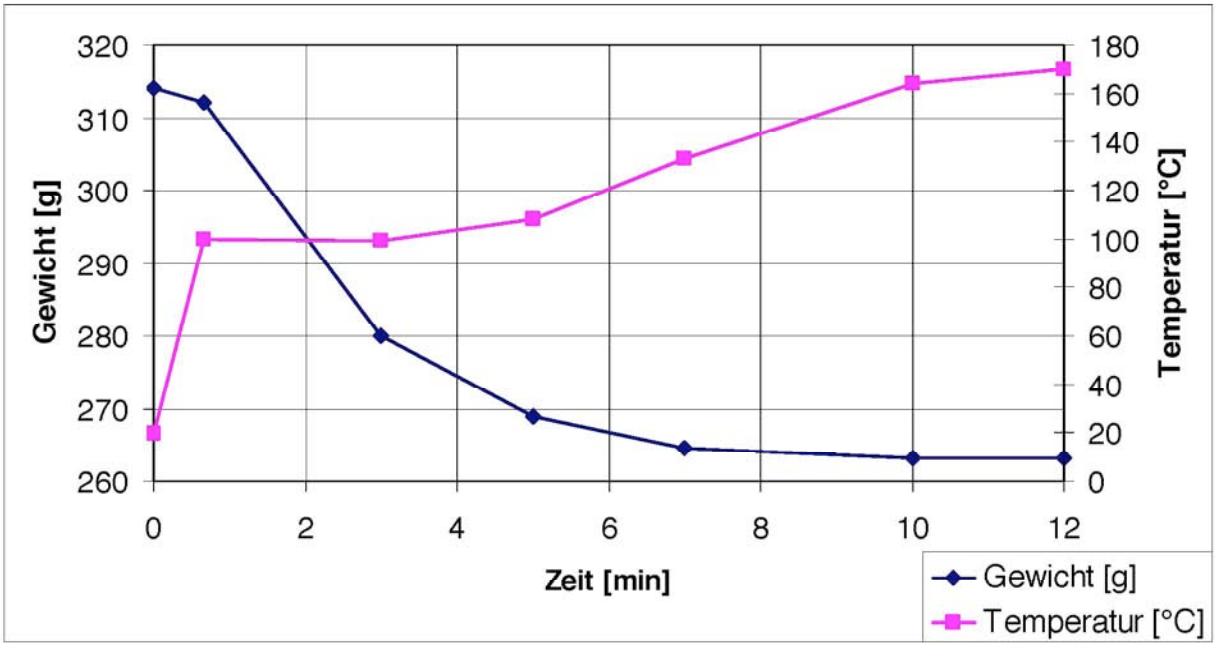


Diagram 3: Aquacore dried at 2000W/m³

Zeit [min]	0	0,66	3	5	7	10	12
Gewicht [g]	314	312	280	269	264	263	263
Temperatur[°C]	20	99	99	108	133	164	172

Tabelle 1: Aquacore dried at 2000 W/m³

4.1.4 Conclusion

Drying of Aquacore can be greatly accelerated by using a microwave oven instead of a conventional following the manufacturer's specifications. Since Aquacore is very porous the generated steam can escape at a sufficient rate.The drying time is presumably limited because of temporary softening in the border regions. This behaviour remains subject to further investigation.

4.2 Aquapour

4.2.1 400W/m³ und 300W/m³

The first experiment with Aquapour is conducted at a power density of 400W/m³. Upon application of microwave energy the temperature rises almost linearly to 79°C within 26 minutes. At that point the specimen is destroyed in an explosion. Its remains can be seen in Fig. 6. Application of 300W/m³ also results in a somewhat less violent destruction of the specimen.

Figure 6: destroyed specimen at 400 W/m³

4.2.2 200W/m³

Safe drying of Aquapour was achieved at 200W/m³. The results of this experiment can be seen in Diagram 4 and Table 2. Measurements indicate that the specimen has completely dried after 180 minutes. Up to that point weight, and consequently water content, decrease linearly. Temperature increases up to the boiling point of water after 45 minutes. 105 minutes into the experiment the temperature starts to decrease again.

