HUNTSMAN

Structural Adhesives

XD 4733 and XD 4734 with Hardeners XD 4735 and XD 4741-1

Epoxy assembly adhesives for wind turbine blades

Key properties

- **Excellent slump resistance in thick sections**
- **Long working time before gelation with hardener XD 4735**
- **Low exotherm with hardener XD 4735**
- **Faster curing with hardener XD 4741-1**
- **Easy to mix and pump**
- **Approved by Germanische Lloyd for bonding epoxy composite blades**

Description

XD 4733 with XD4735 and XD 4734 with XD 4735 are two component room temperature curing epoxy adhesives, particularly suitable as assembly adhesives for wind turbine blades and similar large structures. The adhesives are designed for application by machine or by hand, and allow a working time of 2 hours before pressure is applied for curing. For optimal properties a post-cure at >50ºC is recommended.
Both adhesives are highly thixotropic and can be applied in heavy beads on vertical surfaces without slumping.
XD 4734 with XD 4735 gives a softer product which requires less pressure to squeeze the adhesive beads for mold closure, but as a consequence is slightly lower in thixotropy than XD 4733 with XD 4735
XD 4734 with XD 4741-1 is a faster setting adhesive for use in intermediate assembly stages, which can then be post-cured during the curing of the final bonded assembly

Typical product data

	XD 4733 and XD4734	XD 4735 and XD 4741-1	Mixed Adhesive
Colour (visual)	Yellow	Blue (XD 4735) Red (XD 4741 – 1)	Green (XD 4735) Brown (XD4741-1)
Specific gravity	ca. 1.25	ca. 1.05	ca. 1.2
Viscosity (Pas) at 25°C	Soft thixotropy	soft thixotropy	Highly thixotropic
Pot Life - (100 gm at 25°C) with XD 4735	-	-	ca 4½ hours
- (5cm radius half round bead)	-	-	ca. 2½ hours
-	-	-	ca 20 minutes
Pot Life - (100 gm at 25°C) with XD 4741-1 - (5cm radius half round bead)	-	-	ca 10 minutes

Processing

Pretreatment

The strength and durability of a bonded joint are dependent on proper treatment of the surfaces to be bonded.

Mix ratio	Parts by weight	Parts by volume
XD 4733 or XD 4734	100	100
XD 4735 or XD 4741-1	33	40

Resin and hardener should be blended until they form a homogeneous mix.

Application of adhesive

The resin/hardener mix is mixed with a mix-meter machine and is applied by extrusion to the dry joint surfaces. A bead of adhesive of 5 - 10cm diameter can be applied. The joint components should be assembled and clamped as soon as the adhesive has been applied, remaining within the working life of 2½ hours (or 10 minutes when using XD4741-1) in an uncompressed bead at 23°C. An even contact pressure throughout the joint area will ensure optimum cure.

In order to achieve the longest possible working life after machine mixing the adhesive components should be maintained at 15 - 20°C. Excessive "shear" heating in the pumping systems must also be avoided. Ideally the mixed adhesive should have a temperature of 17 - 23°C for optimal working life.

Mechanical processing

Specialist firms have developed metering, mixing and spreading equipment that enables the bulk processing of adhesive. We will be pleased to advise customers on the choice of equipment for their particular needs.

Equipment maintenance

All tools should be solvent cleaned before adhesives residues have had time to cure. The removal of cured residues is a difficult and time-consuming operation. Environmentally safe cleaning agents are widely available (Citrasolve, Lemsolve, etc), but if solvents such as acetone are used for cleaning, operatives should take the appropriate precautions and, in addition, avoid skin and eye contact.

Typical curing times (Using XD 4735 hardener)

The minimum curing time for light handling will depend on the temperature at which the adhesive is cured. The adhesive is designed to give a safe handling strength after a cure of 3 hours at 60°C, but curing can be made at any temperature greater than 15°C. Full strength will be achieved only after exposure to temperatures of >50°C, and therefore, whilst the adhesive will harden at room temperature, curing by heating at 60 - 70°C is recommended.

Cure temperature	**XD 4735 hardener**	
	Time to 1 N/mm²	**Time to 10 N/mm²**
23°C	15 hours	75 hours
40°C	9 hours	12 hours
60°C	1½ hours	3 hours
80°C	30 minutes	1 hour

Cure measured by DSC (Typical Midpoint values for XD 4735 hardener)

Cure temperature	**23°C**	**40°C**	**60°C**	**70°C**
Cure for 1 hour				33
Cure for 2 hours			42°C	56
Cure for 3 hours			50°C	64
Cure for 4 hours			54°C	69
Cure for 6 hours			65°C	
Cure for 8 hours			68°C	
Cure for 10 hours		49°C		
Cure for 24hours		55°C		74
Cure for 7 days	53°C			

