

**ROHACELL®**  
**“High Performance Foam Cores”**



**Aerospace Seminar**

**Sao Jose dos Campos, Brazil**

**ROHACELL® Products & Application Review**

**September 2, 2009**

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## Presentation Content:



- Evonik Organization (General Overview)
- Sandwich Construction (General Overview)
- Advantages of sandwich structures
- ROHACELL® Production & Products
- Application examples

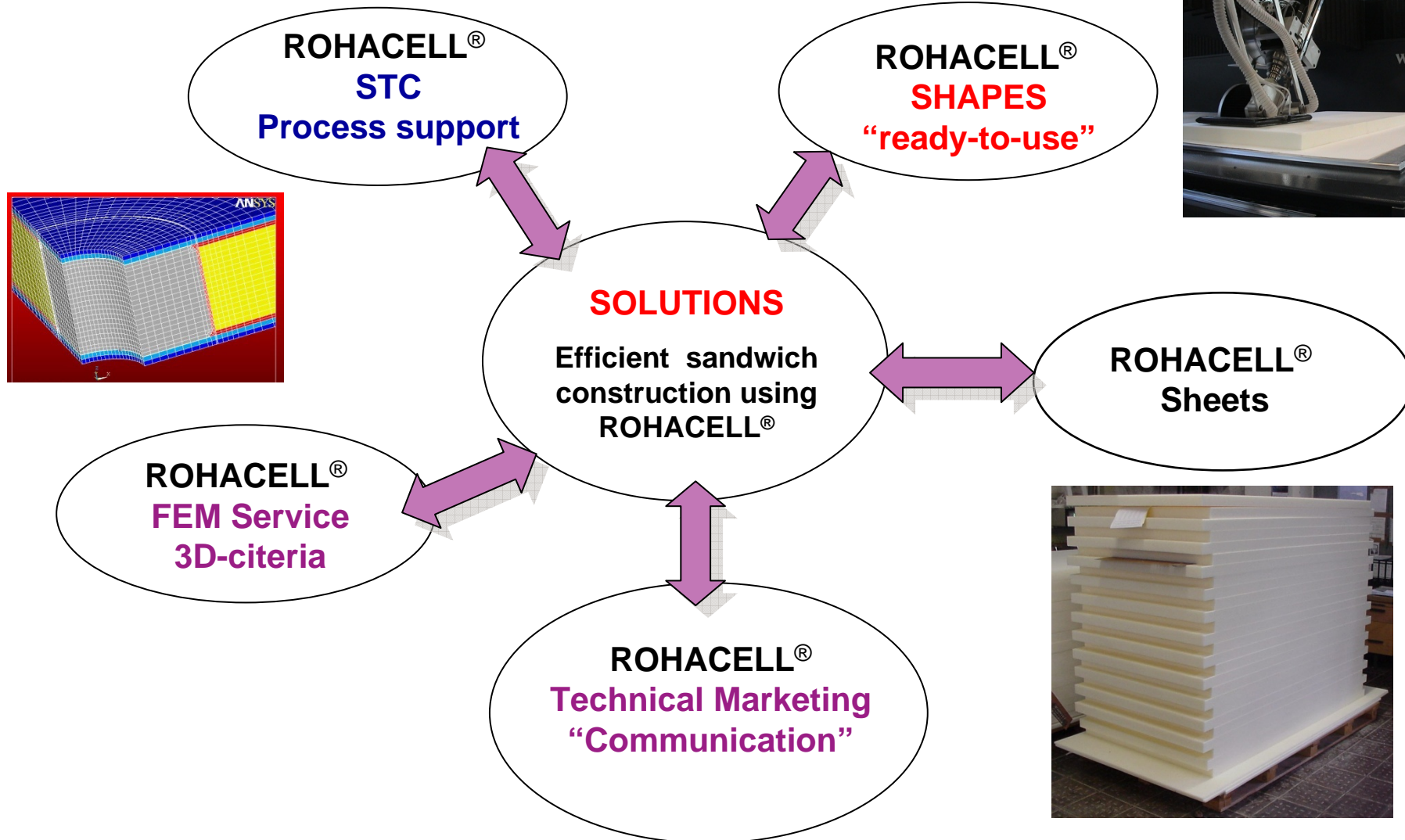
# EVONIK Organization (general overview)



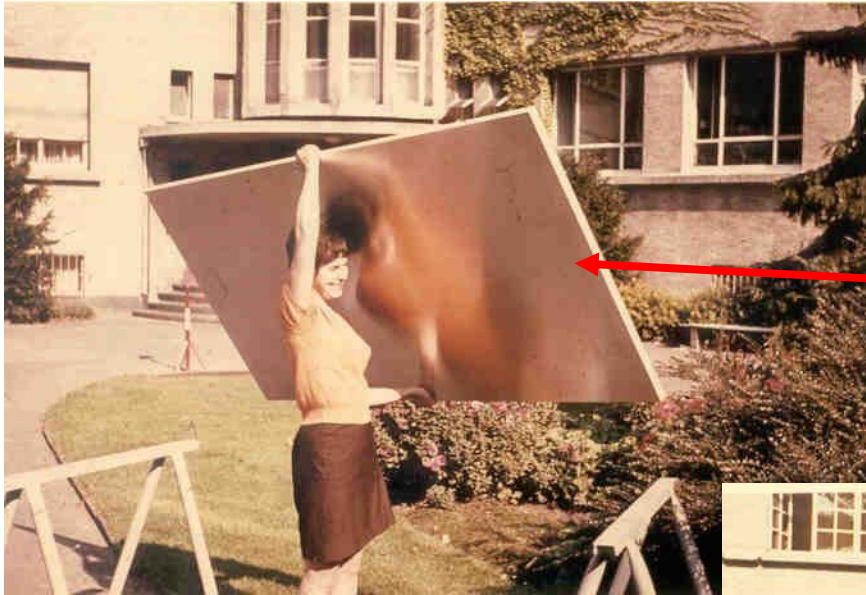
**EVONIK Industries** (43,000 employees, sales of \$21 Billion, 2007)



