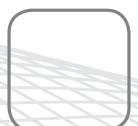
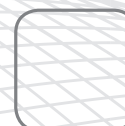


Advanced Materials

Composites, adhesives and repair solutions

Selector
guide for wind
industry





Rely on
us with
confidence



Araldite®
Ren®

The original brands
serving worldwide wind industry
for more than a decade.

A global partner

As a global partner and innovator working in close collaboration with all major wind energy equipment manufacturers for more than 20 years, we provide our customers with reliable, durable and cost effective solutions for wind blade production. To capture the maximum amount of energy from the wind, blades have to be large, stiff and sufficiently robust to withstand every kind of weather condition. Huntsman Advanced Materials has the right technologies and high-performance products that the industry requires. Our products are used in applications ranging from plugs and patterns, to complete composite blade production as well as assembly and repair.

We deliver more than just products

Our know-how and expertise help us to develop standard products as well as custom-made solutions formulated to answer specific project requirements. Huntsman Advanced Materials has a worldwide team of experts to develop composites and tooling materials as well as adhesives:

- > to quickly bring your product to market through rapid model build-up and repair
- > to reduce manufacturing and production costs through process time reduction
- > to improve product quality, stability and durability through physical properties like impact resistance and corrosion.





Proven solutions for the wind industry

Huntsman leverages its core strengths in synthesis and formulation to produce high performance materials that deliver improved mechanical and thermal performance in the area of composites.

Our application engineers can support you with advice and practical recommendations on how to optimize the use of Huntsman's products in your chosen manufacturing process.

- > Wet lay-up
- > Infusion
- > Filament winding
- > Pultrusion
- > Adhesives



Germanischer Lloyd statement of approval

“Rules for Classification and Construction, II- Material and Welding technology – Part 2 Non-Metallic materials”

Huntsman's GL approved resin systems received approval for the construction of FRP laminate components in wind and marine applications on condition that the selected fibre reinforcement both complies with Germanischer Lloyd's requirements and is compatible with the resin.

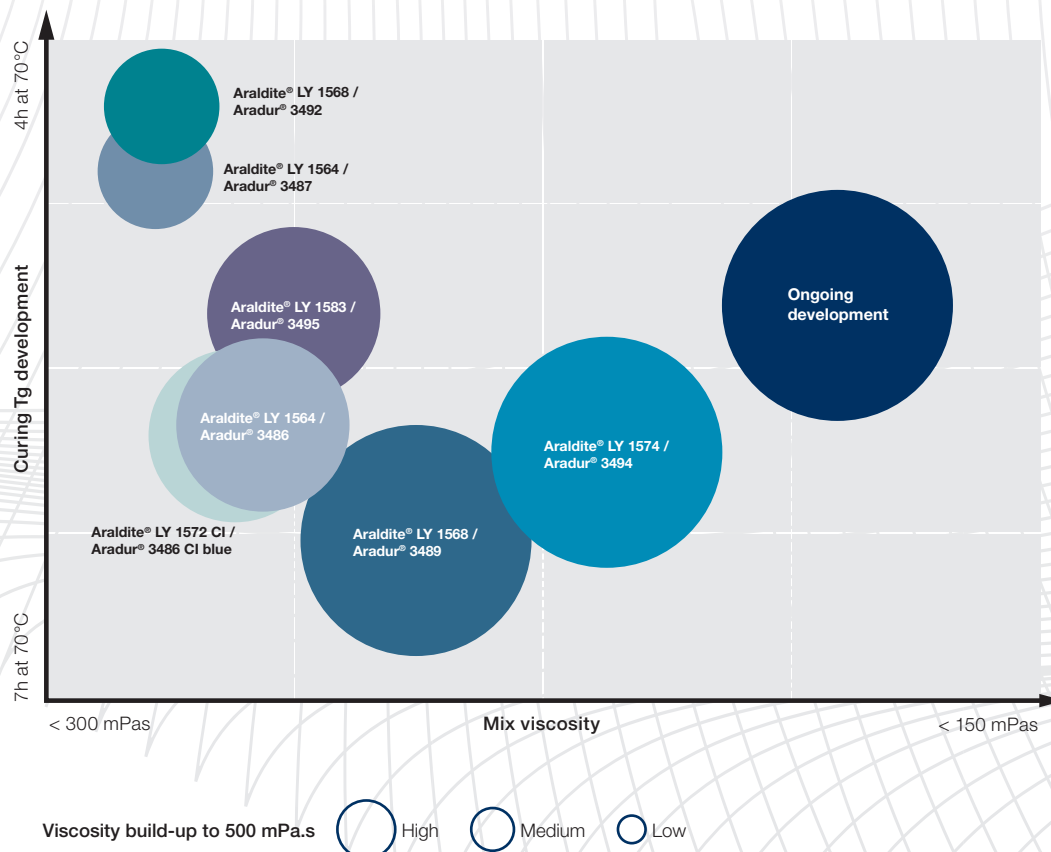
Huntsman Advanced Materials (Switzerland) GmbH Material Testing is accredited by DN International standard ISO/IEC 17025:2005.



