3M™ Wind Blade Bonding Adhesive W1101

Description

3M™ Wind Blade Bonding Adhesive W1101 is a two-part structural epoxy paste adhesive for bonding composite wind turbine blades. This high performance, toughened adhesive combines outstanding shear and peel strength along with excellent durability.

This adhesive has been certified by Germanischer Lloyd (GL) as a duromeric adhesive (approval number WP 1140008 HH).

Features

3M Wind Blade Bonding Adhesive W1101 provides the following benefits compared to standard epoxy wind blade adhesives:

- Faster cure speed
- Equivalent pot life
- Reduced exotherm
- Improved toughness and crack resistance

Unless indicated otherwise, all properties were measured at room temperature (23°C) and 50% relative humidity with adhesive that was cured for 4 hours at 70°C.

Note: The following information and data should be considered representative or typical only, and should not be used for specification purposes.

Typical Uncured Physical Properties

	Part B (Base) Resin	Part A (Accelerator) Hardener/Curative
Chemistry	Epoxy	Amine
Color	Black	White
Density	1.32 g/cm^3	1.29 g/cm^3
Viscosity	Thixotropic Paste	Thixotropic Paste
Mix Ratio (by Weight)	100 parts B	44 parts A
Mix Ratio (by Volume)	100 parts B	45 parts A
Pot Life	2 hours at 30°C	

Notes: 1. Density measured using a helium gas pycnometer with 135 kPa fill pressure.

2. Pot life evaluated using two methods: (a) viscosity build until mixed adhesive becomes difficult to apply and (b) decrease in shear strength from single lap shear bonds made using mixed adhesive.

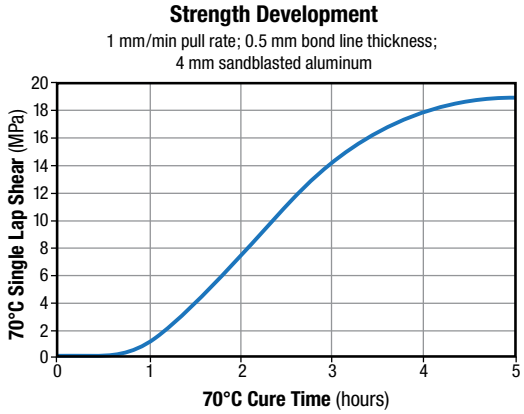
Typical Properties During Cure

Properties	Value
Exotherm	245 J/g
Linear Shrinkage During Cure	<1%

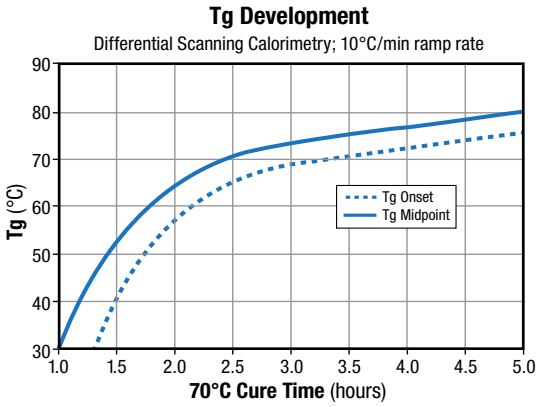
Notes: 1. Exotherm measured using Differential Scanning Calorimetry (DSC) with a 10°C/min ramp rate.

2. Linear shrinkage during cure calculated from measured densities of the mixed adhesive both before and after cure.

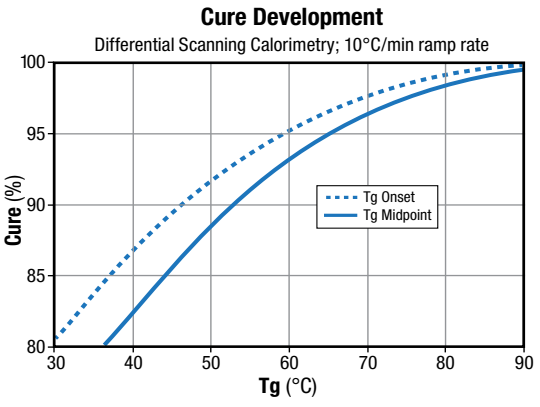
Rate of Strength Build



Rate of Tg Build



Rate of Cure Build



Note: Cure determined from residual enthalpy of reaction after DSC scan as compared to uncured adhesive.