# Our Objective...to be your PARTNER



# What is a sandwich construction ?



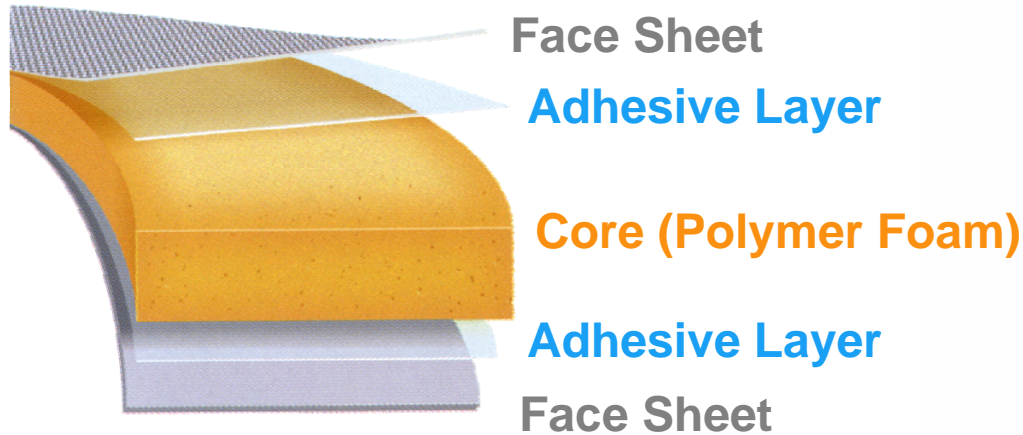
**Light weight**

Pictures taken in 1971 at Röhm

**and stiff**



# Sandwich Construction

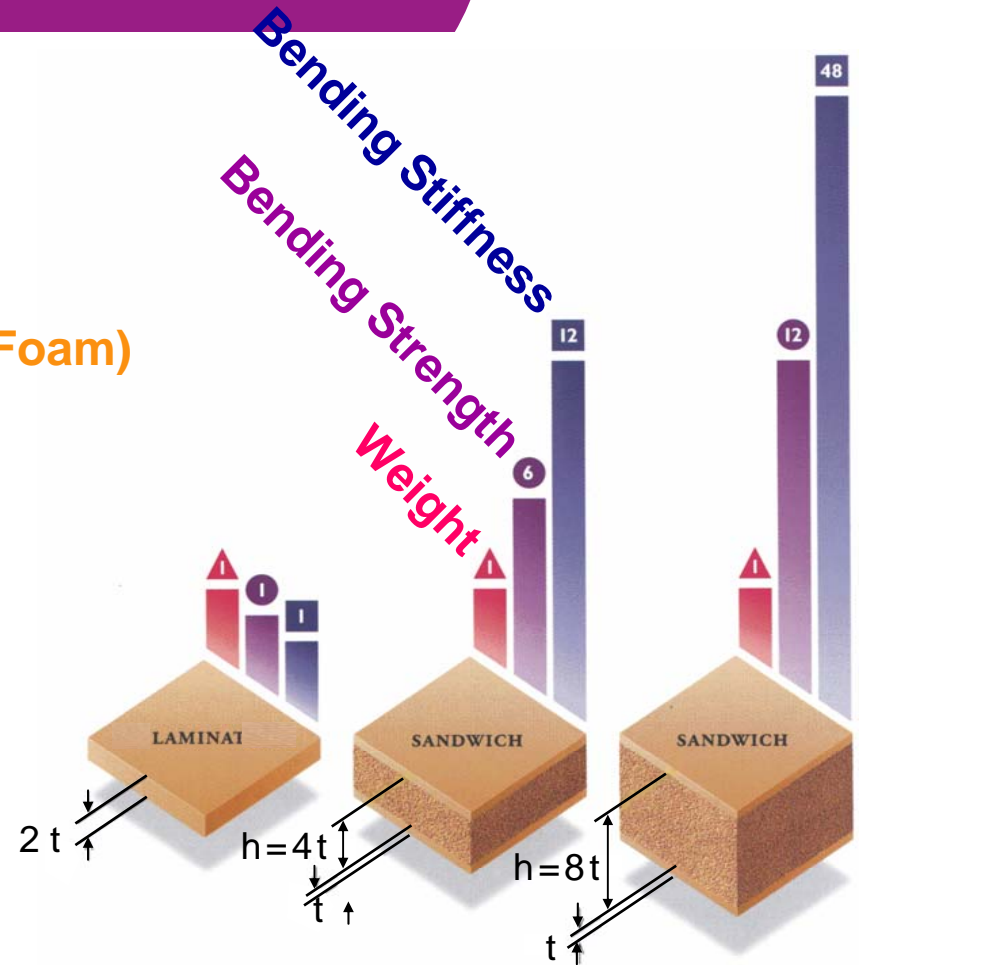


## Face sheet:

Takes in-plane tension and compression

## Core:

separates the face sheets, and takes the shear load





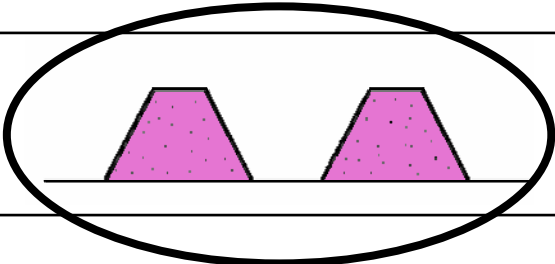
## Max. Bending Stresses

$$\frac{\sigma_{\text{Sandwich}}}{\sigma_{\text{Laminat}}} = \frac{2}{3} \left(\frac{t}{h}\right)$$

## Bending Stiffness

$$\frac{D_{\text{Sandwich}}}{D_{\text{Laminat}}} = \frac{3}{4} \left(\frac{h}{t}\right)^2$$

# Sandwich design (overview)

Design Concept	Sketch	Stiffness	Weight	Effort of Layup	Effort of Assembly
Full Sandwich		++	+	++	++
Skin-Sandwich		+	++	+	0
Profile Stiffened Shell		+	+	0	++

## Legend:

-  ROHACELL®
-  Face Sheet, e. g. CFRP
