

# Business Line of High Performance Polymers Evonik Degussa

## Evonik Polymers for the Aerospace Market

Painel 2009 Aeroespacial – Sao Jose DOS CAMPOS  
02 September 2009

**Lisa Mueller**

**HPP – Americas**

02 September 2009



**EVONIK**  
INDUSTRIES

# Evonik Industries



Evonik is the creative industrial group from Germany active in over 100 countries throughout the world.

## Active in three Business Areas

Workforce: 43,000 employees\*

Turn-Over: € 14.4 billion\*



Workforce: 34,000 employees\*

Turn-Over: €10.8 billion\*

**Chemicals**



Workforce: 4,600 employees\*

Turn-Over: €2.8 billion\*

**Energy**



Workforce: 500 employees\*

Turn-Over: €0.4 billion\*

**Real Estate**

Evonik's aim is to be an industrial group with sustained, above-average innovations in all of its business activities.

\* figures 2007

# Group Structure Chemicals



Chemicals

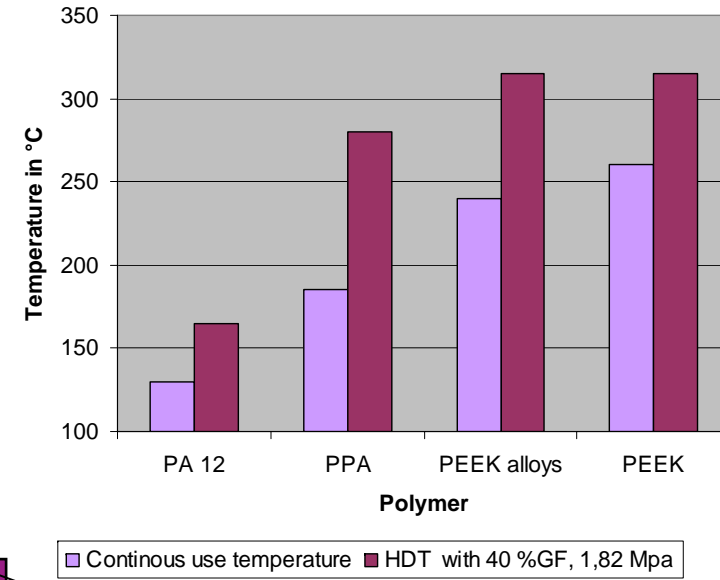
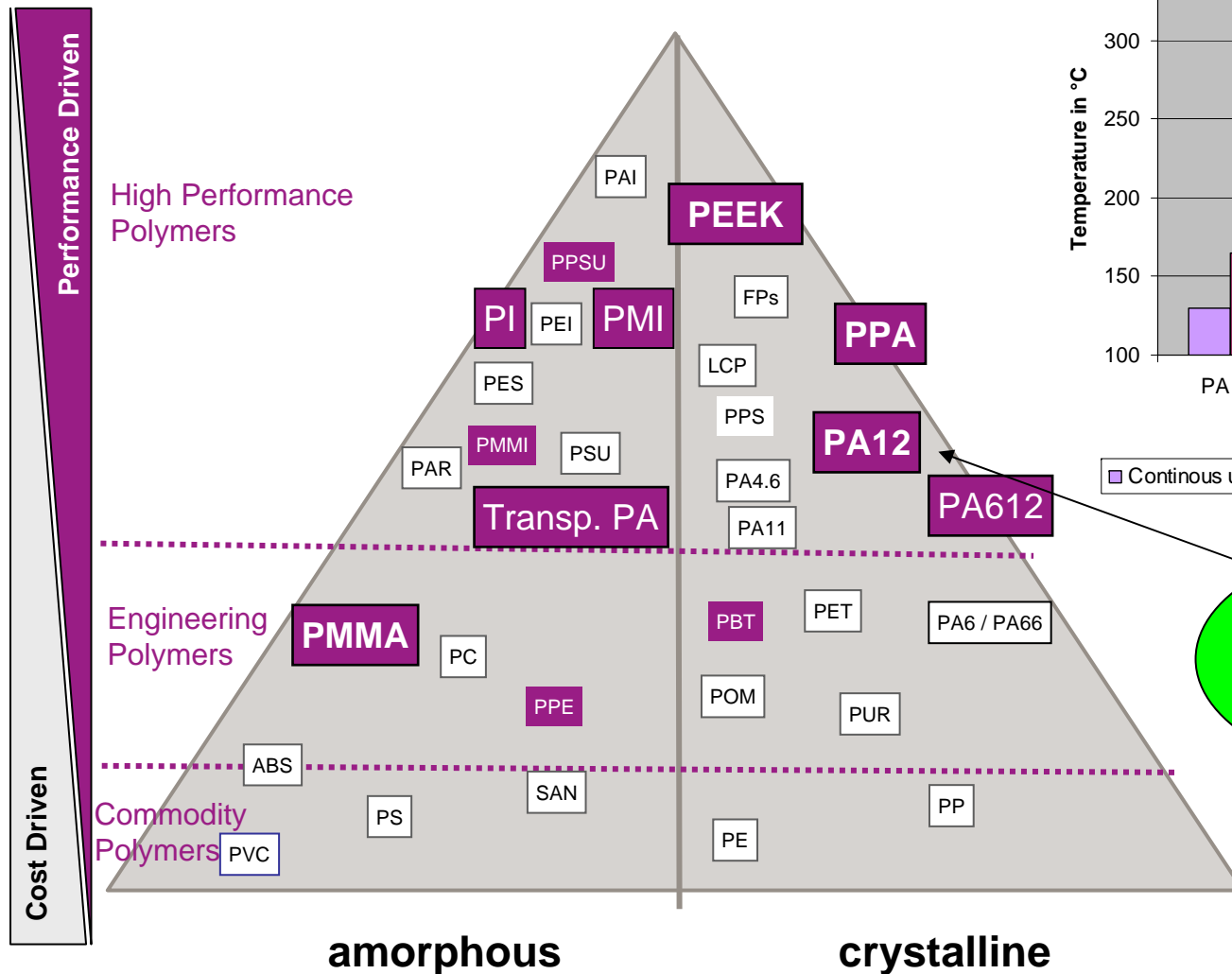
**Performance Polymers**



High  
Performance Polymers

Methacrylates

# Evonik's portfolio of High Performance Polymers



**New PA 12 Biopolymers**

■ = Polymer activities of Evonik

# Evonik R&D – Extending technology leadership



## High Performance Polymers:

- Over 120+ R&D Staff (2,300 Evonik)
- Evonik spends € 360+ M on R&D

- Full scale polymer development, characterization & raw material optimization
- State of the art injection & compression molding equipment – Component development
- Tube extrusion lines, Long history with PA 12 Composites
- Film & sheet extrusion lines
- Rapid prototyping/ SLS – PA12 & VESTAKEEP PEEK
- Laser laboratory
- Part development & prototyping
- Project Houses
- 20,000+ patents, 7,500 + trademarks (Evonik in total)
- 300+ global partnerships with Universities and Institutions
- 35 global R&D Centers

# Markets



Custom-made, high-efficient products, systems and semi-finished products for.....



Automotive  
& Vehicle  
Construction



Lifestyle



Sports &  
Leisure



Aerospace &  
Rail & Marine



Machinery &  
Apparatus



Optics



Asphalt  
Mixing



Medical  
Technology



Chemical  
Industry



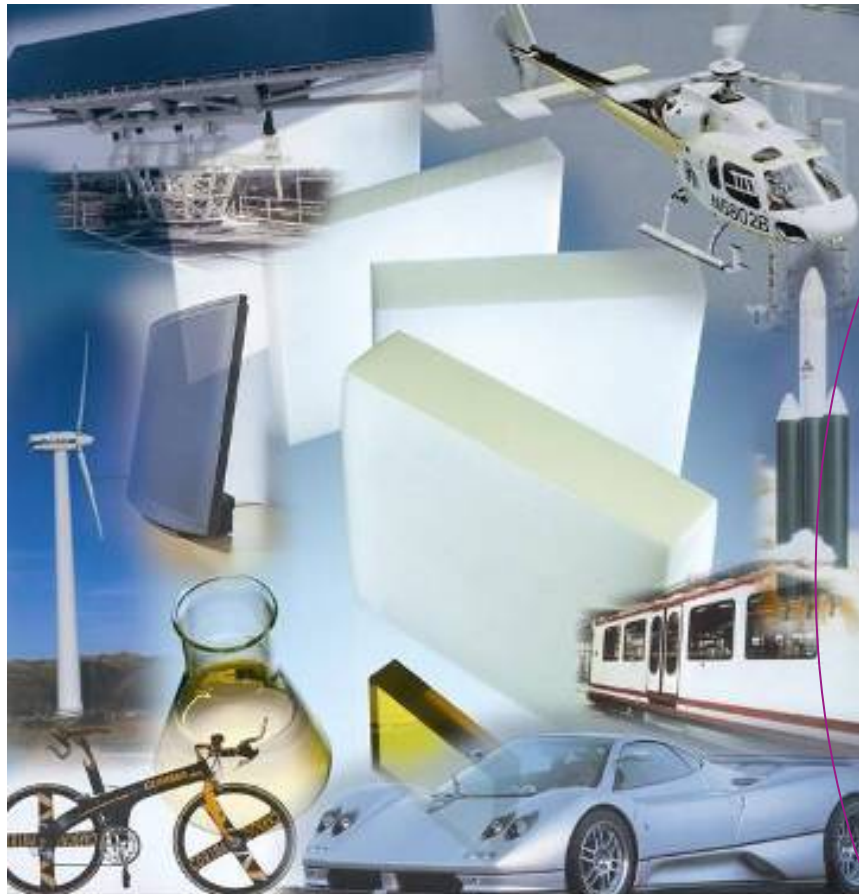
Electrical  
Engineering &  
Communications