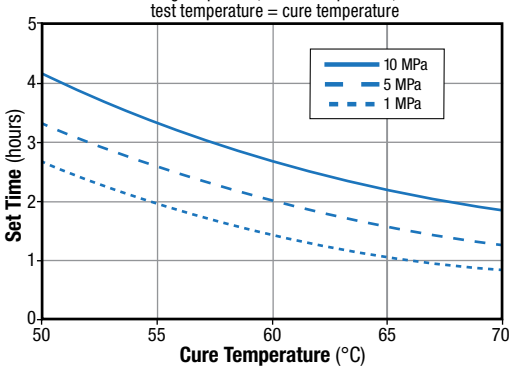
Typical Cured Physical Properties

Properties		Value	
Color		Grey	
Density		1.33 g/cm^3	
Viscosity		Non-sag Thixotropic Paste	
Single Lap Shear	Temperature	23°C	50°C
	Steel	39 MPa CF	27 MPa CF
	Aluminum	26 MPa CF	22 MPa CF
	Epoxy Composite (glass fiber)	23 MPa CF/SF	22 MPa CF/SF
	Epoxy Composite (carbon fiber)	30 MPa CF	25 MPa SF/CF
	Failure Modes	SF=Substrate failure	CF= Cohesive failure
Floating Roller Peel		Aluminum (etched)	5.2 N/mm
T-Peel		Aluminum (etched)	4.1 N/mm
Toughness		Critical Stress Intensity Factor (K_{IC})	2.5 MPa√m
		Fracture Energy (G_{IC})	2,100 J/m^2
Glass Transition Temperature (Tg)		Onset	74°C
		Midpoint	77°C
Coefficient of Thermal Expansion		60 × 10^{-6}/°C	
Shore D Hardness		80	

Notes:
1. Single lap shear values measured using DIN 1465/ISO 4587 test method "Adhesives – Determination of Tensile Lap Shear Strength of Rigid-to-Rigid Bonded Assemblies;" 0.5 mm bond line thickness; samples pulled at 1 mm/min; all surfaces are prepared with sandblasting followed by a tissue wipe using IPA/water to remove loose debris; substrates for overlap shear testing were 4 mm thick steel, 4 mm thick aluminum, 3.3 mm thick glass-fiber composite, and 3.3 mm thick carbon-fiber composite.
2. Floating roller peel values measured using ISO 4578 test method "Adhesives – Determination of Peel Resistance of High-Strength Adhesive Bonds–Floating Roller Method;" 0.5 mm bond line thickness; samples pulled at 100 mm/min.
3. T-Peel values measured using ISO 11339 test method "Adhesives – T-Peel Test for Flexible-to-Flexible Bonded Assemblies"; 0.5 mm bond line thickness; samples pulled at 100 mm/min.
4. Toughness values evaluated using ISO 13586 test method "Plastics – Determination of Fracture Toughness (G_{IC} and K_{IC}) – Linear Elastic Fracture Mechanics (LEFM) Approach."
5. Glass transition temperature measured using differential scanning calorimetry (DSC) with a 10°C/min ramp rate.
6. Coefficient of thermal expansion measured using a thermomechanical analyzer over the temperature range from -40°C to 50°C.
7. Hardness values measured using ASTM D2240 "Standard Test Method for Rubber Property – Durometer Hardness".

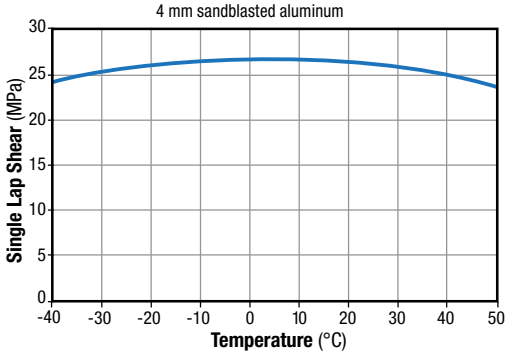
Set Times

Set Times
Single lap shear; 1 mm/min pull rate;
test temperature = cure temperature



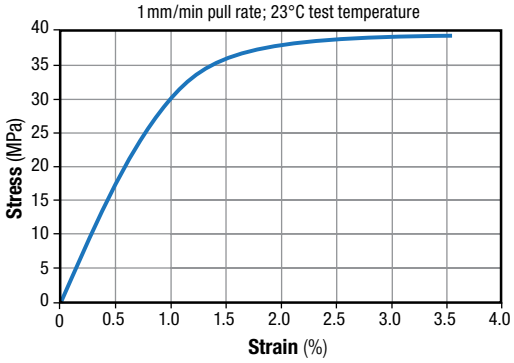
Shear Properties

Single Lap Shear vs. Temperature
1 mm/min pull rate; 0.5 mm bond line thickness;
4 mm sandblasted aluminum