Optimize manufacturing process

Market trend to longer blades requires faster infusion and curing process. Low viscosity systems with long processing window and fast Tg build-up are key element to market requirements.

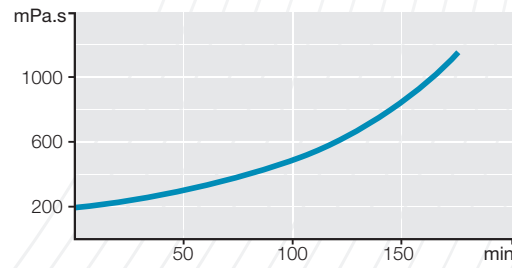
The chart below reflects an overview of the mix viscosity and Tg build-up as well as the processing window of Huntsman infusion system.



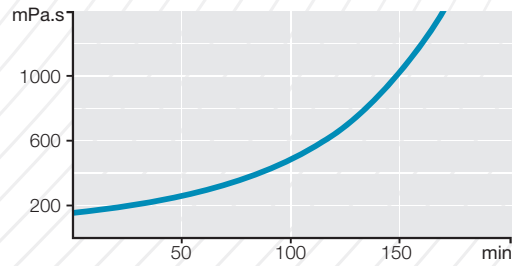
Viscosity build-up at 30°C

Viscosity vs time

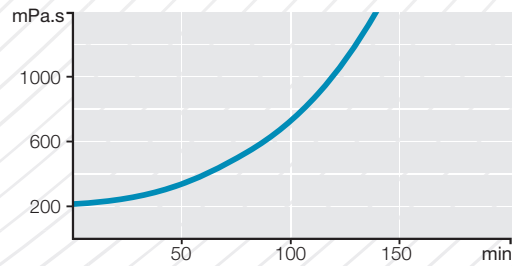
**Araldite® LY 1568 /
Aradur® 3489**



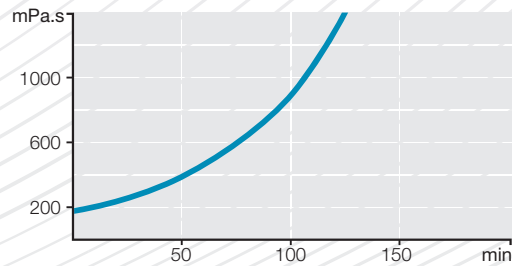
**Araldite® LY 1574 /
Aradur® 3494**



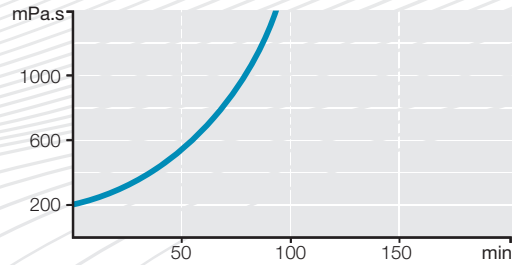
**Araldite® LY 1564 /
Aradur® 3486**



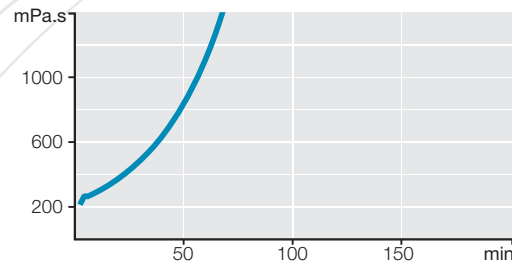
**Araldite® LY 1583 /
Aradur® 3495**



**Araldite® LY 1564 /
Aradur® 3487**

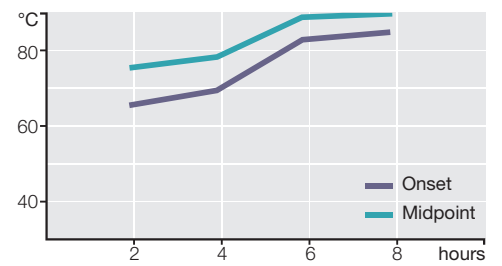
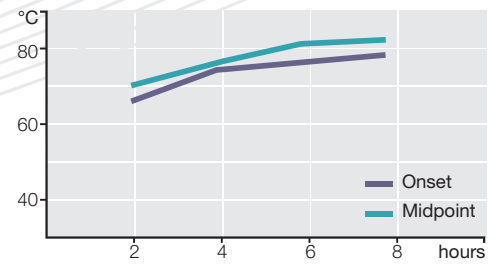
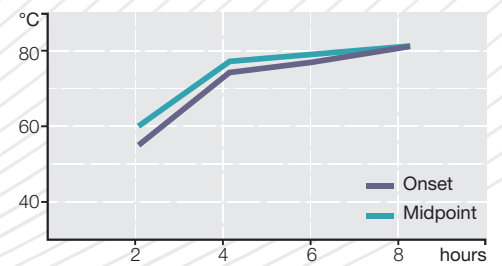
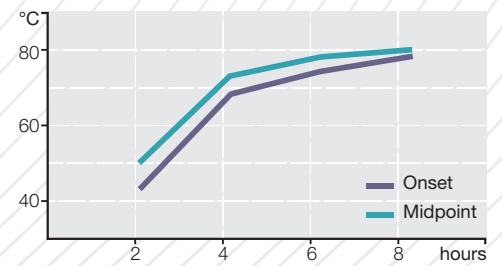
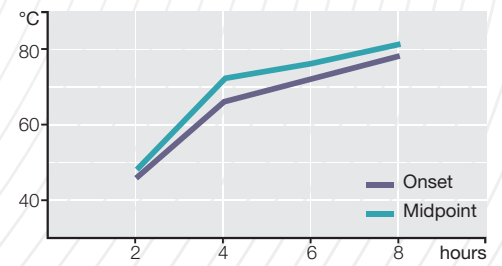
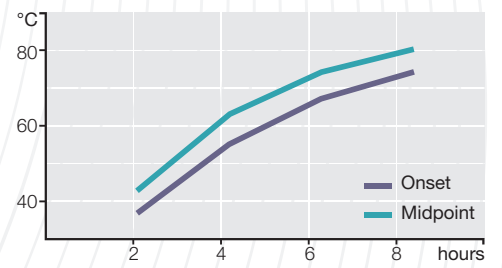


**Araldite® LY 1568 /
Aradur® 3492**










Tg build-up at 70°C

Temperature vs time






Composite resin systems

Infusion process

| | Product designation | Pot life | Mix viscosity | Tg Cure 6h at 70°C | Flexural strength* | Ultimate flexural elongation* | Key features |
