



**GE Energy**  
Materials and Processes Engineering

MATERIAL SPECIFICATION

**A50WE013**

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**EPOXY HLU RESIN SYSTEM**

**DOCUMENT REVISION STATUS: DETERMINED BY THE LAST ENTRY IN THE "REV" AND "DATE" COLUMN**

REV.	DESCRIPTION	SIGNATURE	REV. DATE
B	SPECIFICATION FORMAT REVISED TO REFLECT P28A-WE-0001 CHANGES; LAMINATE PROPERTY REQUIREMENTS NOW DETERMINED BY FABRIC SPECIFICATIONS; REVISED TEST METHODS TO REFLECT CURRENT BEST PRACTICES; ADDED CAV FORM; REVISION SEQUENCE WAS CHANGED FROM NUMERIC TO ALPHA DUE TO REQUIREMENTS IN DWB; THEREFORE, REVISION 1 IS SUPERSEDED BY REVISION B; DCI NO. 09018026. (SA KYRIAKIDES)	CR TRIPEPI	2009 JUN 25

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## **EPOXY HLU RESIN SYSTEM**

### **1. SCOPE**

- 1.1 This specification provides the functional requirements for the epoxy resin system used in the hand lay-up (HLU) applications and repair processes for wind turbine rotor blades. The resin system features three distinct processing times, depending on which hardener is used, which are classified as fast, standard, or slow.

### **2. APPLICABLE DOCUMENTS**

- 2.1 The following documents shall form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue shall apply.

#### **2.1.1 American Society for Testing and Materials**

D 638	Standard Test Method for Tensile Properties of Plastics
D 790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D 1824	Standard Test Method for Apparent Viscosity of Plasticsols and Organosols at Low Shear Rates
D 2471	Standard Test Method for Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins
D 3418	Standard Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry

#### **2.1.2 International Standard Organization**

ISO 178	Plastics - Determination of flexural properties
ISO 527-2	Plastics - Determination of tensile properties - Part 2: Test conditions for molding and extrusion plastics



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ISO 3219

Plastics - Polymers/resins in the liquid state or as emulsions or dispersions - Determination of viscosity using a rotational viscometer with defined shear rate

### 2.1.3 GE Wind Energy Standards

A50WE001	Layered Glass Fabric $\pm 45^\circ$ 1000 g/m <sup>2</sup> Biax
A50WE005	Layered Glass Fabric 1000 g/m <sup>2</sup> UD
A50WE007	Layered Glass Fabric $\pm 45^\circ$ 800 g/m <sup>2</sup> Biax
A50WE018	Roving - 2400 Tex
P28A-WE-0001	Composite Wind Blade Supplier Qualification Requirements

## 3. DEFINITIONS

### 3.1 Personnel

- 3.1.1 Purchaser - GE Wind Energy or its Business Associate.
- 3.1.2 External Supplier - The corporation, company, partnership, sole proprietorship or individual engaged to perform the process covered by this Specification.
- 3.1.3 Internal Supplier - Any GE Wind Energy Manufacturing Department.
- 3.1.4 Supplier - As used herein, unless specifically designated, refers to either an External or an Internal Supplier.
- 3.1.5 MPE - Member of the GE Energy Materials & Processes Engineering organization.
- 3.1.6 Sub Tier Supplier - Any supplier that has been approved to supply to GEWE blade manufactures.
- 3.1.7 GE SQE - A Sourcing Quality Engineer for the General Electric Company.



### 3.2 Technical Terms

- 3.2.1 Lot/Batch - A Batch is all the material produced during one shift of production where the lot of each component is the same throughout. When a batch process is used, a Lot is all the material processed through a single cycle.
- 3.2.2 Room Temperature (RT) - Room temperature is defined as  $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ .
- 3.2.3 Sample - Sample is defined as one test coupon.
- 3.2.4 Resin Cure Cycle - The cure cycle for all qualification material will reflect the resin manufacturer's intended cure procedure.
- 3.2.5 Laminate - A laminate is defined as a composite panel composed of multiple layers glass fibers or fabrics in an epoxy resin matrix. Panel fabrication for a given reinforcement material is described in that material's GE specification.
- 3.2.6 Neat Resin - A prepared sample that consists of 100% resin, either cured or uncured, depending on the test desired. For cured resin samples, follow the curing cycle described in 3.2.4.
- 3.2.7 Pot Life - The time it takes 300 g of the resin and hardener mixture at room temperature to reach  $50\text{ }^{\circ}\text{C}$ .
- 3.2.8 CAV form - A Characteristic Accountability and Verification (CAV) form is a record of actual product characteristic values verified against applicable drawing and specifications in order to determine production product inspection levels and acceptance requirements. The characteristics may be in the form of dimensions, form, function, note compliance, mechanical testing results, etc.