- ++ Very good
- + Good
- 0 Satisfactory

## Main useful properties from ROHACELL® :

- Easy shaping even with complicated double curved shapes
- Stable core during layout, easy handling.
- 100 % closed cell, different cell size to optimize resin uptake
- Isotropic material behaviour allow efficient FEM analyze
- Outstanding creep compression resistance secure a robust curing process
- ROHACELL® provide the full support, no telegraphing
- Low moisture absorption no freeze damage due to free water, low maintenance cost during the life cycle operation.

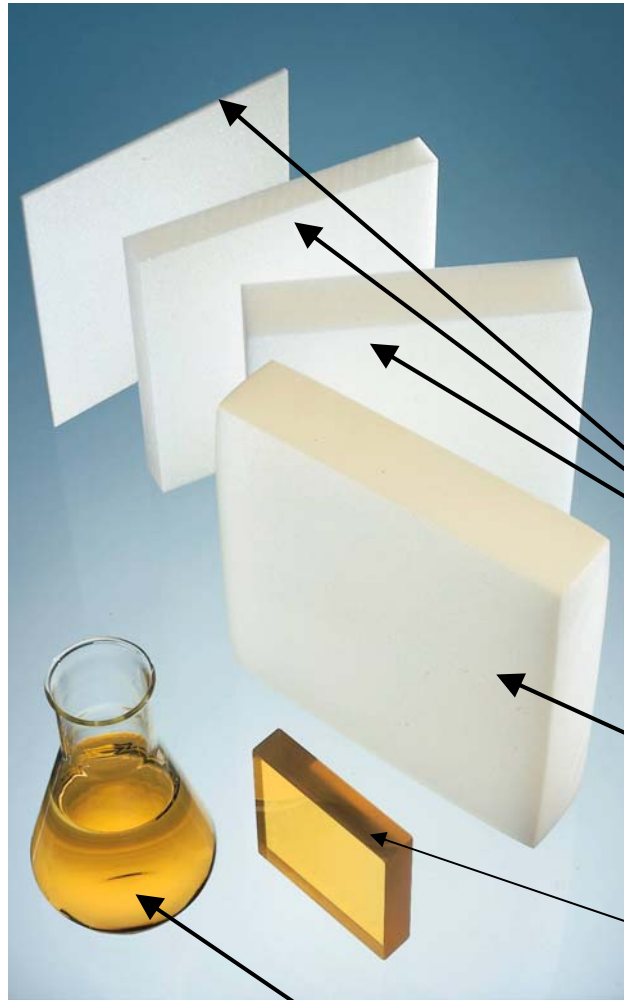
# Advantages of Sandwich Construction



- High Strength to Weight Ratio
- High Bend Stiffness
- Impact robustness (ability to absorb)
- High integral production
- Good Surface Quality
- Good Thermal and Acoustic Insulation/Isolation
- High Degree of Integration of functions