Construction  
Industry

.....based on our High-Performance Polymers

# Evonik Aerospace Competency:



**ROHACELL®**

Rigid PMI-Foam  
- Composite Cores

**SOLIMIDE®**

Polyimide Foam  
- Fire/ Insulation Blankets

**COMPIMIDE®  
VESTAMIN® IPD**

Bismaleimide Resin (BMI)  
- Epoxy Composites/  
Crosslinker

**EUROPLEX® PPSU  
PC Sheet**

Flame Resistant Sheets &  
Films  
- Aircraft Interiors

**P84®**

PI Powder  
- Carbon Fibers

**VESTAMID®**

PA12 Pellets & Powder  
- Boeing 787 Infill & Cable  
Ducts  
- RAPID PROTOTYPING/ SLS

**VESTAKEEP®**

PEEK Pellets and Powder  
- Thermoplastic Composites

**VESTAMID®**

**X7167 PA 12**

**- Aircraft Interior Profiles**



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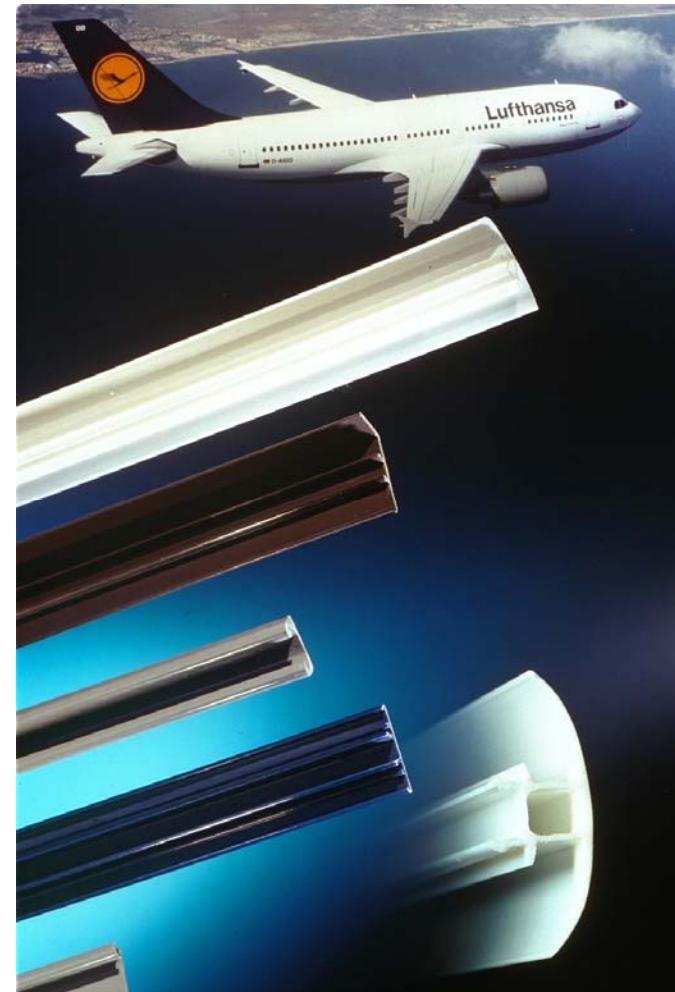


# Why VESTAMID<sup>®</sup> PA12 X7167



## Weight Savings for Aircraft Interiors

- X7167 was developed to replace traditional phenolic based systems for interior aircraft, rail and ships.
- Due to the low density, 1.05 g/ cm<sup>3</sup> density = weight savings by >50% versus the traditional material system
- X7167 – heat stabilized PA12 compound
- Non-migrating, flame retardant
- No Halogens or Phosphorus
- Color Compounded to match decor



# VESTAMID® PA12 X7167 Aerospace Applications & Approvals



## X7167 Meets

**FAR 25.853**

**ATS 1000.001**

**ABD0031 Low Toxicity**

- Approved by Airbus and Boeing
- Self-extinguishing V2 1,6 mm acc. UL 94
- LOI > 32, low smoke, E-Module appr. 1700 MPa
- Good processing, high viscosity cable ducts in aerospace applications – melt temp 210-230C



**EUROPLEX®**

**Extruded Aircraft  
Sheet**



**EVONIK**  
INDUSTRIES

# EUROPLEX® PPSU and PC Flame Retardent Sheet Material



**EUROPLEX PPSU & PC available in Clear, Opaque, Transparent and with Effects**

**Evonik PPSU meets FAR 25 and ABD0031**

The FAA has issued stringent regulations covering materials for use in commercial aircraft interiors – EUROPLEX PPSU meets ALL.



# EUROPLEX PPSU Opaque/ Colors/ Transparent



- First real „transparent“ flame retardant sheet material for large cabin interior parts 0.5mm to 5mm thickness
- Base Resin RADEL R-7000 TR ( Solvay ) Qualified at Airbus
- High Heat Resistance
- Outstanding Impact and Chemical Resistance
- Excellent Flame Behavior
- Meets all FAR Requirements
- Meets all Toxicity Requirements ( ABD 0031 )
- Meets Heat Release Test ( OSU test )
- Different transparent colors and effects possible, including functional surfaces ( KR / DF )
- Process Temperature – 275C

# EUROPLEX PPSU Applications



- Door and Door Frames ( EADS, Fokker )
- Monitor Housing & Oxygen Bottle holster ( EADS )
- Restroom Floor ( Fokker )
- Shower Cub ( Singapore Airlines )
- Large Seat Linings ( First / Business Class seats )
- Instrument Panels / Cockpit
- Other Large Interior Parts, also Structural ( BAe, BE Aerospace )
- Transparent Stairways, Ceilings / Roof Elements
- Large Cabin Dividers
- 1<sup>st</sup> Class Lounges

# EUROPLEX PPSU – FST Stats



## Toxic Gas Emissions, ppm at 4 minutes, flaming

Toxic gas	Specification Limits		Radel
	BMS	ATS 1000.001	R-7700
Carbon Monoxide	500	3,500	40
Hydrogen Cyanide	60	150	<2
Nitrous Gases	60	100	<1
Sulfur Oxides	30	100	3
Hydrogen Chloride	60	500	<1
Hydrogen Fluoride	60	50	<1

## Heat Release Test Ohio State University

	Heat Release		
	FAA Requirements <sup>1</sup>	Radel R-7700 <sup>2</sup>	Units
2 minutes	65	<20	kw-min/m <sup>2</sup>
Peak Rate	65	<55	kw/m <sup>2</sup>

<sup>1</sup> Per 14CFR PART 25.853 Appendix F

<sup>2</sup> Sheet thicknesses of 0.060 - 0.125 inches (1.5 - 3.0 millimeters)

## Smoke Density Test for Aerospace Applications ASTM F-814 - Flaming Mode

Measurement	Radel R-7700	FAA/Industry Requirements
D <sub>s</sub> @ 1.5 minutes	1	
D <sub>m</sub> @ 4.0 minutes	3	200

D<sub>s</sub> - specific optical density

D<sub>m</sub> - maximum specific optical density

# VESTAKEEP®

Polyether ether ketone - PEEK



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# Evonik – established over 40 years in specialty polymers

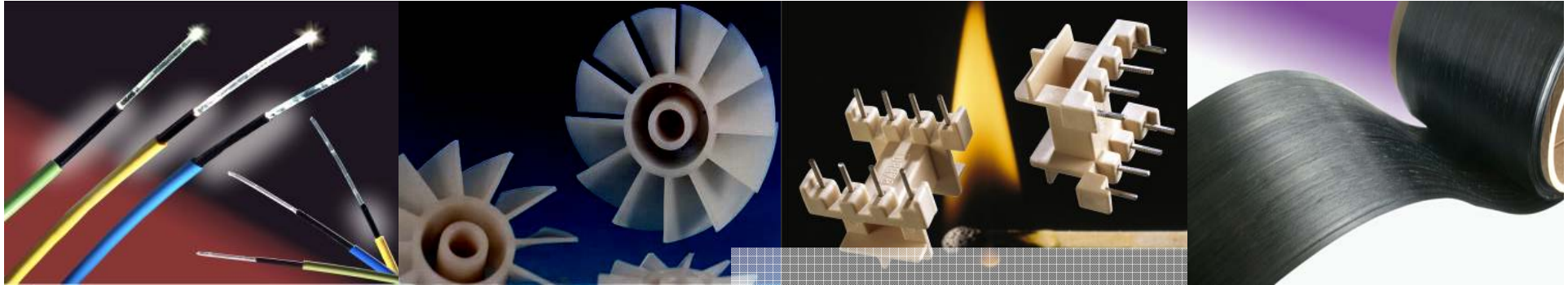


- Polyether ether ketone, manufactured in Changchun, China

No longer a monopoly market.... Evonik offers dedicated Application Development & Support and Proprietary Blends:

- Variety of Reinforced and Unreinforced Pellet Grades & Viscosities:
  - Injection & Compression Molding, Extrusion & Stock Shape Profiles
  - Flexible Grades in development
  - Powders for Thermoplastic Composites, Compounders & Coatings
  - ESD/ Conductive and Specialty Blends
  - Thin Films