|---|--|--------------|---------------|--------------------------|--------------------|----------------------------------|---|
| | Conditions | 23°C, 100 ml | 25°C | DSC, 10K/min | 25°C | 25°C | |
| | Norm | | | ISO 11357-2 | ISO 178 | ISO 178 | |
| | Unit | min | mPa·s | °C | MPa | % | |
|  | Araldite® LY 1564 / Aradur® 3486 | 560 - 620 | 200 - 300 | 68 - 72 | 118 - 130 | 10.5 - 12.5 | Industrie standard system. Hardener can be mixed to adjust reactivity at constant resin / hardener mix ration. |
|  | Araldite® LY 1564 / Aradur® 3487 | 130 - 160 | 200 - 320 | 75 - 78 | 118 - 130 | 10.0 - 12.0 | |
|  | Araldite® LY 1572 CI / Aradur® 3486 CI Blue | 560 - 620 | 220 - 300 | 70 - 72 | 100 - 115 | 9.5 - 13.5 | Standard system for Asia market. |
|  | Araldite® LY 1568 / Aradur® 3489 | 850 - 950 | 200 - 300 | 68 - 70 | 120 - 130 | 9.0 - 10.0 | Standard system for Europe and Americas with low exothermic behavior. Hardener can be mixed to adjust reactivity at constant resin / hardener mix ration. |
|  | Araldite® LY 1568 / Aradur® 3492 | 300 - 350 | 250 - 350 | 74 - 78 | 125 - 135 | 7.0 - 7.5 | |
|  | Araldite® LY 1574 / Aradur® 3494 | 860 - 960 | 200 - 250 | 74 - 76 | 110 - 115 | 9.5 - 10.5 | Low viscosity system with long open time and elevated Tg. |
|  | Araldite® LY 1583 / Aradur® 3495 | 610 - 660 | 250 - 280 | 79 - 80 | 110 - 115 | 11.0 - 12.5 | Low viscosity system with improved latency and high Tg. |