# Polymethacrylimid (PMI) foam ROHACELL® for sandwich core



**1. Liquid Solution**

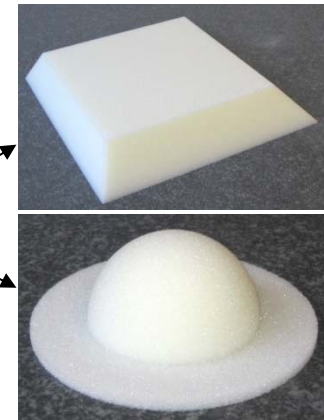
**2. Co-Polymer Sheet = Pre-Product**

**3. Raw Foam Block**

**4. Cut-to-Size Foam Sheets**

**5. Net-shaped cores**

**6. Sandwich (customer)**



# ROHACELL® Product Range



1. ROHACELL® IG      sporting goods, medical, wind turbine blades

2. ROHACELL® A      aircraft applications, curing up to 266°F/45psi

3. ROHACELL® WF      aircraft applications, curing up to 356°F/100psi

4. ROHACELL® XT      extended temperature, curing up to 374°F/100psi  
460°F post cure

5. ROHACELL® RIST      designed for Resin Infusion, Structural application

6. ROHACELL® RIMA      Resin Infusion Minimized resin Absorption

7. ROHACELL® HP      High Performance creep resistance 356°F/ 145 psi

8. ROHACELL® S      good fire behaviour, railcars/ ship/ smaller aircraft

9. ROHACELL® HF      antennas, radomes, medical

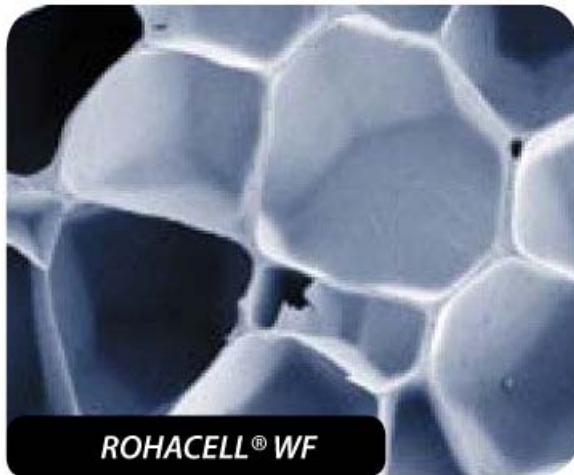
Generally used for Aircraft

# Property Profile of ROHACELL®



- Free of **Chlorofluorocarbons (CFC's)**, halogenes (e.g. bromine)
- Easy to machine/shape, with no special cutting tools required
- Thermoformable
- 100% closed-cell and isotropic
- Compatible with all known resin systems (wet and prepreg)
- High heat distortion temperature, 392°F – 460°F (WF-HT, XT-HT, HP-HT)
- Outstanding strength-to-weight ratio (highest of any other plastic foam of equivalent density)
- Outstanding creep compression resistance
- Certified as burning non-toxic per AIRBUS standard
- Low smoke density when burning
- No release of corrosive emissions when burning
- No freeze issues (closed cell foam) = Not the case for Honeycomb Structures
- Cores available shaped ready to place in your tooling