# VESTAKEEP® Polyether ether ketone - why would you choose this polymer?



## Advantages:

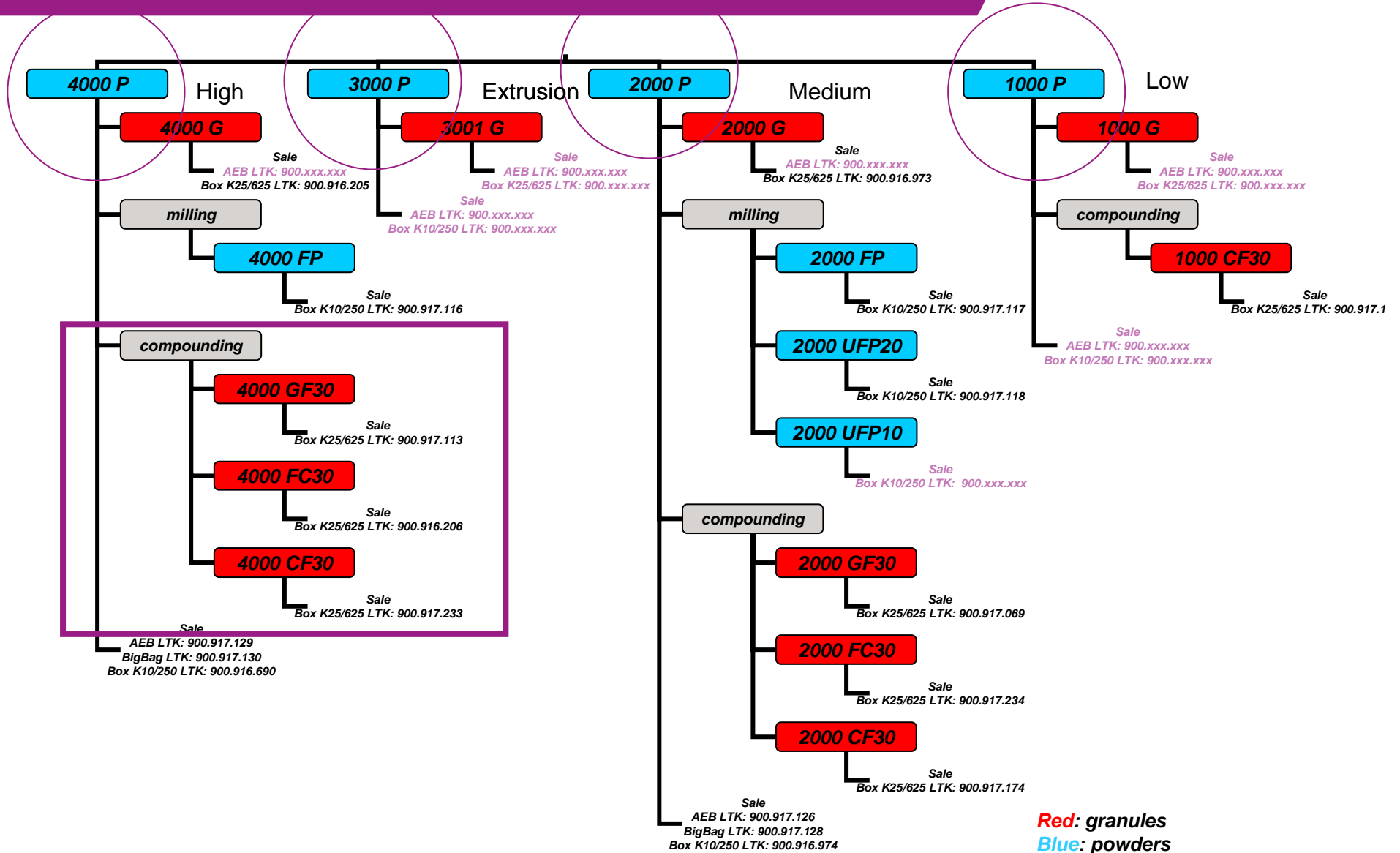
- Exceptional wear and friction properties
- Inherent flame retardant
- FST - Low Smoke Density & no toxic gas
- High Strength & Flexibility
- Excellent Temperature Resistance
- Mechanical strength at elevated temps up to 250°C
- Excellent chemical resistance & corrosion protection
- Films also available

Excellent material for metal replacement – tight tolerances possible

## Typical applications:

- Surface Mounted Devices, Structural Parts
- **Flexible Circuit Boards – New from Evonik**
- Electronic Parts requiring both heat and abrasion resistance
- Semiconductor applications
- Cable Sheathings, Convoluted tubing, flexible grades
- Aircraft Components
- Medical Devices and Biocompatible parts
- Automotive - Gaskets, Gears in transmission
- Oil & Gas - pump parts, shoe pads

# Your VESTAKEEP grades



# VESTAKEEP® Typical Aircraft Applications



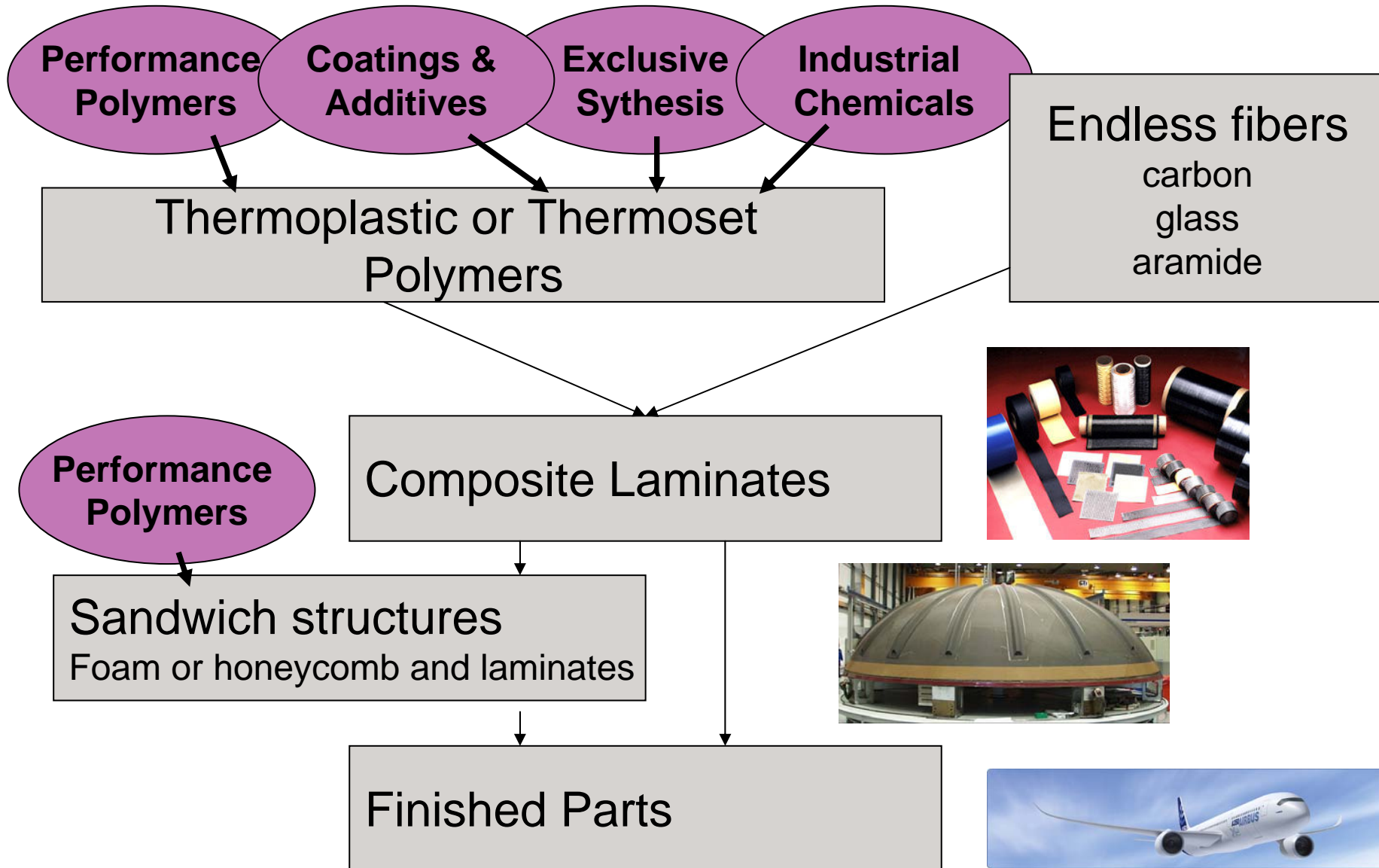
- Fuel, Engine and Wing System Components
- Composite Prepregs – Tapes, Fabrics & Laminates
- Interior components: hinges & cockpits
- Wall Systems
- Clamping Systems
- Screws
- Isolators
- Metal replacement initiatives