* Cure schedule 8h at 80°C

Wet lay-up process

| | Product designation | Pot life | Mix viscosity | Tg | Flexural strength | Ultimate flexural elongation | Key features |
|---|---|--------------|---------------|--------------|-------------------|---------------------------------|--|
| | Conditions | 23°C, 100 ml | 25°C | DSC, 10K/min | 25°C | 25°C | |
| | Norm | | | IEC 1006 | ISO 178 | ISO 178 | |
| | Unit | min | mPa·s | °C | MPa | % | |
|  | Araldite® LY 3505 / Hardener XB 3403 | 600 - 720 | 300 - 400 | 78 - 83 | 110 - 130 | 10.5 - 13.0 | Hardener XB 3403 and Aradur® 3405 can be mixed to adjust reactivity at constant resin / hardener mix ration. Araldite® LY 3505-1 is modified for excellent air release. |
|  | Araldite® LY 3505-1 / Hardener XB 3403 | 600 - 720 | 300 - 400 | 78 - 83 | 110 - 130 | 10.5 - 13.0 | |
|  | Araldite® LY 3505 / Aradur® 3405 | 26 - 36 | 1 000 - 1 200 | 87 - 92 | 135 - 155 | 7.0 - 9.0 | |

Cure schedule 4h at 60°C + 6h at 80°C

Note: Further systems are available upon request

Pultrusion process

Epoxy / Amine chemistry

| Product designation | Pot life | Mix viscosity | Tg | Flexural strength | Ultimate flexural elongation | Key features |
|---|-------------|---------------|--------------|-------------------|------------------------------|---|
| Conditions | 23°C, 100ml | 25°C | DSC, 10K/min | 25°C | 25°C | |
| Norm | | | ISO 11357-2 | ISO 178 | ISO 178 | |
| Unit | hours | mPas | °C | Mpa | % | |
| Araldite® LY 3585 / Aradur® 3489 | 800 - 900 | 500 - 650 | 100 - 105 | 120 - 130 | 9.0 - 10.0 | Very good impregnation properties. Aradur® 3489 and Aradur® 3492 can be mixed to adjust reactivity. |
| Araldite® LY 3585 / Aradur® 3492 | 220 - 300 | 500 - 650 | 105 - 110 | 125 - 135 | 7.0 - 7.5 | |

Cure schedule 8h at 80 °C

Epoxy / Anhydride chemistry

| | | | | | | |
|---|---------|-----------|-----------|---------|-----------|--|
| Araldite® LY 3585 / Aradur® 917-1 / Accelerator DY 080 | 48 - 50 | 600 - 700 | 125 - 130 | 76 - 78 | 7.0 - 8.0 | Very latent system, very good impregnation properties and high line speed (>1m/min). |
|---|---------|-----------|-----------|---------|-----------|--|