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#### 4. REQUIREMENTS

##### 4.1 Functional Requirements

##### 4.1.1 Properties (as uncured neat resin)

**TABLE 1 – PROPERTIES (AS-RECEIVED RESIN)**

Para.	Property	Requirement	Test Method
4.1.1.1	Viscosity, cp, at RT	250 – 1000	5.3.1
4.1.1.2	Pot life, minutes		5.3.2
	Fast hardener	5-15	
	Standard hardener	15-25	
	Slow hardener	180-240	
4.1.1.3	Gel time, minutes, at 35 °C, min	30	5.3.3
4.1.1.4	Glass transition temperature, (T <sub>g</sub> ), °C, min	65	5.3.4
4.1.1.5	Density, g/cm <sup>3</sup> , max	1.2	5.3.5

##### 4.1.2 Mechanical Properties (as cured neat resin)

**TABLE 2 – MECHANICAL PROPERTIES (AS NEAT RESIN)**

Para.	Property	Requirement	Test Method
4.1.2.1	Tensile strength, ultimate, MPa	70	5.3.6.1
4.1.2.2	Tensile modulus, MPa	3000	5.3.6.1
4.1.2.3	Tensile strain, %	5.0	5.3.6.1
4.1.2.4	Flexural strength, MPa	110	5.3.6.2

4.1.3 Mechanical Properties (of laminates) – See Requirements sections of A50WE001, A50WE005, A50WE007, and A50WE018. A completed CAV form from each of these specifications must be submitted.



## 5. QUALITY ASSURANCE PROVISIONS

5.1 See the Material Certification section of P28A-WE-0001 for GE material qualification requirements.

### 5.2 Incoming Inspection and Test Requirements

5.2.1 Visual - Every lot shall be inspected for visual defects such as dirt, metallic particles, crystals, unmixed liquids, or other contaminants. The material shall be free of any such defects.

5.2.2 Viscosity - Measure viscosity of each lot per section 5.3.1.

5.2.3 Pot Life - Determine the pot life of each lot per section 5.3.2.

5.2.4 Glass Transition Temperature - Measure the  $T_g$  of each lot per section 5.3.4.

### 5.3 Test Methods

5.3.1 Viscosity - Viscosity on the catalyzed resin shall be measured using a Brookfield viscometer either in accordance with ASTM D1824 or in accordance with ISO 3219.

5.3.2 Pot life - Allow both resin and hardener to stabilize at RT, separately, for a minimum of 24 hours. Mix a total of 300 g resin and catalyst in a 500 mL beaker. Measure time versus temperature from completion of mixing until exotherm is complete by using a thermocouple or IR device. Report the time from initial mixing until the resin/catalyst mix's temperature rises to 50 °C.

5.3.3 Gel Time - Perform test in accordance with ASTM D 2471 and report the test results per the test standard.

5.3.4 Glass transition temperature – Report the cure cycle used for manufacturing samples. Perform test in accordance with ASTM D 3418. Report the onset and midpoint  $T_g$  for both scans. Both must exceed requirement.

5.3.5 Density - Report the density of both the uncured resin system and the cured resin system. Follow test methods and calculations per ASTM D792.