# Evonik's High Performance Polymers Competences in Composites



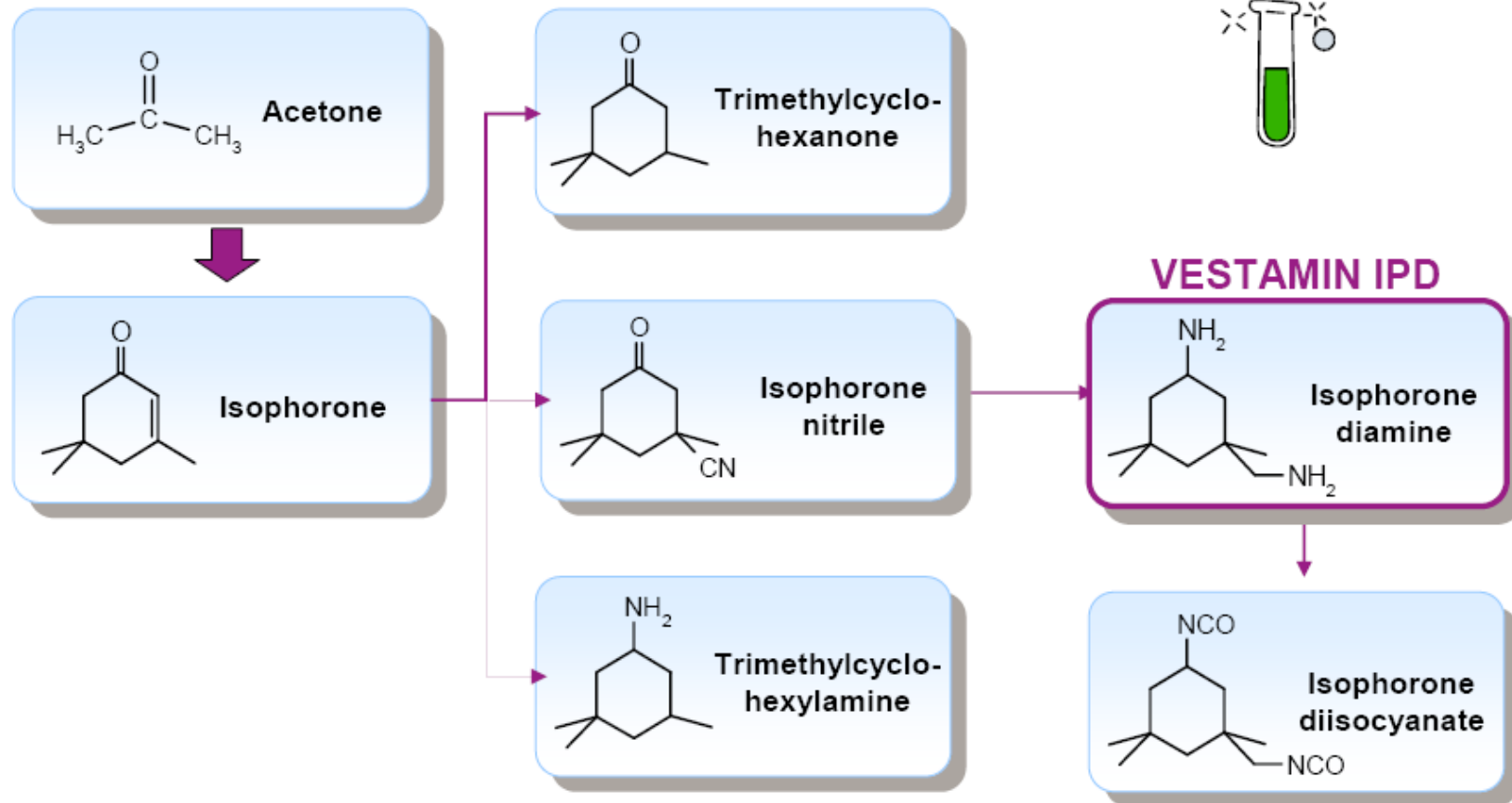
**EVONIK**  
INDUSTRIES

# Evonik Products in the Composite Market



# Coatings & Additives

## VESTAMIN IPD



Hardener for thermoset resins

# Exclusive Synthesis The COMPIMIDE Portfolio



**BMI-Monomers**

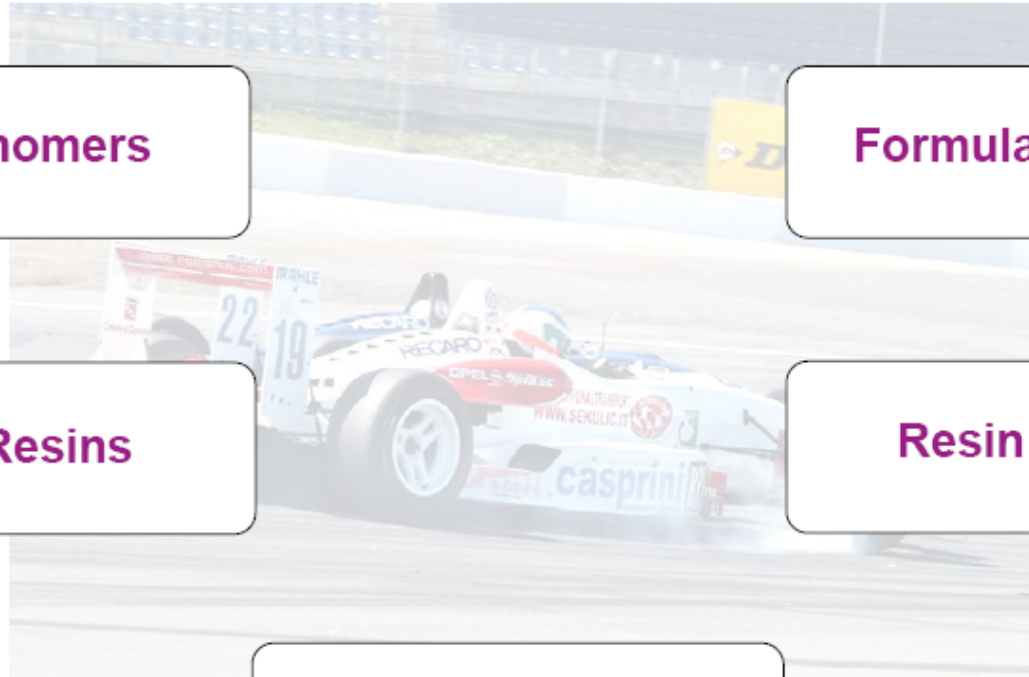
**Co-Monomers**

**Formulated Resins**

**RTM-Resins**

**Resin Powders**

**Resin Solutions**



High temperature Bismaleimide resin family (BMI) for composite laminates



# Industrial Chemicals

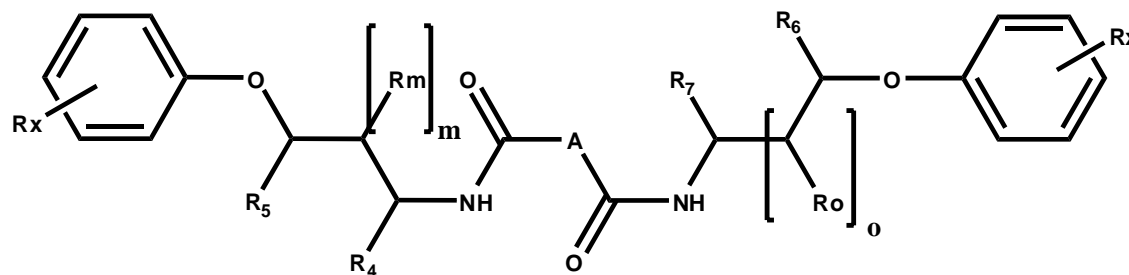
## A new resin for high performance composites



### CALIDUR®

polyether amide resin with  
exceptional performance:

- **CALor** = high temp stability, high Tg
- **Dur** = high strength and toughness





**Thermoplastic Composites with  
VESTAKEEP PEEK for Aircraft**



**EVONIK**  
INDUSTRIES

# The Main Target for Evonik's Composite Project



## Target:

- to develop tape and fabric composites with VESTAKEEP PEEK
- to do this development with partners in the composite market
- to qualify these composites at all Aircraft OEM's

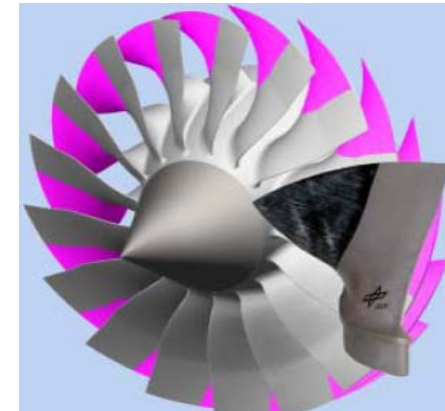
# VESTAKEEP® Composite Current Status



- Non exclusive partnership with for the development of thermoplastic composite tapes, fabrics and prepregs:

Applications:

- Secondary Structures
- Jet Turbine Blades
- Leading Edge Wing
- Aircraft Interiors



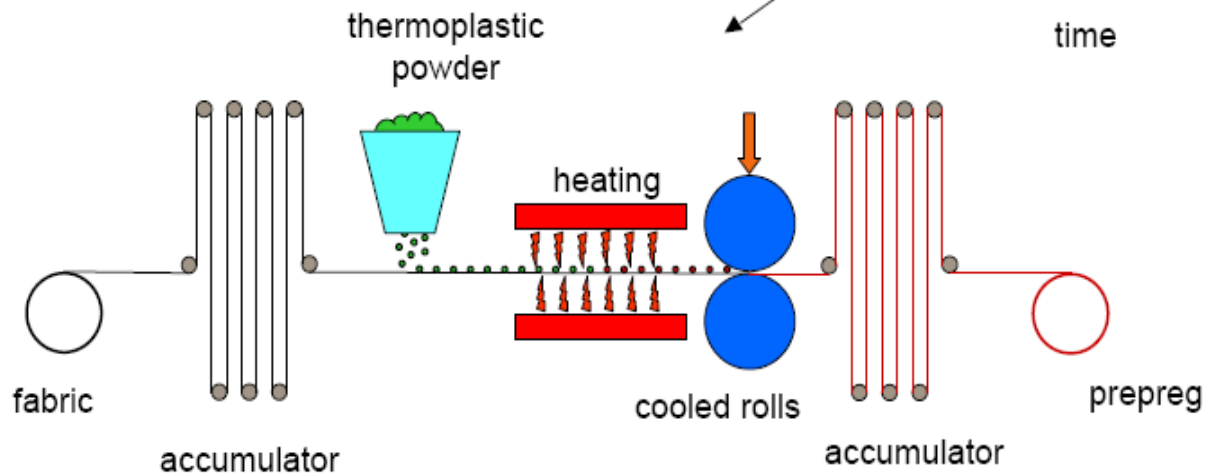
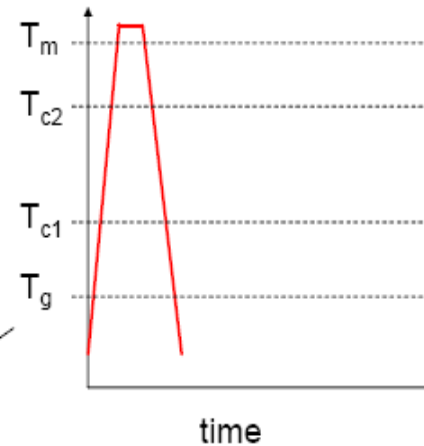
- Development of new PEEK grades suitable for better fiber impregnation without losing the mechanical properties
- Qualification and test programs are running with Key Aerospace OEMs and Tier I composite producers
- Evonik VESTAKEEP® PEEK in laminate form was found full comparable to incumbent material