Cure schedule 2h at 80 °C and 4h at 140 °C

Note: Compatible with common commercially available internal release agent

Filament winding process

Epoxy / Amine chemistry

| Product designation | Pot life | Mix viscosity | Tg | Flexural strength | Ultimate flexural elongation | Key features |
|---|-------------|---------------|--------------|-------------------|------------------------------|--|
| Conditions | 23°C, 100ml | 25°C | DSC, 10K/min | 25°C | 25°C | |
| Norm | | | ISO 11357-2 | ISO 178 | ISO 178 | |
| Unit | hours | mPas | °C | Mpa | % | |
| Araldite® LY 3585 / Aradur® 3403 | 12 - 16 | 300 - 500 | 80 - 85 | 118 - 132 | 10.5 - 12.5 | Low viscosity, reactivity can be accelerated with faster hardener. |
| Araldite® LY 1564 / Aradur® 3474 | 4 - 5 | 1 400 - 1 600 | 115 - 120 | 120 - 130 | 8.0 - 9.0 | Excellent flexibility and high reactivity. |

Cure schedule 8h at 80°C

Epoxy / Anhydride chemistry

| | | | | | | |
|--|---------|-------------|-----------|-----------|-----------|---|
| Araldite® LY 1564* / Aradur® 917-1 / Accelerator 960-1 | 80 - 90 | 450 - 700 | 115 - 125 | 140 - 150 | 6.0 - 7.0 | Very latent system reactivity adjustable. |
| Araldite® LY 1135-1 A** / Aradur® 917-1 / Accelerator 960-1 | 56 - 62 | 600 - 1 000 | 130 - 140 | 150 - 160 | 6.5 - 8.0 | Very latent system reactivity adjustable. |

* Cure schedule 4h at 80 °C and 4h at 120 °C

** Cure schedule 4h at 80°C and 4h at 140°C

Shell bonding adhesive, gap filling

| Product designation | Mixing ratio | Pot life | Typical cure schedule | LSS* | Tg | Gap filling | Key features |
|---|--------------|------------|-----------------------|--------------------------------------|---------|-------------|--|
| Conditions | | 23°C, 500g | | | | | |
| Unit | by volume | min | | MPa | °C | mm | |
| Araldite® AW 4856 / Hardener HW 4856 | 1 : 1 | 240 - 280 | 5h at 70°C | 25 - 30 on 0.5 mm 13 - 16 on 3 mm | 80 - 85 | up to 40 | Assembly adhesive for large structures, particularly where thick bond lines may occur. |

* On aluminium - LSS = Lap Shear Strength

Structural adhesives

| Product designation | Chemistry | Pot life | Recommended cure schedule | LSS* | Tg** | Gap filling | Key features |
|---|-----------|------------|-------------------------------|------|-----------|-------------|--|
| Conditions | | 23°C, 100g | | | | | |
| Unit | | min | | MPa | °C | mm | |
| Araldite® AV 4858 / Hardener HW 4858 | EP system | 150 | RT or at elevated temperature | 38 | 60 - 65 | 10 | High peel strength, high toughness. |
| Araldite® 2015-1 | EP system | 45 - 60 | RT or at elevated temperature | 15 | 70 - 75 | 10 | Bonding of lightening conductor, monitoring sensors, ideal for dissimilar substrates. |
| Araldite® 2031-1 | EP system | 60 - 70 | RT or at elevated temperature | 20 | 70 - 75 | 10 | For insert on composite (CFRP; GRP), toughened, resistant to weathering. Repair of voids. |
| Araldite® 2014-2 | EP system | 110 | RT or at elevated temperature | 15 | 75 - 85 | 5 | Bonding tip, control shaft components, high temperature and chemical resistance, ideal for metals. |
| Araldite® AV 4076-1 / Hardener HV 5309-2 | EP system | 60 | RT or at elevated temperature | 16 | 70 - 80 | 5 | Root joints insert bonding. |
| Araldite® AV 4859 / Hardener HW 4859 | EP system | 100 | RT or at elevated temperature | 33 | 50 - 120 | 10 | Resistant to high temperature after post cure, high toughness. |
| Araldite® AW 4510 / Hardener HV 4511-1 | EP system | 80 - 90 | 2h at 110°C | 19 | 110 - 125 | 10 | Non sagging paste, for gap filling or vertical application, high temperature resistance. |

* On epoxy composites - LSS = Lap Shear Strength

** Cured in standard blade cycle after initial fixing of shear webs at 25°C, DSC, 10K/min

Note: All adhesives are available in different pack sizes including cartridges for easy use in the field