# ROHACELL® RIST and RIMA designed for Resin Infusion



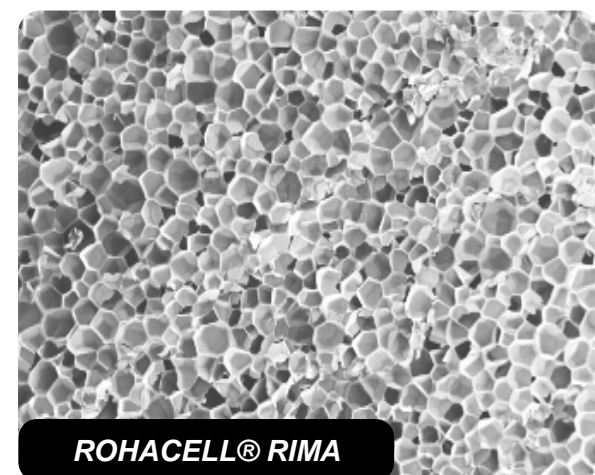
ROHACELL® WF

~500 g/m<sup>2</sup>



ROHACELL® RIST

~250 g/m<sup>2</sup>



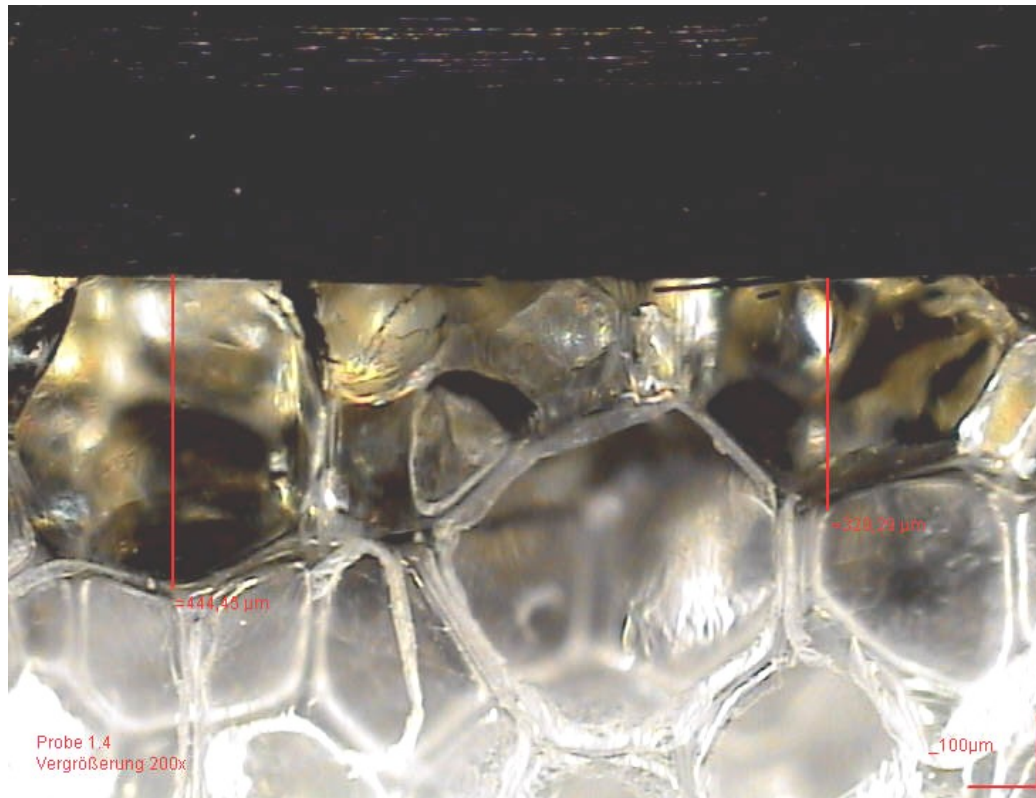
ROHACELL® RIMA

< 100 g/m<sup>2</sup>

Best suited for  
prepregs  
with moderate  
viscosity profile

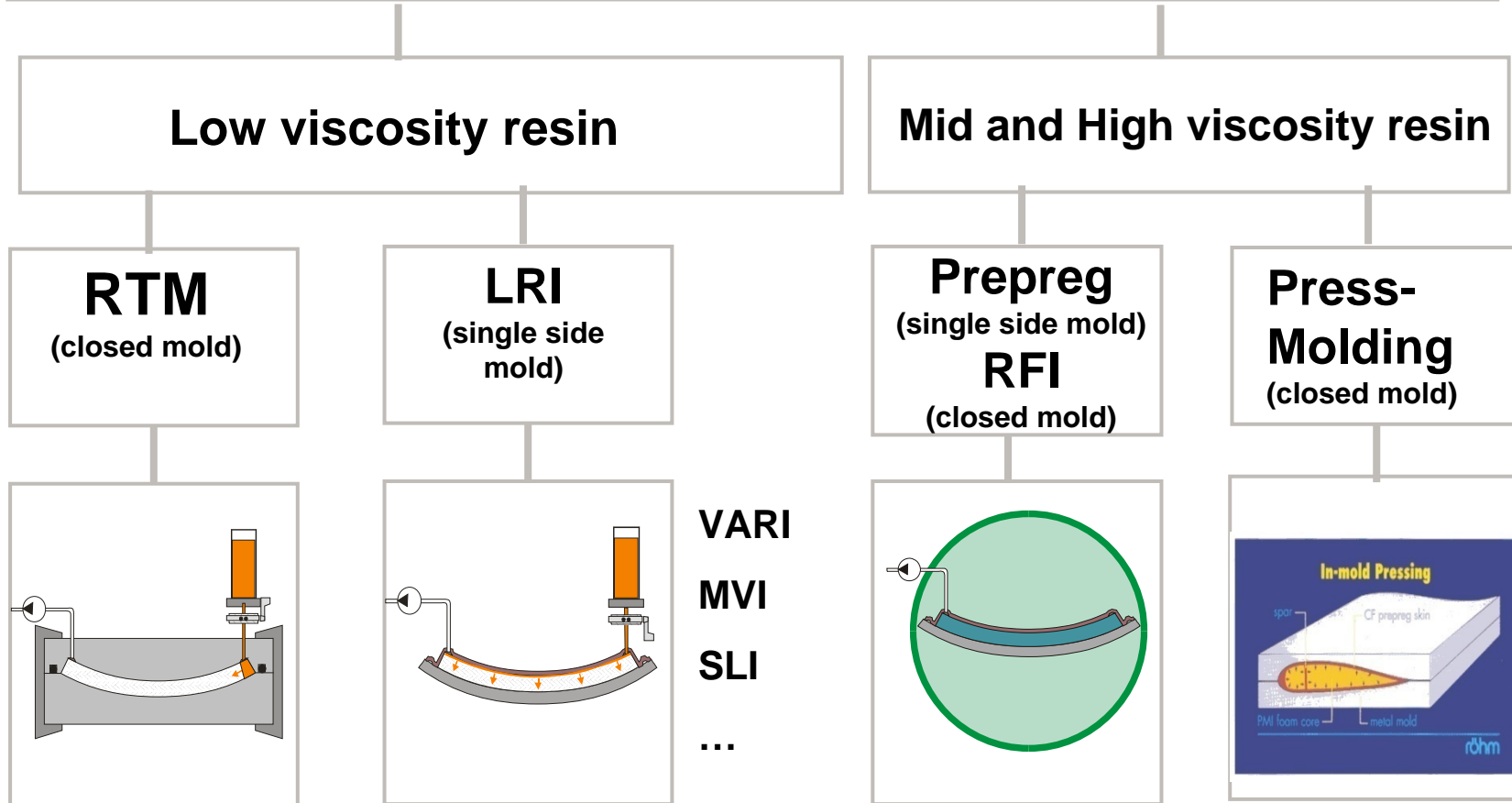
Best suited for prepregs  
with good flow characteristics and  
any kind of infusion process or  
RTM

