Starting Formulation

SF 8039

Toughened Epoxy Resin Systems for Filament Winding

Epoxy Research Resin RSL-4515 / EPIKURE™ Curing Agent 3300 and Epoxy Research Curing Agent RSC-4577

Introduction

Epoxy Research Resin RSL-4515/EPIKOTE Curing Agent 3300 or Epoxy Research Curing Agent RSC-4577 is based on a toughened epoxy cured with very low viscosity cycloaliphatic amines. The systems low viscosity and high toughness make it favorable for good fiber wet-out for filament wildings for all composite pressure vessels (including Type IV vessels). It will allow the manufacture of an all carbon tank without increase in cost (via reduction in wall thickness).

Suggested Uses

- Composite Structures
- Pressure Vessels

Features

- Low Viscosity
- Good Elongation
- High Toughness

Typical Properties

Table 1 / Typical Component Properties

	Method	Units	Epoxy Research Resin RSL-4515
Epoxide Equivalent Weight	ASTM D1652	g/eq	177
Viscosity @ 25°C (77°F)	ASTM D1545	cP or mPa·s	5,800
Density @ 25°C (77°F)	ASTM D1475	g/cc	1.18

	Method	Units	EPIKURE Curing Agent 3300
Amine Value	ASTM D 2896	mg KOH/g	630-670
Amine Hydrogen Equivalent Weight	calculated	g/H eq	43
Viscosity @ 25°C (77°F)	ASTM D1545	cP or mPa·s	12-19
Color	ASTM D1544	Gardner	250 max.
Density @ 25°C	ASTM D1475	g/cc	0.92

	Method	Units	Epoxy Research Curing Agent RSC-4577
Amine Value	ASTM D 2896	mg KOH/g	400-600
Amine Hydrogen Equivalent Weight	calculated	g/H eq	52
Viscosity @ 25°C (77°F)	ASTM D1545	cP or mPa·s	10-50
Density @ 25°C	ASTM D1475	g/cc	0.93-0.98

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Mix Ratio	Material	1	2
	Epoxy Research Resin RSL-4515, pbw[1]	100	100
	EPIKURE Curing Agent 3300, pbw	24	
	Epoxy Research Curing Agent RSC-4577, pbw		29

[1] pbw = parts by weight

Mixing Instructions

The stated mixing ratio should be followed carefully. Adding more or less hardener than desired will result in an incomplete cure with limited performance that cannot be corrected. Resin and curing agent must be mixed carefully. Mix until no clouding is visible in the mixing container. Special attention must be paid to the walls and bottom of the mixing container when mixing by hand.

Typical System Properties

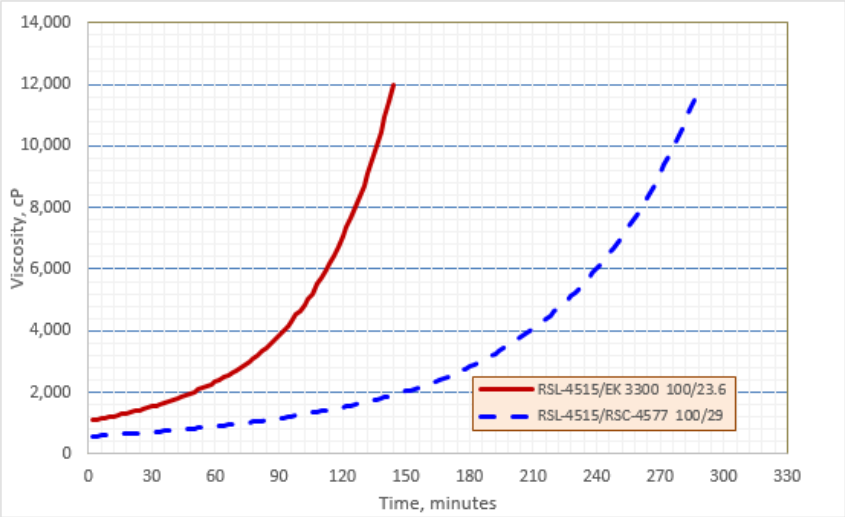
Table 2 / Properties of Resin System	Units	1	2
Viscosity at 25°C (77°F)	cP or mPa·s	1115	573
Pot Life[1] (time to double initial viscosity @ 25°C)	minutes	58	90
Working time[2] at 25°C (77°F)	hrs	115	256
Gel time[3] at 30°C (77°F), 100g	minutes	109	210