Figure 7: destroyed specimen at 300W/m³

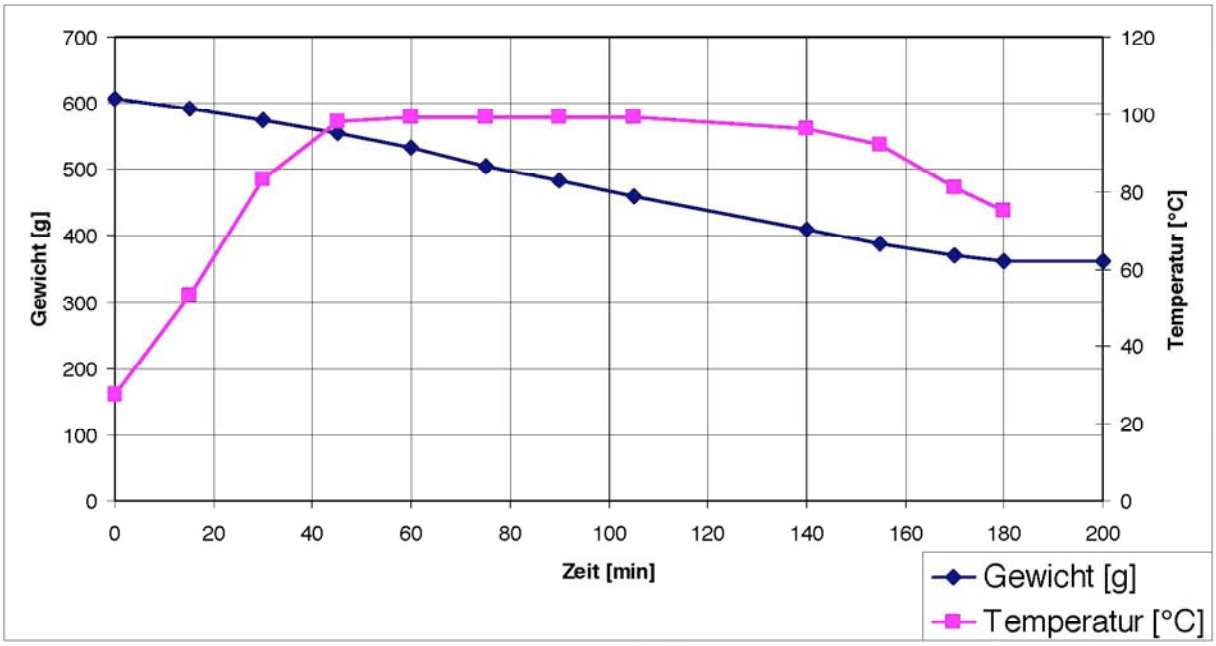


Diagram 4: Aquapour dried at 200W/m³

Zeit [min]	0	15	30	45	60	75	90	105	140	155	170	180	200
Gewicht [g]	607	592	574	555	533	506	483	460	409	388	369	362	362
Temperatur[°C]	27	53	83	98	99	99	99	99	96	92	81	75	

Table 2: Aquapour dried at 200 W/m³

4.2.3 Conclusion

Specifications for Aquapour state a drying time of about 1,5 hours per inch of thickness. These drying speeds can also be achieved using microwave heating.
Drying time is limited by the material's low porosity. Since the developing steam can not escape quickly enough, resulting in an explosion.
It should be noted that the microwave oven used was not designed for drying processes. It is possible that e.g. a different atmosphere inside the cavity could accelerate drying.

4.3 Aquaseal

The drying of Aquaseal using microwave heating was examined at different powers and using different substrates. The results obtained from the experiments can be found in Table 5. The diagram shows that the drying time depends on sealant thickness as well as applied power.
Bad results were obtained only for thick coats and using a power density of 2000W/m³. This experiment resulted in a rough surface interspersed with bubbles as can be seen in Fig. 8.