# Resin infusion of ROHACELL®



**100% closed cell structure, resin absorption only at the surface**

## Main manufacturing processes for aircraft CF-structures



# Processing



Withstands the curing conditions (Temp./Pressure/Time)

e.g. creep diagram 71 WF-HT (see next chart)

## Foam core supports the skins:

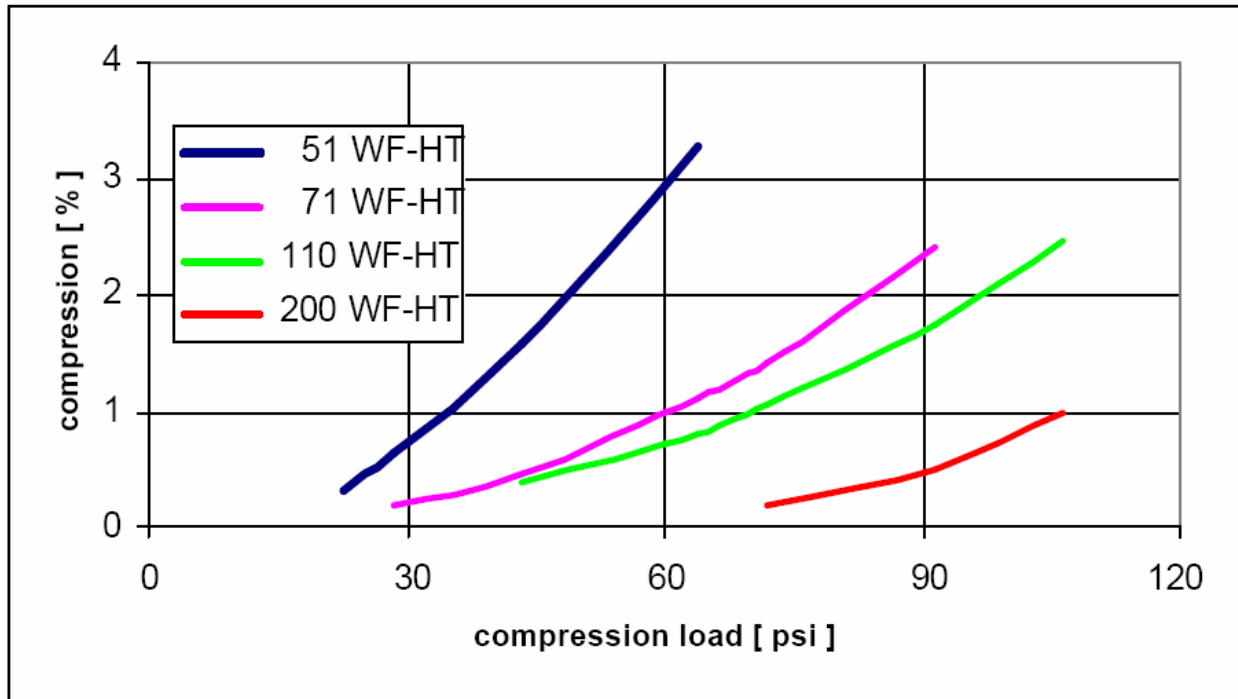
- Shaped core is easy to handle and position (holds shape)
- less bridging/skin wrinkling during lay-up & debulk associated with under core movement common to Honeycomb lay-ups
- No lateral compression
- Will not absorb resin (100% closed cell)
- Core is stable, can be used as a gage for post assembly of inserts and other parts...



# Understanding Compressive Creep



**ROHACELL® WF-HT Specimens: 50 x 50 x 25mm**  
**Dried 260F for 2h, Heat-treated 374F for 48h**  
**Test conditions: 356F for 2h**