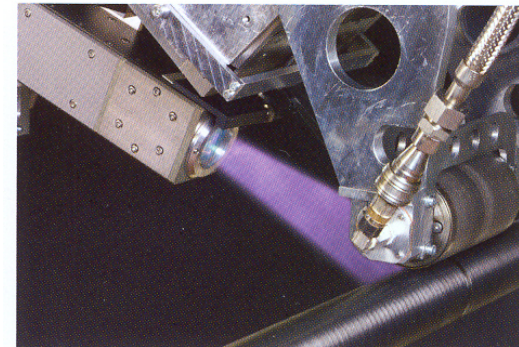
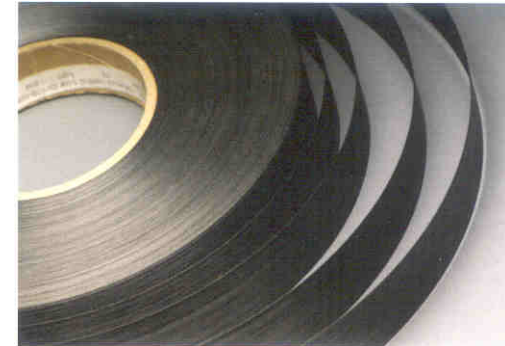
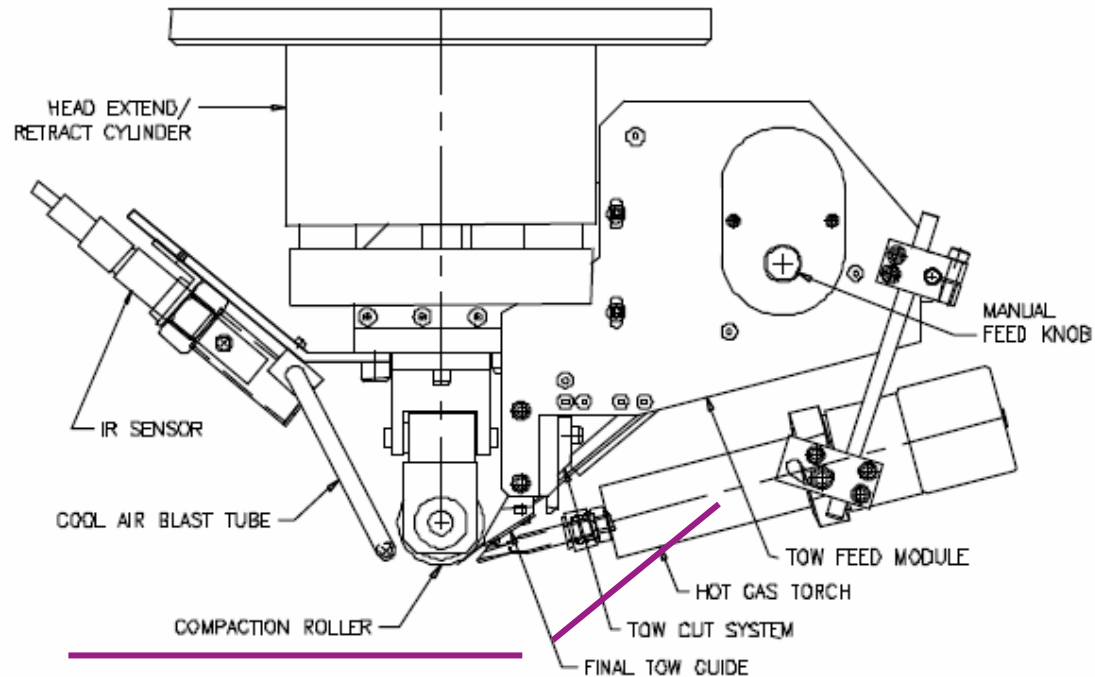
# Typical Process to produce Fabric Prepregs



- Powder Coating Process
- Chemical Slurry
- Development of PEEK powder with particle size suitable for this process

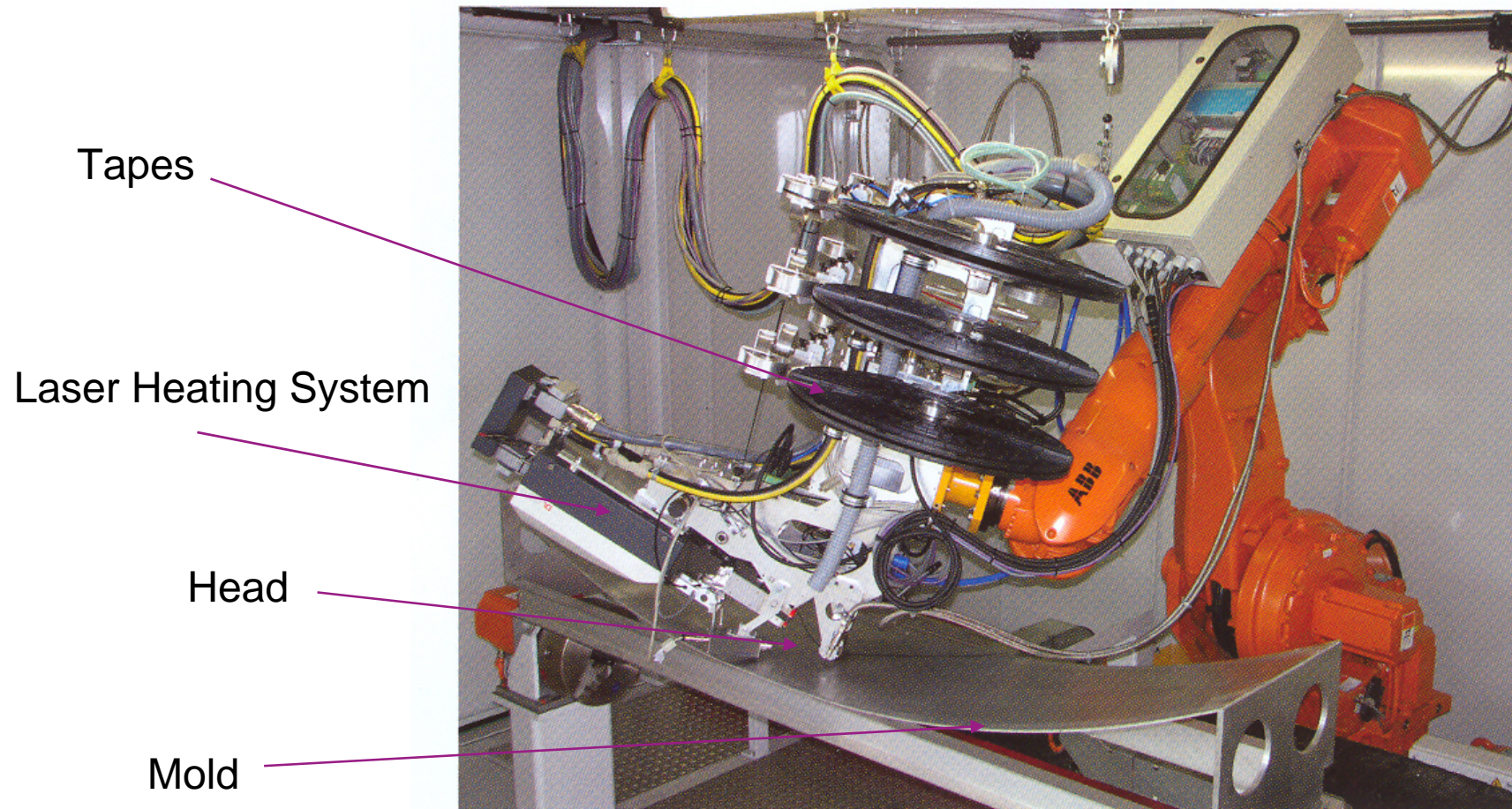


# How do you work with Tapes? Tape Laying Process



- CNC controlled
- surface heating of the tape
- consolidation over a roller system