Fast assembly and repair

| Product designation | Chemistry | Pot life | Fixture time | LSS* | Tg | Gap filling | Key features |
|---|------------|------------|--------------|------|---------|---------------|--|
| Conditions | | 23°C, 100g | 23°C | | | | |
| Unit | | min | min | MPa | °C | mm | |
| Araldite® 2029-1 | PU system | 35 - 45 | 12h | 24 | 25 - 35 | 5 | Medium open time, filling holes, high flexibility and strength. |
| Araldite® 2012 | EP system | 6 | 20 | 18 | 40 - 50 | self leveling | Fast setting, multipurpose adhesive. |
| Araldite® AW 2101 / Hardener HW 2951 | EP system | 6 | 60 | 20 | 40 - 45 | 5 | Fast setting, multipurpose gap filling adhesive, with low shrinkage. |
| Araldite® 2021-1 | MMA system | 3 - 5 | 9 | 26 | 65 - 80 | 3 - 5 | Very fast setting, tough adhesive for rapid fixing and filling of small voids. |
| Araldite® 2022-1 | MMA system | 10 | 12 | 25 | 65 - 80 | 5 | Non sagging, fast curing tough adhesive for field / workshop operations. |
| Araldite® 2048-1 | MMA system | 10 | 35 | 24 | 65 - 75 | 8 | Rapid attachment of parts, high flexibility and gap filling adhesive. |

* On aluminium - LSS = Lap Shear Strength

Note: All adhesives are available in different pack sizes including cartridges for easy use in the field

PU: Polyurethane

EP: Epoxy

MMA: Methacrylate

Advanced process simulation is used to determine suitable resin solutions and to tailor production process to each part

Accurate rheokinetic data of the resin systems are used to generate material models which are projected onto CAD data.

Generation of material models

This enables the prediction of the material behavior during the injection and curing process at each point on a composite part.

Cure simulation

Cure simulation can substantially reduce production and part development times by simplifying process engineering and selection of resin system and process parameters.

- > curing cycle
- > exotherm temperature
- > evolution of Tg and conversion rate during cure

Flow simulation

Flow simulation in liquid composite molding helps process engineers to evaluate injection strategies and find optimum processing parameters leading to properly filled parts.

- > flow front evolution and filling time
- > pressure evolution
- > process induced filling variability

Reduced production cycles and development times

Resin system selection

Early stage process design

Process parameter determination

Process safety

Improved flow patterns

Improved injection concepts



Explore how to improve manufacturing performance using simulation
Scan to download the App on iPad

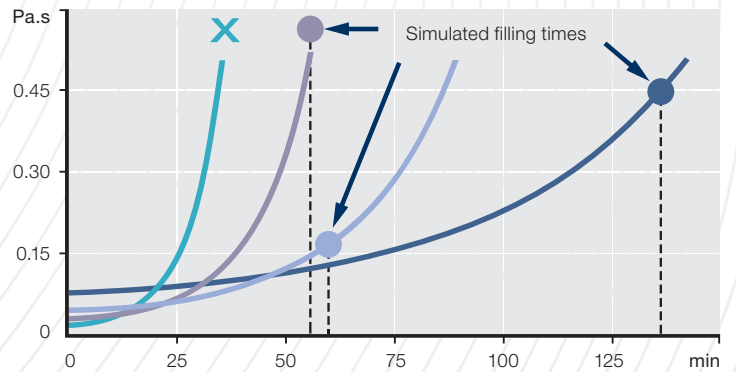
Typical applications for the wind industry

Resin infusion: optimum process temperature

Increasing infusion temperature decreases viscosity, giving a higher resin flow. However, higher temperature also increases reactivity, reducing the process window. Simulation is used to find the optimum process temperature to balance these two effects. For the simulated generic rotor blade (35 m length) geometry, a tool temperature of 50°C is optimum: short filling time, enough margin in process time (Fig. 1).

- Tool temperature 40°C
- Tool temperature 50°C
- Tool temperature 60°C
- Tool temperature 70°C

Figure 1: Viscosity vs time



Cycle time reduction: cure strategies

Cycle time reduction can be achieved by using systems with higher reactivity. Simulation supports material choice and highlights the effect of different heating systems (Fig. 2: Electrical heating, Fig. 3: Powerful oil-heating/-cooling).