### 5.3.6 Mechanical Properties

- 5.3.6.1 Neat resin tensile properties (strength, modulus, strain) - Perform testing in accordance with ASTM D638 (ISO 527-2 can be substituted with Purchaser's approval). All stocks for specimens are to be manufactured and cured in accordance with section 3.2.4. Edges must also be free of notches, undercuts, rough and uneven surfaces. Take a minimum of 3 measurements of width and thickness, averaging these for use in calculations. Calculate tensile strength, modulus and strain using proper test methods and equations. A minimum of 10 samples is to be tested for material qualification.
- 5.3.6.2 Neat resin flexural properties (strength) - Perform test in accordance with ASTM D790 (ISO 178 can be substituted with Purchaser's approval). All stock for specimens is to be manufactured and cured in accordance with section 3.2.4. Width edges and front and rear surfaces must be parallel within 0.05 mm. Edges must also be free of notches, undercuts, rough and uneven surfaces. Calculate flexural strength using proper test method and equation. A minimum of 10 samples is to be tested for material qualification.

### 5.4 Certificate of Test

- 5.4.1 Internal Supplier - The Internal Supplier shall submit the Certificate of Test to Manufacturing Quality Assurance.
- 5.4.2 External Supplier - The External Supplier shall submit the Certificate of Test to the Purchaser address shown on the Purchase Order.
- 5.4.3 A Certificate of Test shall be submitted for each Lot stating that the components were processed in accordance with the requirements of this Specification and other applicable documents. The Certificate shall be signed and dated by an authorized Supplier Representative and shall, as a minimum, include the following information:
- Supplier Name, Address and GE Specification Number
  - Product Identification Number
  - Lot Number
  - Date of Manufacture
  - Test and Inspection Data (in accordance with Para. 5.2 of this document.)



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5.4.4 Audit - The Purchaser reserves the right to periodically audit the Supplier's facilities and practices. Such audits shall not relieve the Supplier from the responsibility of producing the material in a suitable condition.

## 6. PREPARATION FOR DELIVERY

### 6.1 Packing and Marking

6.1.1 Material shall be shipped in standard commercial containers that are suitable to meet DOT and carrier regulations and protect against material contamination or damage during shipping and storage.

6.1.2 Each container shall be legibly labeled and include the following:

- Purchase Order Number
- GE Specification Number
- Manufacturer's Name
- Quantity
- Lot Number
- Manufacturing Date
- Appropriate safety and hazard information

## 7. NOTES

None

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**APPENDIX A - EXAMPLE CAV FORM**

Blade Supplier Name		<b>CHARACTERISTIC ACCOUNTABILITY and VERIFICATION</b>					GE MPP NO:			
Product Identification number							GE QUAL NO:			
Materials Supplier							GE/SQE:			
Material Specification Number		A50WE013 rev_B		CAV REV:		-		GE/MPE:		
Units of Measurement:		<b>Metric</b>			REV DATE:		<b>6/25/2009</b>			
Characteristic or Number	Dwg Zone	CTQ Type	Dim. Type	Feature Nominal	Max Limit	Min Limit	Meas. Value or LSL	Accept Plan	Justification <100%	Comments
Viscosity	4.1.1.1	<b>SPEC</b>	RANGE	cp						
Pot life - Fast hardener	4.1.1.2	<b>SPEC</b>	RANGE	minutes						
Pot life - Standard hardener	4.1.1.2	<b>SPEC</b>	RANGE	minutes						
Pot life - Slow hardener	4.1.1.2	<b>SPEC</b>	RANGE	minutes						
Gel time	4.1.1.3	<b>SPEC</b>	MIN	minutes						
T <sub>g</sub> onset	4.1.1.4	<b>SPEC</b>	MIN	°C						
Density	4.1.1.5	<b>SPEC</b>	MAX	g/cm <sup>3</sup>						
Tensile strength	4.1.2.1	<b>SPEC</b>	MIN	MPa						
Tensile modulus	4.1.2.2	<b>SPEC</b>	MIN	MPa						
Tensile strain	4.1.2.3	<b>SPEC</b>	MIN	%						
Flexural strength	4.1.2.4	<b>SPEC</b>	MIN	MPa						
CAV form: A50WE001	4.1.3	<b>SPEC</b>		See spec						
CAV form: A50WE005	4.1.3	<b>SPEC</b>		See spec						
CAV form: A50WE007	4.1.3	<b>SPEC</b>		See spec						
CAV form: A50WE018	4.1.3	<b>SPEC</b>		See spec						