Tensile Properties

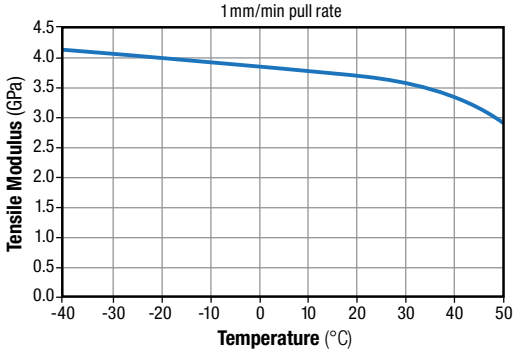
Tensile Stress-Strain Curve
1 mm/min pull rate; 23°C test temperature



Properties	Value
Tensile Modulus	3.7 GPa
Tensile Strength	39 MPa
Tensile Strain at Break	3.5%

Note: Tensile properties measured using ISO 527 test method "Plastics – Determination of Tensile Properties" and Type IV test specimens made according to ASTM D638 Test Method "Standard Test Method for Tensile Properties of Plastics;" 3.5 mm thick adhesive specimens.

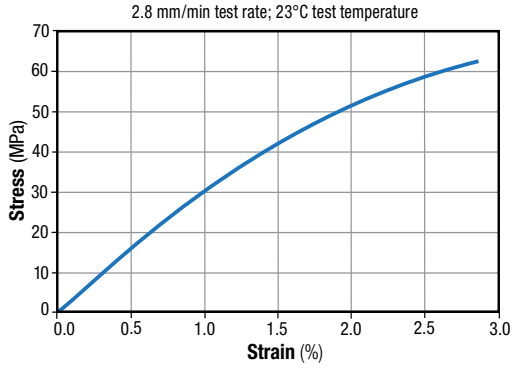
Tensile Modulus vs. Temperature
1 mm/min pull rate



Flexural Properties

Flexural Stress-Strain Curve

2.8 mm/min test rate; 23°C test temperature



Properties	Value
Flexural Modulus	3.2 GPa
Flexural Strength	63 MPa
Flexural Strain at Break	2.9%

Note: Flexural properties measured using ASTM D790 test method "Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials"; 6.4 mm thick adhesive specimens; 102 mm span between supports.

Environmental Resistance

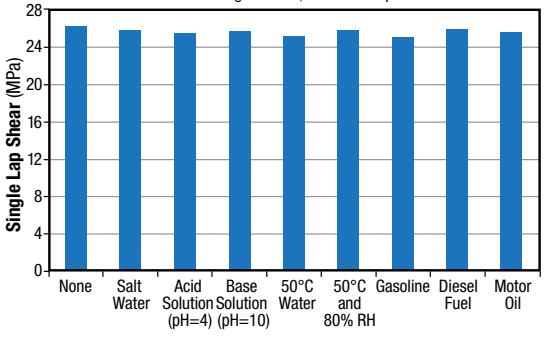
Shear strength retention after 1,000 hours exposure to a wide variety of environments.

Properties		Value
Single Lap Shear	None	26 MPa
	Salt water	26 MPa
	Acid solution (pH=4)	26 MPa
	Base solution (pH=10)	26 MPa
	50°C water	25 MPa
	50°C and 80% relative humidity	26 MPa
	Gasoline	25 MPa
	Diesel fuel	26 MPa
	Motor oil	26 MPa

Note: Single lap shear values measured using DIN 1465/ISO 4587 test method "Adhesives – Determination of Tensile Lap Shear Strength of Rigid-to-Rigid Bonded Assemblies;" 0.5 mm bond line thickness; samples pulled at 1 mm/min; sandblasted 4 mm thick aluminum substrates; samples pulled within 1 hour after removal from environment.

Environmental Resistance

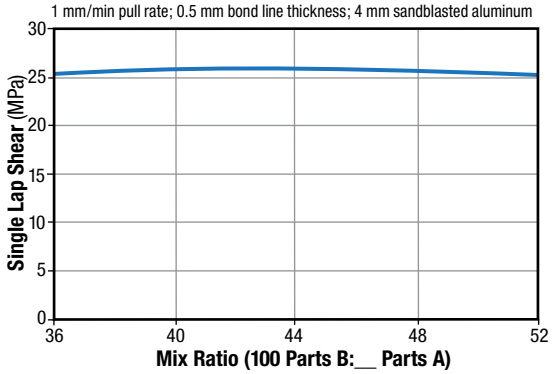
Shear strength after 1,000 hours exposure