- Interface laminate tool
- Center of laminate
- Top surface of laminate

Figure 2: Temperature vs time

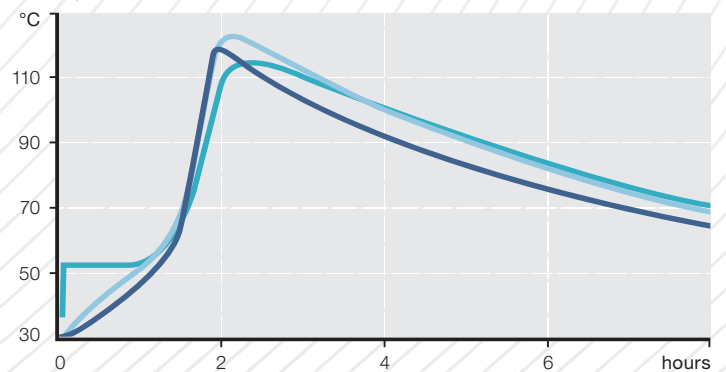
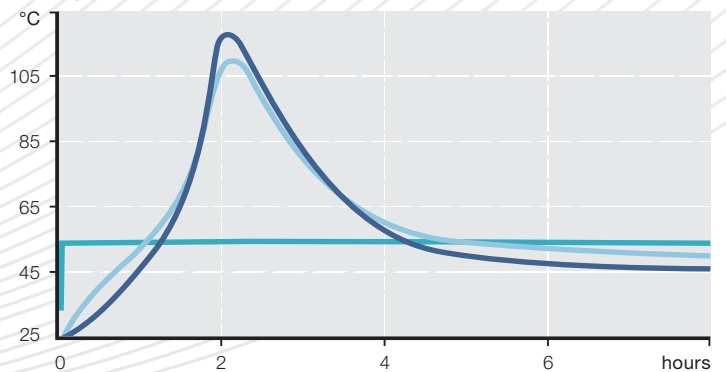


Figure 3: Temperature vs time

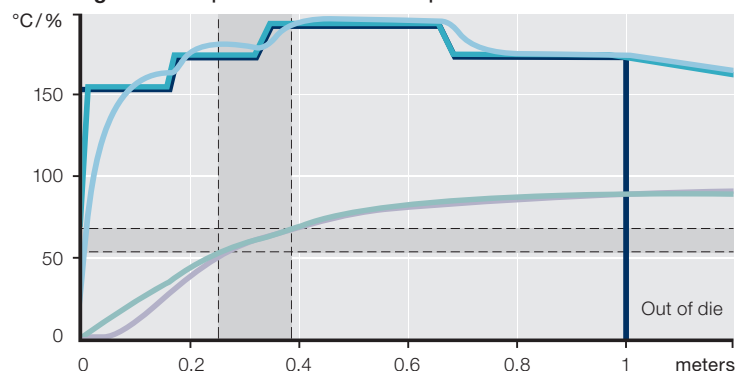


Spar cap pultrusion: increasing line speed

In order to increase spar pultrusion speed, the complex interaction of the tool and the pultruded composite in its different cure states (liquid to solid) must be understood. Simulations enable matching of the curing process to the line speed to maximise output whilst ensuring part quality (Fig. 4).

- Temperature tool/environment
- Temperature at laminate surface
- Temperature at laminate center
- Conversion at laminate surface
- Conversion at laminate center
- Gelation area 55-70%

Figure 4: Temperature/conversion vs position





With innovation

Every day, all over the world, our Technical Competence centers engage in intensive research and development focusing on one goal : to deliver innovative solutions by working hand-in-hand with our business partners. Together through a continual exchange of ideas, supported by an experienced team of sales and technical specialists, we strive to deliver innovative solutions.

We track both new market expectations and changing regulations. Protection of the environment, as well as health and safety are paramount concerns, playing an integral part in our development projects.

By providing certified technologies, combined with high quality and reliability, our chemists and experts bring enhanced value to our customers, ensuring their success.

With customer intimacy

We market a unique product portfolio and a broad range of forward-looking solutions for our customers. Customers and partners benefit from an advanced level of service in:

- > product development and quality
- > product trials in-house and with customers
- > customer seminars and training
- > trouble-shooting and problem-solving

Partnership with our customers is more than simply «putting them first». It requires long-term commitment to forging close relationships that create synergies of knowledge, security and adaptability to create a successful, shared future.