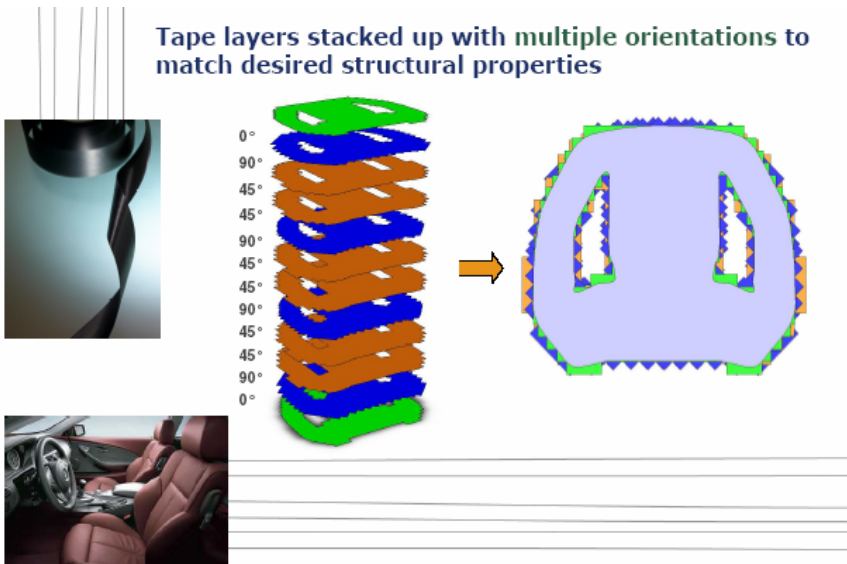
# Tape Laying Process



# Press Process for net 2D & 3D parts



Tape layers stacked up with multiple orientations to match desired structural properties



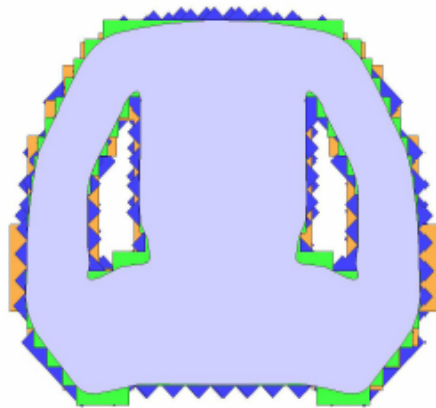
FIBERFORGE tailored blank

Thermoform the Tailored Blank into a 3 Dimensional Part

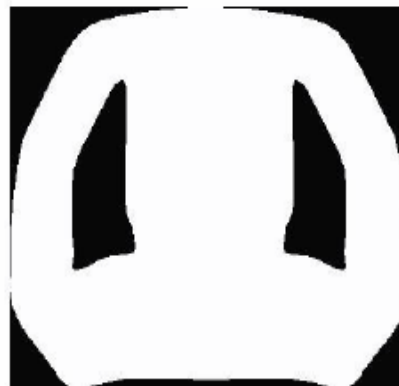
- Heat *Tailored Blank* in infrared oven
- Shuttle into tool
- Close press to form and "freeze" part



Comparison blank



Trim scrap = 11%



Trim scrap = 33%



## Fiberforge Case Study: Commercial Aircraft Seating

The benefits of 'lightweighting'

- 25% reduction in weight vs. aluminum seat frame
- Saves over \$500 / seat in fuel costs over life of aircraft
- For 320 seat aircraft, \$160,000 in fuel cost savings
- ROI is less than 5 years

Source: Fiberforge



# Press Process Applications

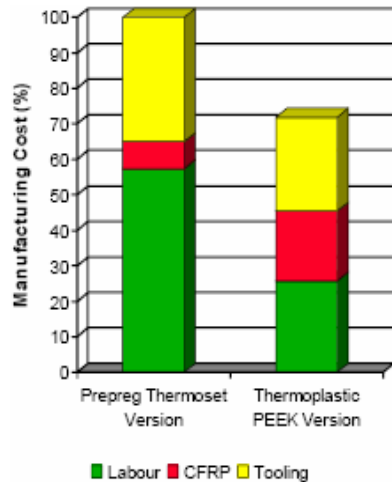


PRO: Low Cycle Time

- Engine Pylon: Panels
- Keel Beam: Ribs/ Profiles
- Wing Leading Edge: J-Nose
- Ailerons: Associated Ribs & Leading Edges

CON: Part size limited to press

# Advantages of TPC Composites



Production cost

Advantages:

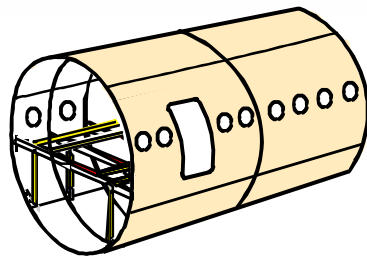
-60% lighter than Steel, 500% stronger

-25% lighter than aluminum, 300% stronger

-Faster Processing: some tape TPC Processes can produce a part in < 1 minute

- Lower capital costs versus metal forming

- Less scrap, fuel savings, recyclable & longer life



Impact resistance



Fusibility

# Press Process Applications



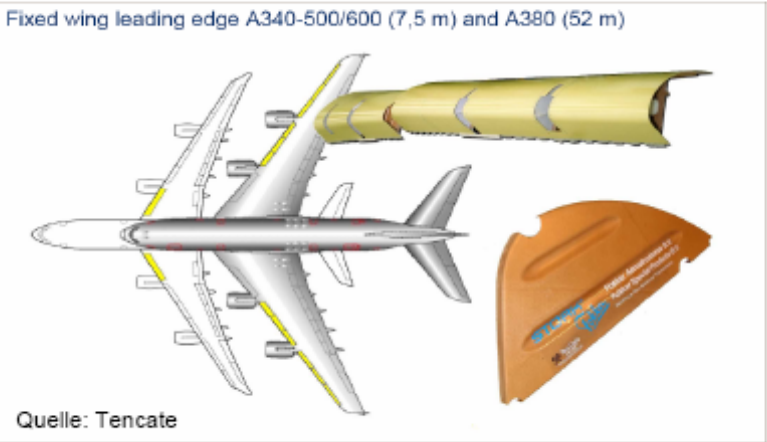
J-Nose A380 & A340-600

## Flügelnasenvorderkante A380 & A340-600



Quelle: Tencate

Engine covering & Secondary Support Structures & Exterior Panels



Quelle: Tencate



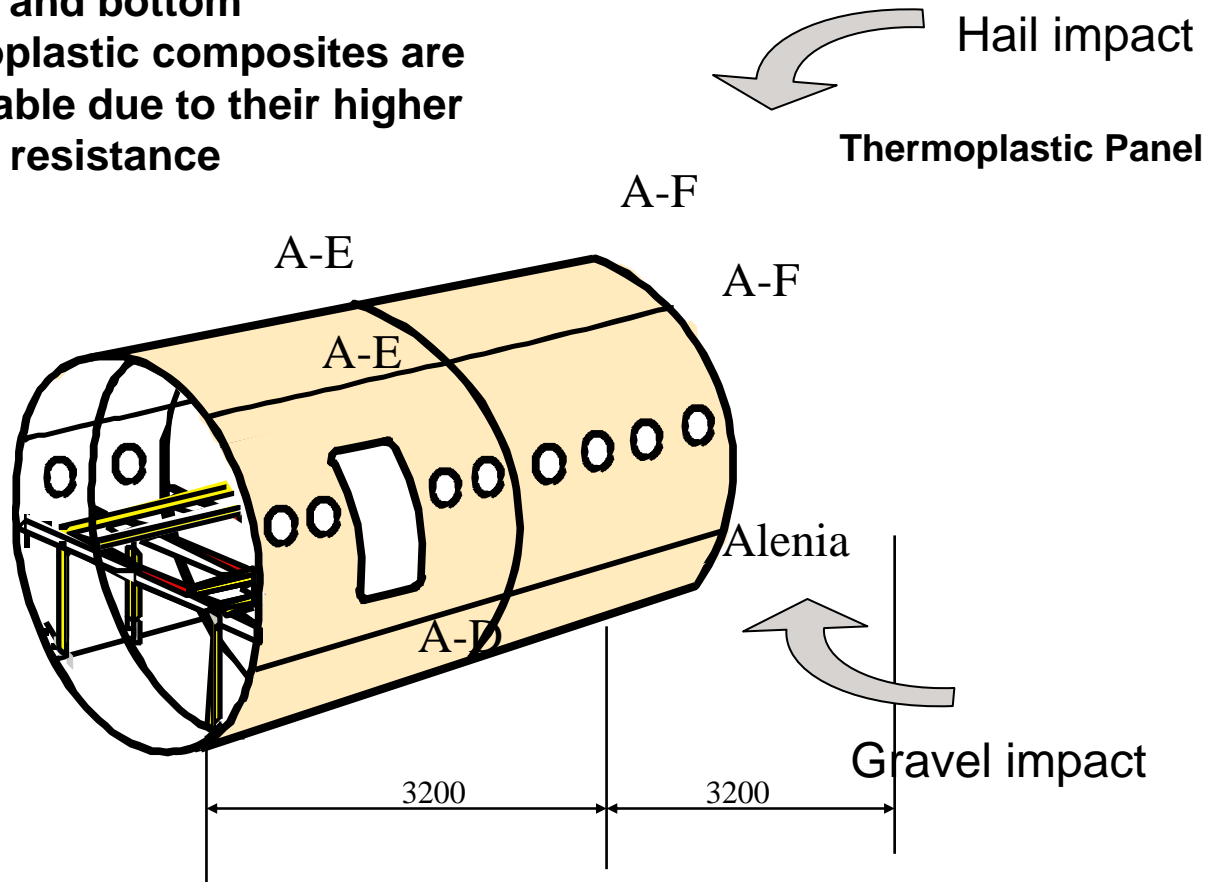
Quelle: airliners.net

Triebwerksauskleidung

# TPC: impact resistance – Press Process example



On top and bottom thermoplastic composites are favourable due to their higher impact resistance



# VESTAKEEP® Conductive Composites R&D

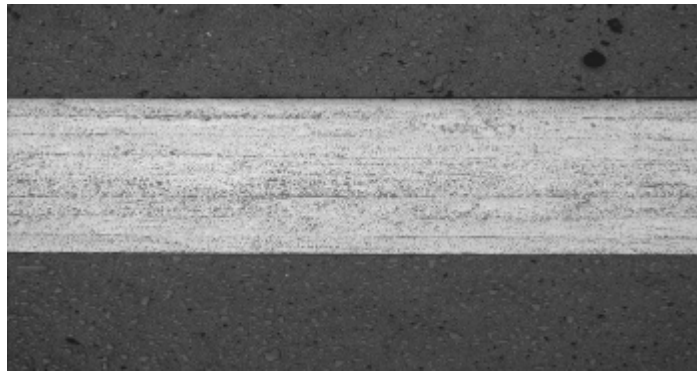


- Testing is underway to determine specific ESD and Structural properties of Conductive Evonik VESTAKEEP® PEEK in the form of unidirectional tapes and laminates for multifunctional use in specific aircraft components.
- Specialty grades of VESTAKEEP® PEEK are in development to further decrease labor and processing/ tooling costs.