Mix Ratio Tolerance

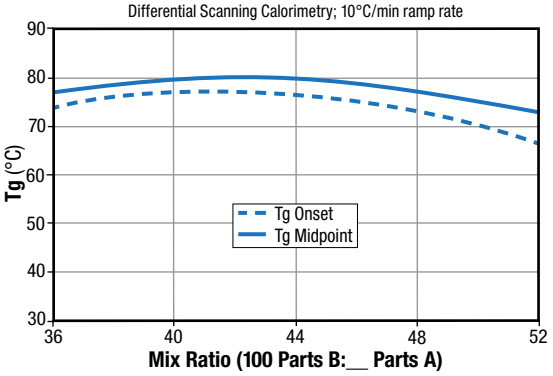
Single Lap Shear vs. Mix Ratio

1 mm/min pull rate; 0.5 mm bond line thickness; 4 mm sandblasted aluminum



Tg vs. Mix Ratio

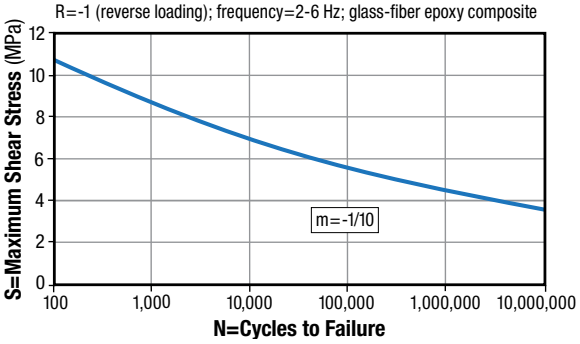
Differential Scanning Calorimetry; 10°C/min ramp rate



Cyclic Load Resistance

Cyclic Load Resistance

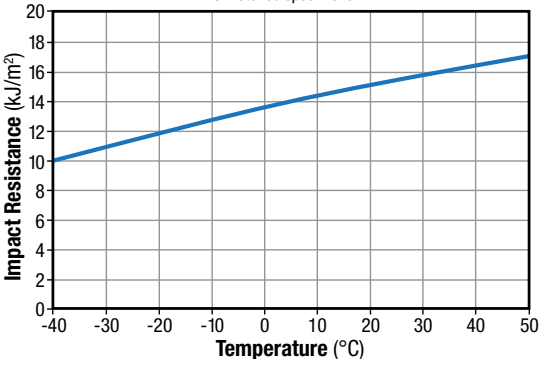
R=-1 (reverse loading); frequency=2-6 Hz; glass-fiber epoxy composite



Impact Resistance

Charpy Impact

Unnotched specimens



Note: Impact resistance values measured using ISO 179-2 test method "Plastics – Determination of Charpy Impact Properties;" 80 mm × 10 mm × 4 mm unnotched adhesive specimens.

Directions for Use

1. To obtain high strength structural bonds, all surfaces must be clean, rough, and dry. For molded composite laminates, these conditions can typically be achieved using a peel-ply material that must be removed immediately prior to adhesive application. Otherwise, the surface must be prepared using the following procedure:

A. Dust, mold release agents, oils, and all other surface contaminants must be completely removed using a solvent or some other degreaser.*

B. The surface must then be lightly abraded using either Scotch-Brite™ pads or fine to medium grit sandpaper to increase surface area and remove gloss.

C. The loose debris from abrasion must then be removed using a clean cloth and solvent (such as a 50:50 mixture of isopropyl alcohol and water).*

2. The two adhesive components must be thoroughly mixed using either the weight or volume mix ratio specified in this document. Adequate mixing can typically be achieved using meter-mix dispensing equipment with a static mixing nozzle. The mixed adhesive should be a uniform medium grey color with no streaks.

3. The mixed adhesive should be applied to the bond area, and the two surfaces mated together, before the pot life stated in this document expires. The joined parts must be kept from moving around, using contact pressure or clamps to fix the parts in place, during the cure process. Optimal bond line thickness ranges from 0.5 to 10 mm.

4. Although this two-part epoxy adhesive will cure at room temperature, a thermal cure will be necessary to achieve the Tg and elevated temperature mechanical properties typically desired for many applications. The preferred cure cycle for this product is 4 hours at 70ºC actual temperature at the adhesive bond. Other times and temperatures are possible depending on the exact cure conditions and performance attributes desired; the optimal cure cycle will need to be determined for each specific application.

* **Note:** When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use. Use solvents in accordance with local regulations.

Equipment

3M™ Wind Blade Bonding Adhesive W1101 is a highly viscous, thixotropic paste adhesive that provides excellent non-sag properties, even when applied on a vertical surface at elevated temperatures. The ability to pump this adhesive has been confirmed on meter/mix systems from leading equipment manufacturers.

Storage

Store products at 15-25ºC for maximum shelf life. Opened containers with leftover adhesive should be resealed after applying a nitrogen purge of the headspace.

Shelf Life

This product has a shelf life of 24 months from the date of manufacture when stored in the original sealed containers at room temperature.

Precautionary Information

Refer to the product label and Material Safety Data Sheet for health and safety information before using this product. For additional health and safety information, call 1-800-364-3577 or (651) 737-6501.

For more information on our wind energy product line, contact 3M Renewable Energy at 800-755-2654 or visit us at www.3M.com/wind.

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