With care

Sustainability is a fundamental part of our corporate and business strategy. We see a better world in which our innovations help reduce consumption of natural resources and improve the quality of life for people everywhere. We are identifying the long-term trends that affect our markets and looking to see how products and applications can play a part in supporting and providing solutions to the challenges those markets face.





We value
your
challenge

Huntsman Advanced Materials

Our Advanced Materials division is a leading global chemical solutions provider with a long heritage of pioneering technologically advanced epoxy, acrylic, phenolic and polyurethane-based polymer products.

Our capabilities in high-performance adhesives and composites, delivered by more than 1 600 associates, serve over 2 000 global customers with innovative, tailor-made solutions and more than 1 500 products which address global engineering challenges.

We operate synthesis, formulating and production facilities around the world



Find the right adhesive to fulfill your needs



www.AralditeAdhesives.com

HUNTSMAN

Enriching lives through innovation

For more information

www.huntsman.com/advanced_materials
advanced_materials@huntsman.com

Europe, Middle East & Africa

Huntsman Advanced Materials (Switzerland) GmbH
Klybeckstrasse 200
P.O. Box
4002 Basel
Switzerland
Tel. +41 61 299 1111
Fax +41 61 299 1112

Asia Pacific & India

Huntsman Advanced Materials (Guangdong) Co., Ltd.
Room 4903-4906, Maxdo Centre,
8 Xing Yi Road,
Shanghai 200336,
P.R.China
Tel. + 86 21 2325 7888
Fax + 86 21 2325 7808

Americas

Huntsman Advanced Materials Americas Inc.
10003 Woodloch Forest Drive
The Woodlands
Texas 77380
USA
Tel. +1 888 564 9318
Fax +1 281 719 4047

Legal information

All trademarks mentioned are either property of or licensed to Huntsman Corporation or an affiliate thereof in one or more, but not all, countries.

Sales of the product described herein ("Product") are subject to the general terms and conditions of sale of either Huntsman Advanced Materials LLC, or its appropriate affiliate including without limitation Huntsman Advanced Materials (Europe) BVBA, Huntsman Advanced Materials Americas Inc., or Huntsman Advanced Materials (Hong Kong) Ltd. or Huntsman Advanced Materials (Guangdong) Ltd. ("Huntsman"). The following supercedes Buyer's documents. While the information and recommendations included in this publication are, to the best of Huntsman's knowledge, accurate as of the date of publication, NOTHING CONTAINED HEREIN IS TO BE CONSTRUED AS A REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, NON-INFRINGEMENT OF ANY INTELLECTUAL PROPERTY RIGHTS, OR WARRANTIES AS TO QUALITY OR CORRESPONDENCE WITH PRIOR DESCRIPTION OR SAMPLE, AND THE BUYER ASSUMES ALL RISK AND LIABILITY WHATSOEVER RESULTING FROM THE USE OF SUCH PRODUCT, WHETHER USED SINGLY OR IN COMBINATION WITH OTHER SUBSTANCES. No statements or recommendations made herein are to be construed as a representation about the suitability of any Product for the particular application of Buyer or user or as an inducement to infringe any patent or other intellectual property right. Data and results are based on controlled conditions and/or lab work. Buyer is responsible to determine the applicability of such information and recommendations and the suitability of any Product for its own particular purpose, and to ensure that its intended use of the Product does not infringe any intellectual property rights.

The Product may be or become hazardous. Buyer should (i) obtain Material Safety Data Sheets and Technical Data Sheets from Huntsman containing detailed information on Product hazards and toxicity, together with proper shipping, handling and storage procedures for the Product, (ii) take all steps necessary to adequately inform, warn and familiarize its employees, agents, direct and indirect customers and contractors who may handle or be exposed to the Product with all safety information contained in the applicable Material Safety Data Sheets, Technical Data Sheets or other instructions provided by Huntsman and all applicable laws, regulations and standards relating to the handling, use, storage, distribution and disposal of and exposure to the Product. Please note that products may differ from country to country. If you have any queries, kindly contact your local Huntsman representative.

© 2018 Huntsman Corporation. All rights reserved.
Ref. No. AdMat Wind selector guide 03.18_EN_EU



Registered for
REACH