## Goals:

- Lightning Strike
- Enhance Structural Performance/
- Increase Impact Properties
- Decrease production time/ costs

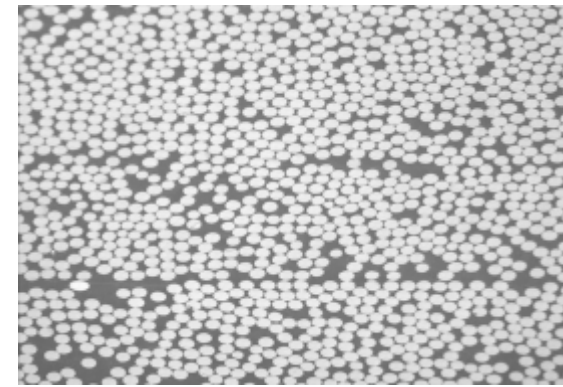
# Cross section of thermoplastic laminates with VESTAKEEP PEEK



37,6 :  
1

1m  
m

P-Yarn/ VESTAKEEP laminate  
out of 8 plies (+/- 45°)



376  
: 1

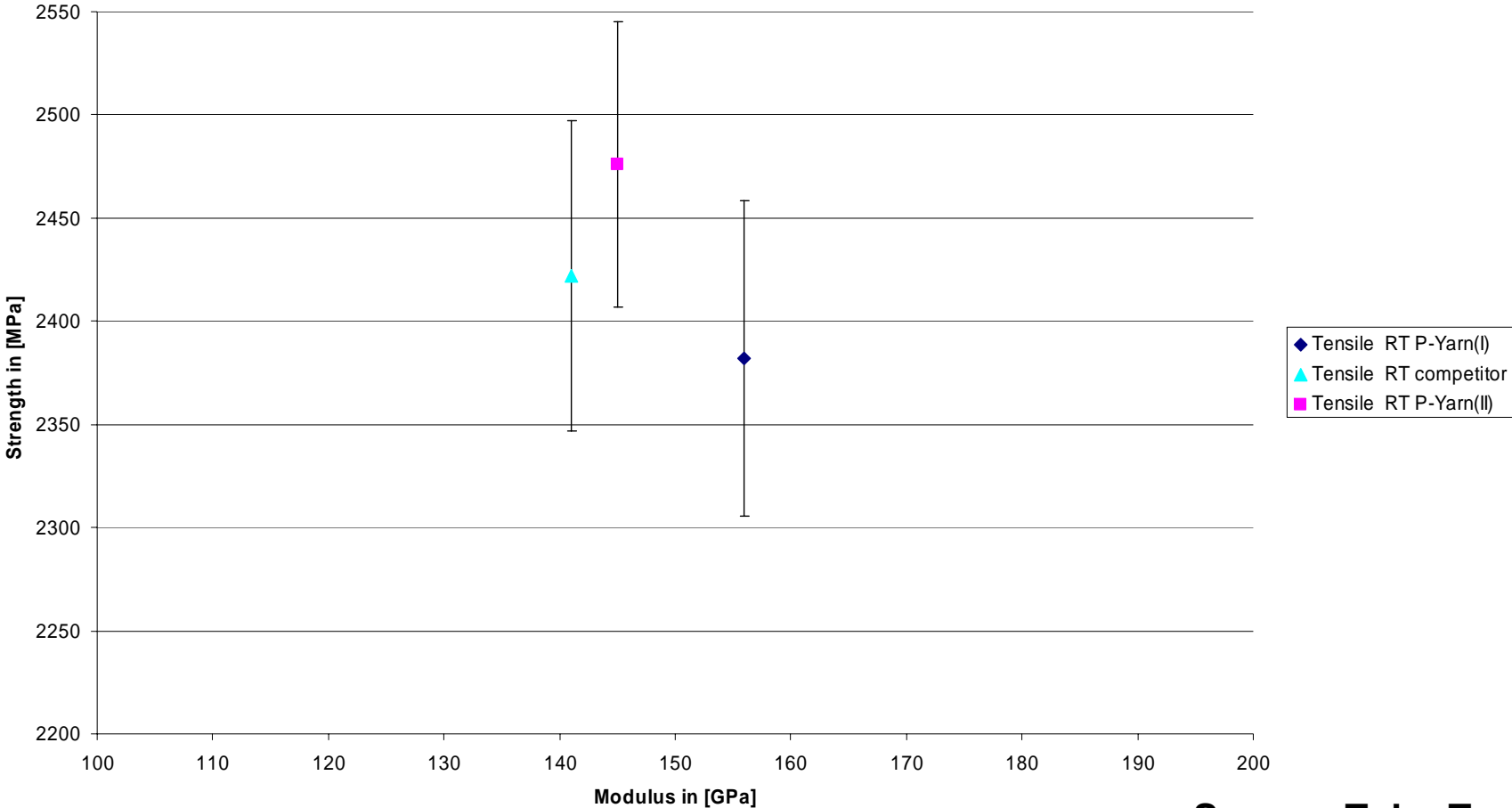
100  
µm

Source: Toho Tenax

# Mechanical properties of thermoplastic laminates - customer feedback



### Tensile Test 0°UD (EN2561)

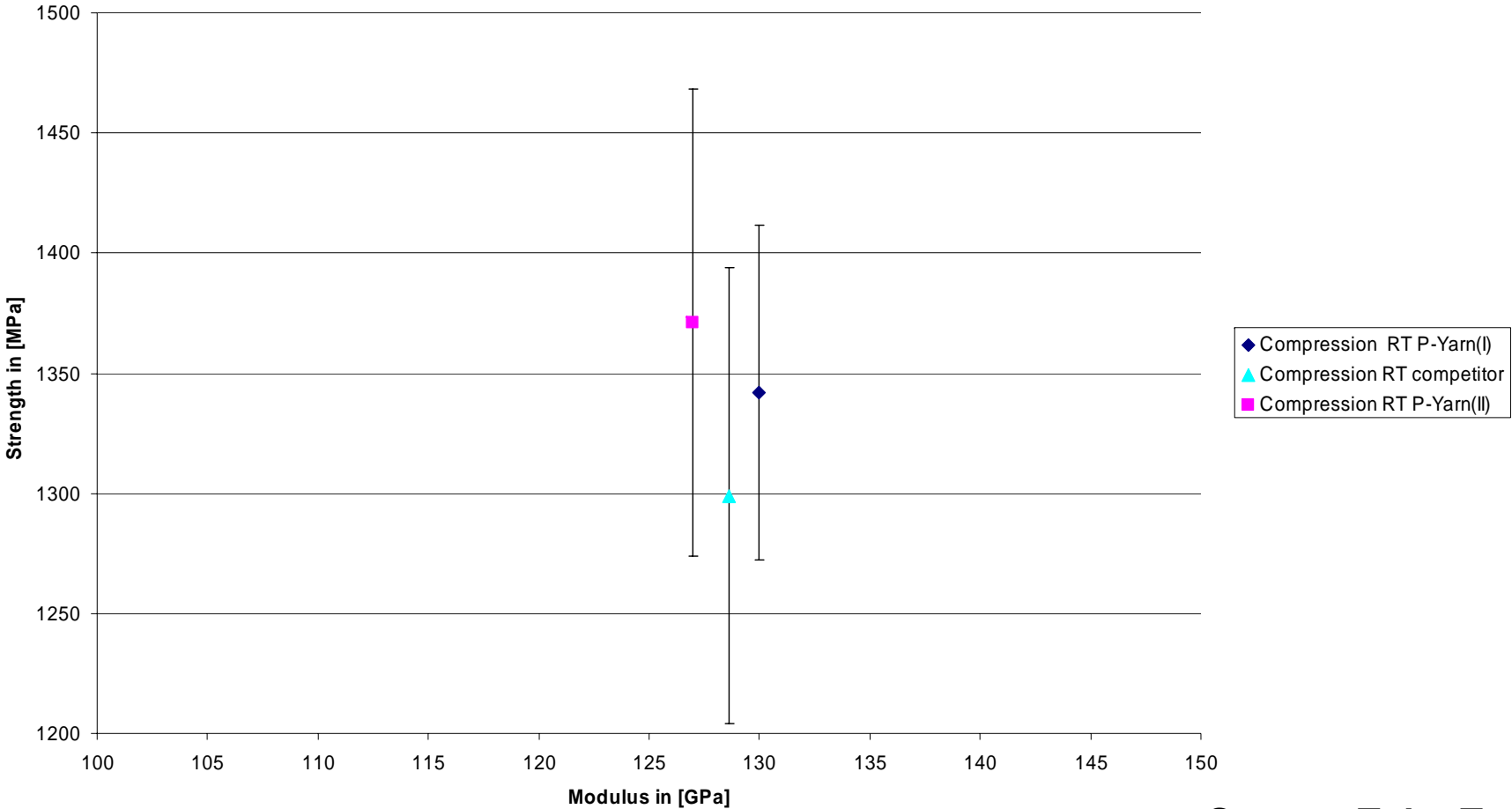


Source: Toho Tenax

# Mechanical properties of thermoplastic laminates



### Compression Test 0°UD (EN2850)



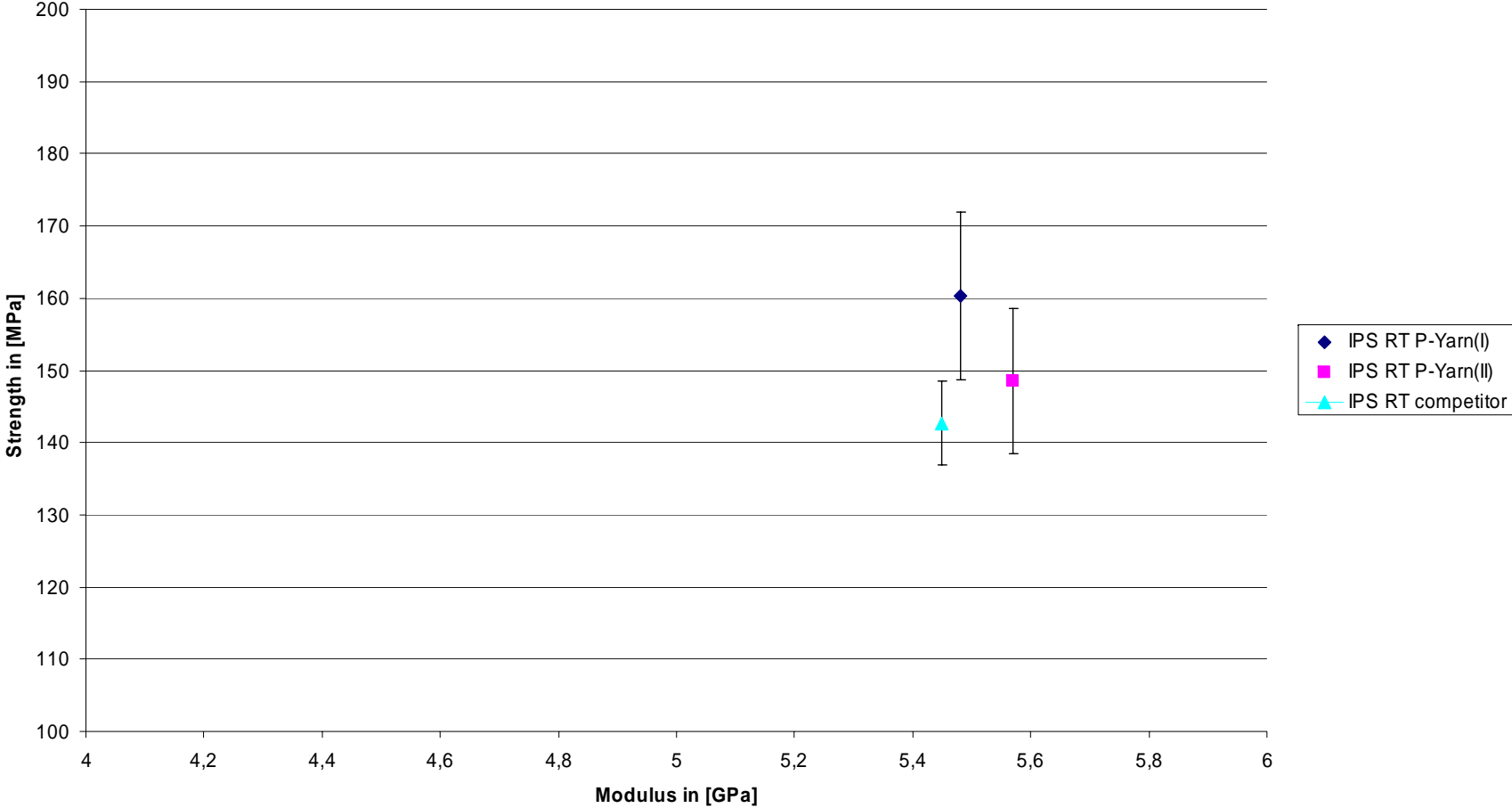
Source: Toho Tenax



# Mechanical properties of thermoplastic laminates



IPS Test (AITM 1-0002 EN2489)



Source: Toho Tenax

# Composites in Aerospace – Requirements and Challenges



## Requirements for thermoplastic composites:

- Weight reduction
- Flammability, low smoke generation
- High strength, high E-modulus
- High temperature resistance
- Low part production costs

## Challenges:

- Establishing industry performance history/ database/ repair workscopes