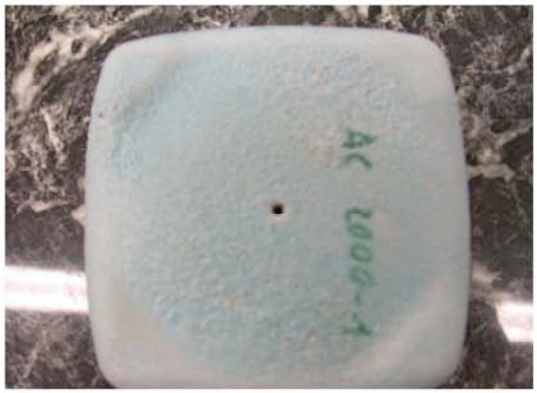


Figure 8: drying at 2000W/m³

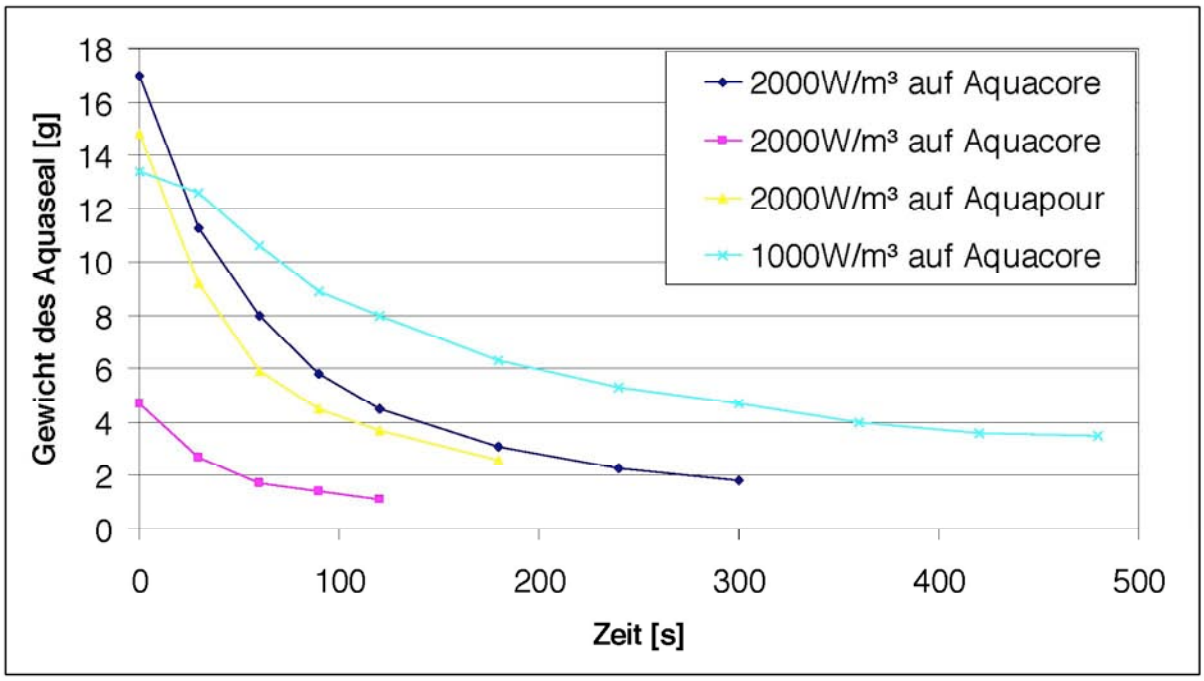


Diagram 5: drying of Aquaseal

4.3.1 Conclusion

The higher the radiated power, the shorter the drying time, as can be seen by comparing the drying process of Aquaseal on Aquacore at 1000W/m³ versus 2000W/m³.
The lower the amount of Aquaseal used, the thinner the layer. Thinner layers result in decreased drying time, although the drying time does not quite decrease at the same rate as the thickness.
Drying time is limited because for thick layers the radiated power has to be reduced, e.g. at 2000W/m³ a 17g coat of Aquacore will blister while 5g of Aquacore will dry at the same power without adverse effect.
A comparison shows that the same amount of releasing agent applied to Aquacore or Aquapour and then dried at the same power level will induce blistering with Aquacore but not with Aquacore. In general Aquaseal will dry slightly quicker on Aquacore.