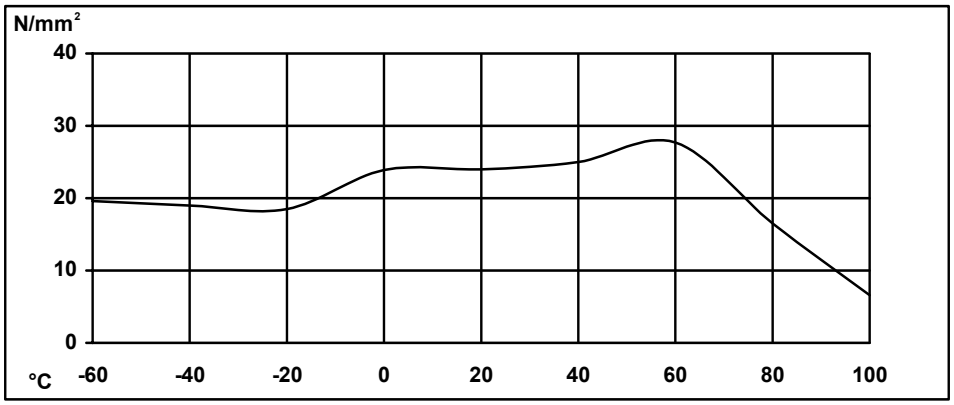
When using XD 4741-1 hardener light handling strength will be obtained in 1 – 2 hours at normal ambient temperatures, but post curing for at least 3 hours at 60°C is essential in order to obtain full properties.
After this curing schedule a midpoint Tg of ca 71°C is obtained with the combination XD 4734/XD 4741-1

Typical Bonding strengths

Single lap shear strength (Chromic acid etched aluminium)	cure 2 hours/70°C	26 N/mm²
	cure 3 hours/70°C	28 N/mm²
	cure 4 hours/70°C	30 N/mm²
Single lap shear strength (Grit blasted stainless steel)	cure 16 hrs/40°C	23 N/mm²
Single lap shear strength on cured Prepreg (Hexcel M11)	cure 3 hours at 70°C	10 N/mm²
Double lap shear strength on epoxy laminate cured 4 hours at 70°C. Tested at -20°C		15 N/mm²
	Tested at 23°C	17 N/mm²
	Tested at 50°C	17 N/mm²

Typical roller peel strength (Chromic acid etched aluminium) when fully cured 5 - 6 N/mm

Lap shear strength variation vs. Temperature (tested on chromate treated aluminium)



Mechanical strength

Tensile strength at 23°C	ca 70 MPa
E modulus (Tensile at 23°C)	ca 4 GPa
Elongation at break	3%
Tensile strength at 60°C	ca 24 MPa
E Modulus (Tensile at 60°C)	ca 2.5 GPa

Heat Distortion temperature	after curing 4 hours at 60°C (1.8 MPa load)	58°C
	after curing 3 hours at 70°C (1.8 MPa load)	64°C
	after curing 4 hours at 70°C (1.8 MPa load)	66°C
	after curing 4 hours at 70°C (0.45 MPa load)	70°C
	fully cured (0.45 MPa load)	73°C

Maximum Glass transition temperature (DSC) midpoint

after curing 3 hours at 70°C	63°C
after curing 4 hours at 70°C	68°C
fully cured	79°C

Peak exotherm in 150g bulk in insulated container 70°C

Sag resistance - 5cm bead on vertical surface No sagging

Linear shrinkage during curing ca 0.2% after full post-cure.

Environmental resistance

90 day immersion tests indicate virtually no loss of strength after 90 days exposure to lubricating oils, fuels, and water at 23°C or to Tropical humidity (DIN 50015 40/92)

Impact strength

Cured 3 hours at 70°C	K1c (Jm^{-2})	1.97	G1c (MPa $\sqrt{m}$)	1040

Coefficient of thermal expansion (-50 to +50°C) ca 60 x 10^{-6}

Shear Modulus G' (cured 4 hours at 70°C)

25°C	1.6 GPa
50°C	1.4 GPa
65°C	1.1 GPa

Storage

XD 4733, XD 4734, XD 4735 and XD 4741-1 may be stored for up to 2 years at 2 - 40°C provided the components are stored in sealed containers.

Handling precautions

Caution

Our products are generally quite harmless to handle provided that certain precautions normally taken when handling chemicals are observed. The uncured materials must not, for instance, be allowed to come into contact with foodstuffs or food utensils, and measures should be taken to prevent the uncured materials from coming in contact with the skin, since people with particularly sensitive skin may be affected. The wearing of impervious rubber or plastic gloves will normally be necessary; likewise the use of eye protection. The skin should be thoroughly cleansed at the end of each working period by washing with soap and warm water. The use of solvents is to be avoided. Disposable paper - not cloth towels - should be used to dry the skin. Adequate ventilation of the working area is recommended. These precautions are described in greater detail in the Material Safety Data sheets for the individual products and should be referred to for fuller information.

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