- Technology transfer from thermoset to thermoplastic composites.
- Cost Goal within reach - lower part production / costs etc.

Source: E-Composites, Inc.; report

**Evonik**  
**VESTAKEEP**  
**PEEK – other**  
**activities**



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# VESTAKEEP® Films - Flexible Circuit Board Development

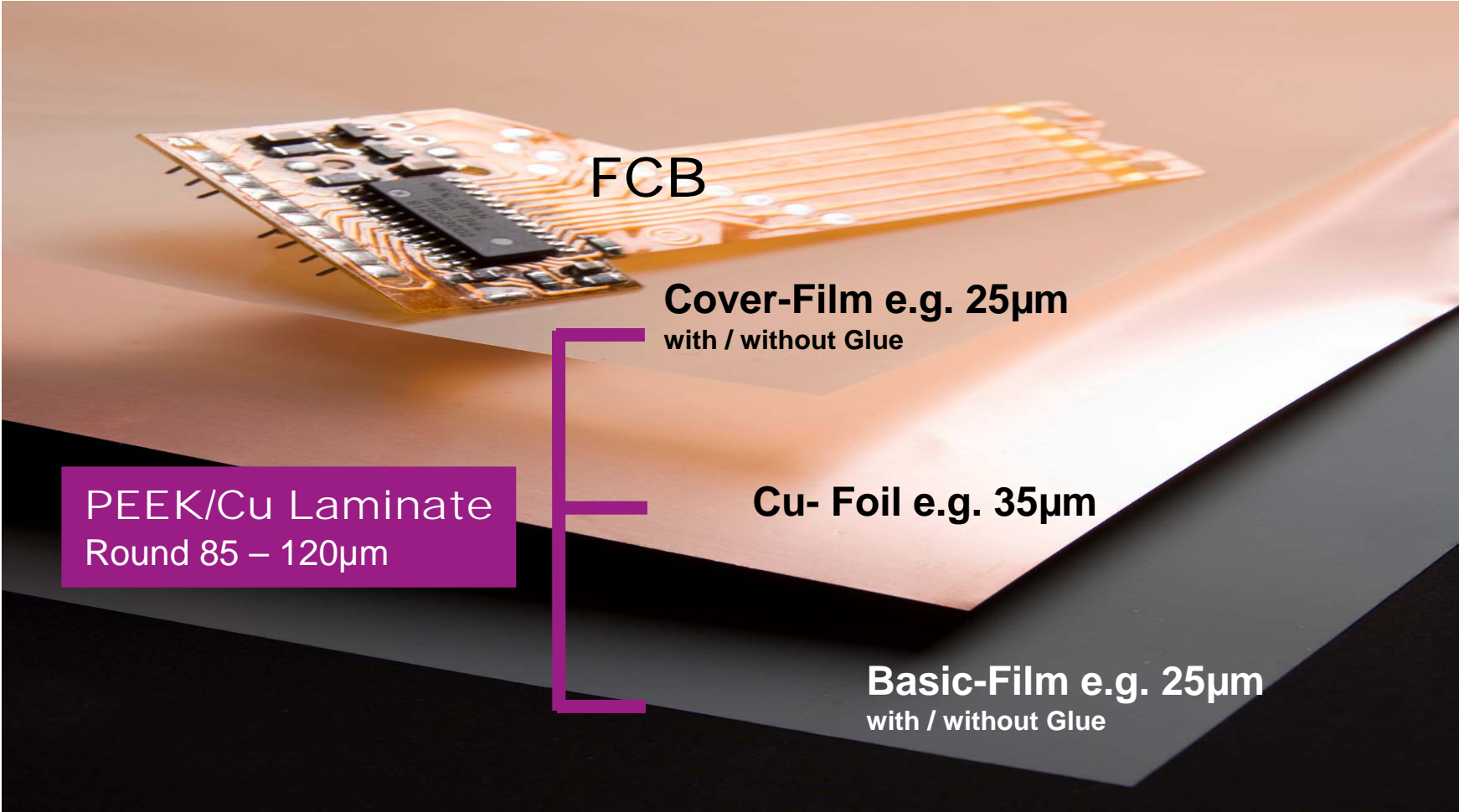


## *Make it*

- Light, small, less H<sub>2</sub>O absorption
- Elimination of manufacturing steps
- Flexible
- Aerospace community has high interest



# FCB : How do they look like



# Rapid Prototyping – Selective Laser Sintering: PA12 and PEEK Boeing Consortium



Osteon Designer-Stuhl



Designer lamp,  
[www.futurefactories.com](http://www.futurefactories.com), found  
at [www.designspotter.com](http://www.designspotter.com).

And the examples from today for additive fabrication processes:



[http://www.stylehive.com/tag/freedom\\_of\\_creation](http://www.stylehive.com/tag/freedom_of_creation)



**Other Key Markets: Automotive & Aerospace (not pictured) –**

**Evonik a major participant in Boeing's Rapid Prototyping Forum**



**No Limits !**