# ROHACELL®

## Resistance to Compression Example



**Total support for the full consolidation of the skins**

### **Conditions:**

**ROHACELL density: 51 kg/m<sup>3</sup>**

**Cure temperature: 356F**

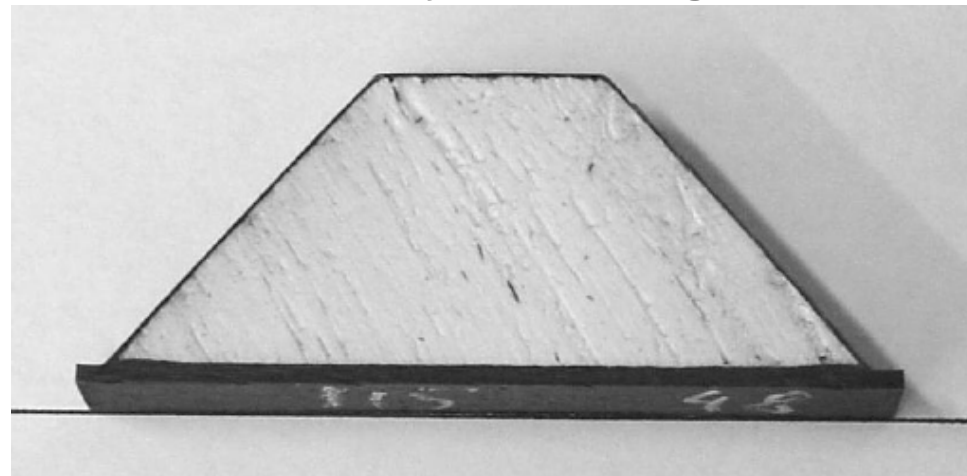
**Cure Pressure: 100 psi**

**Vacuum: Full**

**Thin caul sheet on flat surface**

**Cure duration: 2 hours**

### **Geometry: Hat Stringer**



### **Result:**

**Maximum deflection measured: 0.002"**

**Compression Creep (%): 0.15**

**Crisp...well consolidated corners**

**No lateral compression**

# Damage: Service/Repair



**A340-500/600**  
STRUCTURAL REPAIR MANUAL

## Honeycomb Repair Using ROHACELL® Example:

AIRBUS Structural Repair Manual 51-77-13

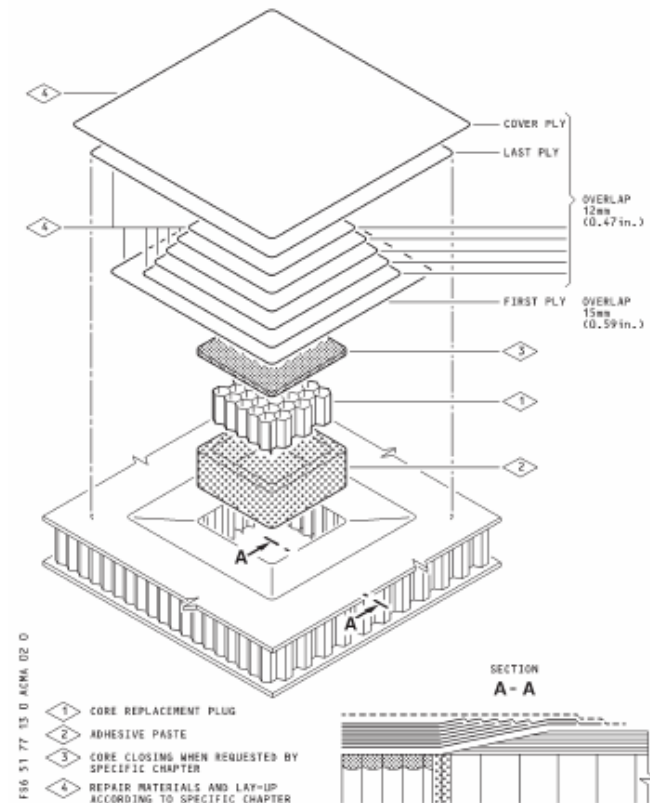
### Why a ROHACELL® foam repair?

ROHACELL's closed cells and high mechanical stability offers a fast, weight efficient and reliable repair option.

Other recognized companies using ROHACELL® for Repairs...

McDonnell Douglas/Boeing  
Alliant Techsystems (ATK)  
Northrop Grumman  
Cessna Aircraft Company  
Others...

REPAIR OF COMPOSITE AND METALLIC SANDWICH STRUCTURES



Wet Lay-Up Repair - one skin damaged  
Option A (applicable if skin thickness >1mm (0.04in.))  
Figure 2 (sheet 1)

# Non-Destructive Testing (NDT)



## Sandwich Structure (all core types) Failure Modes

- Skin/laminate
- Core (foam and/or honeycomb)
- Bonding

**NDT** = Depends on the structure, accessibility and what kind of failure...but one or more of the following methods can be used:

- Ultrasonic (C-scan)
- X-ray
- Shearography (thermal, vacuum)
- (Coin) Tap test

...

More detailed information is available

# Shaping ROHACELL® (general overview)

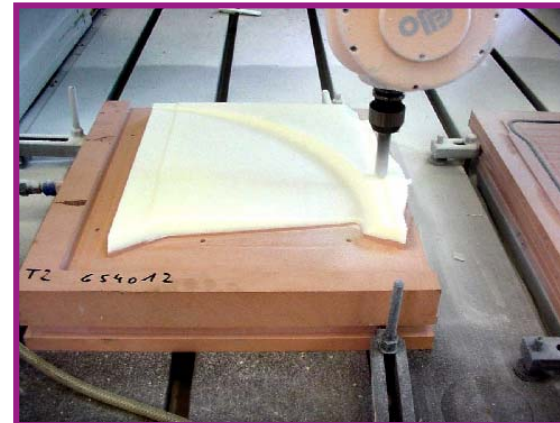


- **ROHACELL® must be dried prior to shaping**
- **No cutting/cooling liquids are to be used**
- **Common high-speed steel and carbide cutters work well**
- **Remove dust during the machining operation**
- **Spindle speed: 18,000 RPM (generally speaking)**
- **Recommended feed rate: (straight line cut 1/2" deep) 300-400 in/min**