[1] Brookfield Viscometer

[2] Time to peak temperature, based on 100g mass

[3] Shyodu gel time

Graph 1 / Viscosity Development @25°C (77°F), 10 grams



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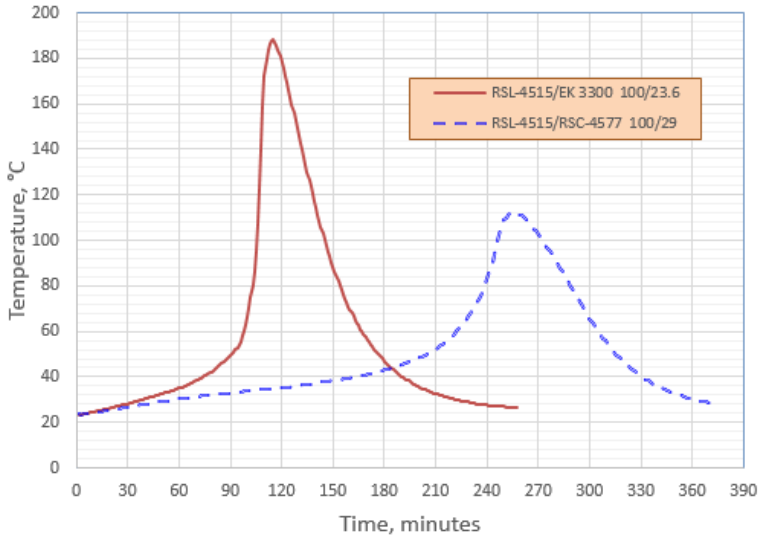
Graph 2 / Temperature Development @25°C (77°F), 100 grams



Typical Cured State Properties

Table 3 / Typical cured properties of neat resin system

Epoxy Research Resin RSL-4515/EPIKURE™ Curing Agent 3300

	Method	Units	1	2
Cure Schedule				
Step 1 followed by		hrs/°C (°F)	1/66 (151)	1.5/82 (180)
Step 2		hrs/°C (°F)	4/96 (205)	1.5/150 (302)
Tg by				
DSC (20°C/min)	ASTM D-3418	°C (°F)	109 (228)	134 (273)
DMA - E' onset	ASTM D-4065	°C (°F)	112 (234)	135 (275)
DMA – tan delta peak		°C (°F)	121 (250)	143 (289)
Tensile				
Strength at Yield	ASTM D-638	ksi	12.6	12.5
Strength at Break		ksi	11.4	11.8
Elongation at Yield		%	5	6
Elongation at Break		%	7	9
Modulus		ksi	472	456
Fracture Toughness, K_Q	ASTM E-399	$psi\text{-}in^{1/2}$	1596	1070

Typical Cured State Properties

Table 4 / Typical cured properties of neat resin system

Epoxy Research Resin RSL-4515/Epoxy Research Curing Agent RSC-4577

	Method	Units	1	2
Cure Schedule				
Step 1 followed by		hrs/°C (°F)	1/66 (151)	1.5/82 (180)
Step 2		hrs/°C (°F)	4/96 (205)	1.5/150 (302)
Tg by				
DSC (20°C/min)	ASTM D-3418	°C (°F)	95 (203)	101 (214)
DMA - E' onset	ASTM D-4065	°C (°F)	96 (205)	98 (208)
DMA – tan delta peak		°C (°F)	104 (219)	109 (228)
Tensile				
Strength at Yield	ASTM D-638	ksi	10.7	11.3
Strength at Break		ksi	9.3	9.1
Elongation at Yield		%	5	5
Elongation at Break		%	10	11
Modulus		ksi	456	452
Fracture Toughness, K_Q	ASTM E-399	psi-in$^{1/2}$	1217	1739

Composite Fabrication / Filament Winding

The low viscosity and long working life of the resin system make it desirable for Filament Winding.

Mixing – A high shear mixer is recommended to insure complete mixing. Mixing time should be kept to a minimum to avoid excess heat build-up of the resin system, as this can reduce the working life of the system.

Resin bath – The resin impregnation bath temperature should be as close to 25 °C (77 °F) as possible to maximize working life. However, slightly elevated temperatures may be required to obtain the appropriate viscosity for fiber wet-out.

Process – A suggested cure cycle would include 1-2 hours at 60-80°C, followed by 1-3 hours at 90-150°C, using a ramp rate of 0.5-2.0°C/minute. The optimum temperatures will depend on parameters such as part thickness.

General Information

These are starting formulations and are not proven in the user's particular application but are simply meant to demonstrate the efficacy of the products and to assist in the development of the user's own formulation. It is the user's responsibility to fully-test and qualify the formulation, along with the ingredients, methods, applications or equipment identified herein ("Information"), by the user's knowledgeable formulator or scientist, and to determine the appropriate use conditions and legal restrictions, prior to use of any Information.

Safety, Storage & Handling

Please refer to the SDS for the most current Safety and Handling information.

Please refer to the Hexion Inc. web site for Shelf Life and recommended Storage information.

Exposure to these materials should be minimized and avoided, if feasible, through the observance of proper precautions, use of appropriate engineering controls and proper personal protective clothing and equipment, and adherence to proper handling procedures. None of these materials should be used, stored, or transported until the handling precautions and recommendations as stated in the Safety Data Sheet (SDS) for these and all other products being used are understood by all persons who will work with them. Questions and requests for information on Hexion Inc. ("Hexion") products should be directed to your Hexion sales representative, or the nearest Hexion sales office. Information and SDSs on non-Hexion, Inc. products should be obtained from the respective manufacturer.

Contact Information

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