# ROHACELL Shapes...cont...



**SRB - Exterior profile**



**CNC Cutting / Vacuum fixture**

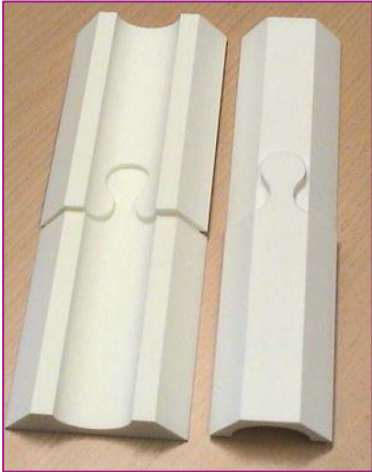


**SRB - Interior profile**



**High speed routing**

# ROHACELL® Specialty Shapes



**Mortise & Tenon Joint**



**Leading edge "HAT", CNC & Formed**



**Hat Stringer**



**Wing-to-body transition**



**Winglet**

# Thermoforming ROHACELL® (general overview)



- ROHACELL® must be dried prior to thermoforming
- ROHACELL® must be insulated during the transfer from the heat source to the forming tool. (unless formed in the oven)
- Optimum through thickness temperature must be obtained prior to forming. (reference Temperature Guidelines on Data CD)
- Heat-up rate: 1 minute per millimeter thickness – Plus 20-30 minutes

Reference Evonik “Thermoforming Guideline” as well as “Drying and Heat-treating Procedural Documents prior to thermoforming.

# Thermoforming



- ◆ Gulfstream IV radome
  - sitting on top of vertical stabilizer



**thermoformed core of ROHACELL 71 A**  
**assembly of 3 formed core segments**  
**skins : epoxy / glass (VARTM)**



# Thermoforming Video



# Pressure bulkhead applications:

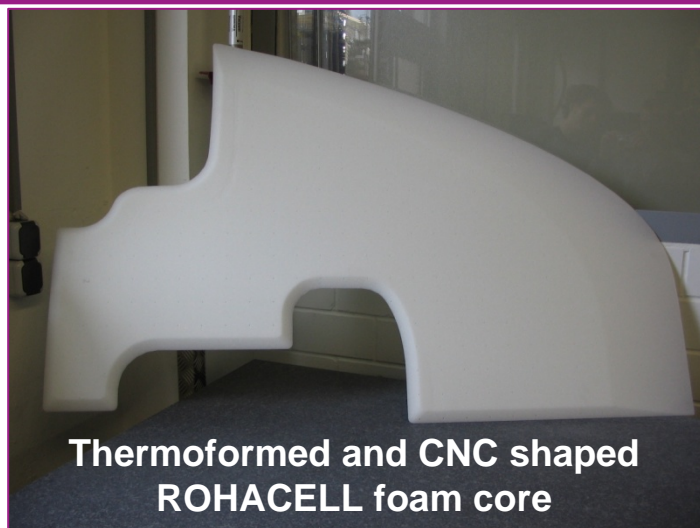


- A330/340 shell and stiffener 71 WF-HT cured in one step (prepreg autoclave), A380 two step production
- Used as mandrel, high creep resistance
- Manufacturing : 350°F / 45psi / 2hrs



By courtesy of AIRBUS Deutschland GmbH

# G150 Belly fairing LRI / ROHACELL<sup>®</sup> 71 RIST



Thermoformed and CNC shaped  
ROHACELL foam core



ROHACELL foam core plus  
stitched-on CF-fabric



infusion



Fairing mounted to aircraft

# Aircraft Flaps



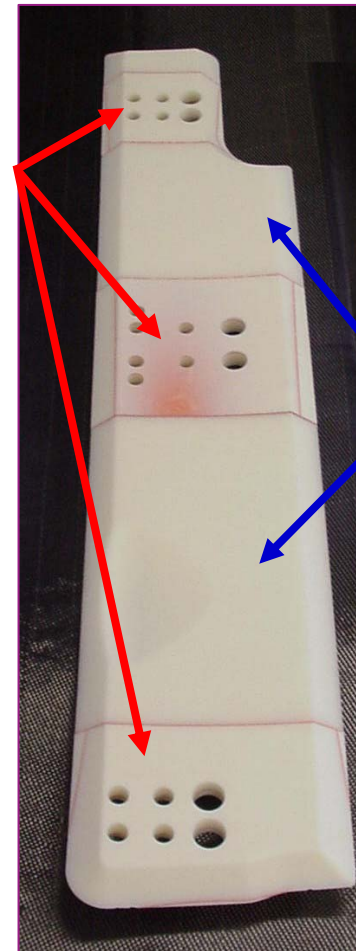
- ROHACELL® 110WF & 200WF**
- Thermoformed
  - CNC-machined
  - Vacuum Bagged
  - Autoclave Cure 350F @ 50psi

# Nose Landing Gear Door



200WF

71WF



- ROHACELL® : RC 71WF/200WF
- Density optimization for added benefit
- Production method : SLI



## Flap Vanes

- ROHACELL® : 71 WF
- Production method : autoclave
- Curing Conditions : 250°F, 2h

## Inlet-Duct = Parallel Hat Stiffeners

- ROHACELL® : 51 WF-HT
- Production method : autoclave
- Curing Conditions : 350°F, 45 psi, 2h

## Miscellaneous, discussion



For further ROHACELL® information please contact:

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**Thank you for your attention!**

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