

Ancamine® 2167 & 2264 Curing Agents

DESCRIPTION

Ancamine 2167 and 2264 epoxy curing agents exhibit some of the beneficial properties of both cycloaliphatic and aromatic amines. These curing agents are an ideal alternative to aromatic diamines in the elevated temperature cure of epoxy resins.

ADVANTAGES

- Excellent mechanical properties following elevated temperature cure
- Good resistance against acids, alkali, water and hydrocarbon solvents when heat cured
- Ancamine 2167 Curative Advantages
 - Increased fracture toughness and fatigue properties
 - Longer pot life at elevated temperatures
 - Lower viscosity
- Ancamine 2264 Curative Advantages
 - Increased chemical resistance
 - Faster cure

APPLICATIONS

- Structural Composites
 - High Temperature Pipes & Fittings
 - Wind Blades
 - Tanks
 - Casting and Tooling
- Adhesives

STORAGE AND HANDLING

At least 24 months from the date of manufacture in the original sealed container at ambient temperature. Store away from excessive heat and humidity in tightly closed containers.

Material may crystallize or solidify upon exposure to low temperatures.

Crystallized or solidified material can be utilized after melting at elevated temperatures without impacting handling or physical properties. It is recommended that the material be heated to 50-70°C while mixing continuously for 1 hour. Once the solidified material has fully homogenized, it can be cooled to room temperature and utilized under normal conditions.

Refer to the Safety Data Sheets for Ancamine 2167 & 2264 curing agents.

TYPICAL CURE SCHEDULE

- 2 hours at 176°F, then 3 hours at 302°F.
- 2 hours at 80°C, then 3 hours at 150°C.

RECOMMENDED PROCESSING

- Filament Winding
- Wet lay-up Laminates
- Resin Transfer Molding

TABLE 1: TYPICAL PROPERTIES

	Ancamine 2167	Ancamine 2264
Appearance	Clear Liquid	Clear Liquid
Color (Gardner)	3	9
Viscosity @ 77°F / 25°C	210 cPs	2,600 cPs
Specific Gravity @ 77°F/25°C	0.975	1.0
Amine Value (mg KOH/g)	520	502
Flash Point (closed cup)	90°C/194°F	90°C/194°F
Equivalent Wt/{H}	53	54
Use Level (PHR)	30	30

TABLE 2: TYPICAL HANDLING PROPERTIES

	Ancamine 2167	Ancamine 2264
Mixed Viscosity @ 104°F / 40°C	700 cPs	1,020 CPS
Gel Time (150g mix @ 77°F / 25°C)	182 min	181 min
Time to 10,000 cPs @ 104°F / 40°C	84 min	71 min

TABLE 3: THERMAL PERFORMANCE

	Ancamine 2167		Ancamine 2264	
Heat Deflection Temperature (ASTM D648-264)	160°C	320°F	160°C	320°F
Glass Transition Temperature (DSC second scan)	158°C	316°F	158°C	316°F

TABLE 4: MECHANICAL PERFORMANCE - CAST PANEL¹

	Ancamine 2167		Ancamine 2264	
Flexural Strength	131 MPa	19.0 ksi	135 MPa	19.6 ksi
Flexural Modulus	3.0 GPa	0.44 Msi	3.5 GPa	0.51 Msi
Tensile Strength	76 MPa	11.0 ksi	73 MPa	10.6 ksi
Tensile Modulus	2.6 GPa	0.38 Msi	2.7 GPa	0.39 Msi
Tensile Elongation @ Break	6.9%	4.9%	158°C	316°F
Compressive Strength	114 MPa	16.5 ksi	116 MPa	16.8 ksi
Compressive Modulus	2.1 GPa	0.3 Msi	2.5 GPa	0.36 Msi
Fracture Toughness K_{1c}	0.78 MPa.m ^{1/2}	710 psi.in ^{1/2}	0.75 MPa.m ^{1/2}	683 psi.in ^{1/2}
Fracture Toughness G_{1c}	195 J/m ²	1.09 in-lb/in ²	174 J/m ²	0.97 in-lb/in ²
Izod Impact Strength	40.0 J/m	0.2 ft-lb/in	36.0 J/m	0.2 ft-lb/in

TABLE 5: MECHANICAL PERFORMANCE - COMPOSITE PANEL¹

	Ancamine 2167		Ancamine 2264	
ILSS 0° Longitude	73.0 MPa	10.6 ksi	78.0 MPa	11.3 ksi
ILSS 90° Transverse	22.0 MPa	3.2 ksi	30.0 MPa	4.35 ksi
Flexural Strength - Composite 0° Longitude	1083 MPa	157.1 ksi	1040 MPa	150.8 ksi
Flexural Modulus - Composite 0° Longitude	50.0 GPa	7.25 Msi	48.0 GPa	6.96 Msi

Footnotes:

(1) Curing agents formulated with standard Bisphenol-A based (DGEBA, EEW=180) epoxy resin

REFER TO THE MATERIAL SAFETY DATA SHEETS FOR:

LOW TEMPERATURE REACTIVITY AND RAPID DEVELOPMENT OF CURE:

Ancamine[®] 2264 and Ancamine 2167 curing agents are cycloaliphatic amines designed for use with liquid epoxy resins in the fabrication of industrial composites. Ancamine 2264 and Ancamine 2167 curing agents contain polycycloaliphatic poly-amines (high functionality cycloaliphatic amines). Incorporation of polycycloaliphatic polyamines in these curing agents can improve stiffness and elevated temperature performance in cured systems as compared with cycloaliphatic diamine cured systems. Ancamine 2264 and Ancamine 2167 curing agents react readily with epoxy resin at temperatures less than 100°C. This low-temperature reactivity contributes to rapid viscosity build before and during the initial stages of cure. Although rapid viscosity builds before cure can shorten pot life, it can also reduce resin loss during composite part

fabrication. Ancamine 2264- and Ancamine 2167 curative-based formulations used with low-viscosity diglycidyl ether of bisphenol-F (DGEBF) epoxy resins offer a 30 to 40% viscosity reduction compared with standard diglycidyl ether of bisphenol-A (DGEBA) epoxy resin formulations. Such formulations also maintain a 2- to 3-hour pot life.

During the initial stage of cure, the viscosity of the epoxy matrix decreases and then rapidly builds to gelation as the composite part is heated. The magnitude and duration of this initial viscosity drop can influence the loss of matrix resin and/or part integrity. Ancamine 2264 and Ancamine 2167 curing agents exhibit minimal viscosity reduction, with minimum viscosities as much as four times that of an aromatic diamine (methylenedianiline)-cured formulation. Furthermore, as shown in Figure 3, the poly-cycloaliphatic polyamine curing agent formulations begin to increase viscosity rapidly after less than 10 minutes.

The low-temperature reactivity of Ancamine 2264 and Ancamine 2167 curing agents allows for reduced cure times or lower cure temperatures compared with higher activation temperature aromatic diamines. This can translate into higher throughput capability. The recommended cure schedule of 0.5 hours at 176°F (80°C) followed by 1 to 2 hours at 338°F (170°C) is designed to maximize development of cure and productivity. This cure schedule may require adjustment to accommodate part thickness, part geometry or heat transfer.

FIGURE 1
Resin bath behaviors for Ancamine 2264 and Ancamine 2167 with DGEBA epoxy resin

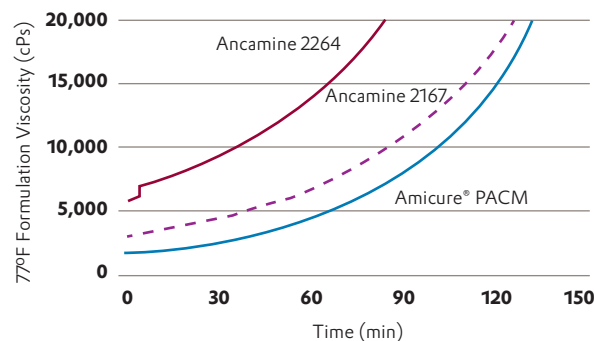


FIGURE 2

Using DGEBF Epoxy Resin with Ancamine 2264 and Ancamine 2167 can reduce formulation viscosity

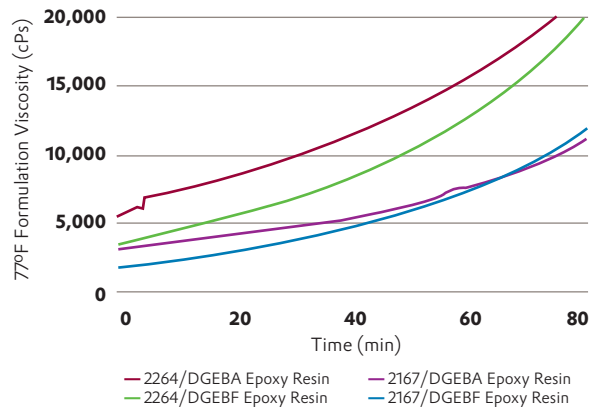
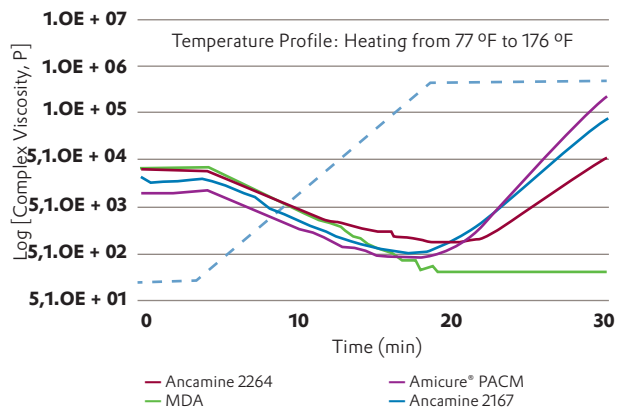


FIGURE 3

Ancamine 2264 and Ancamine 2167 can reduce resin loss during initial stage of cure



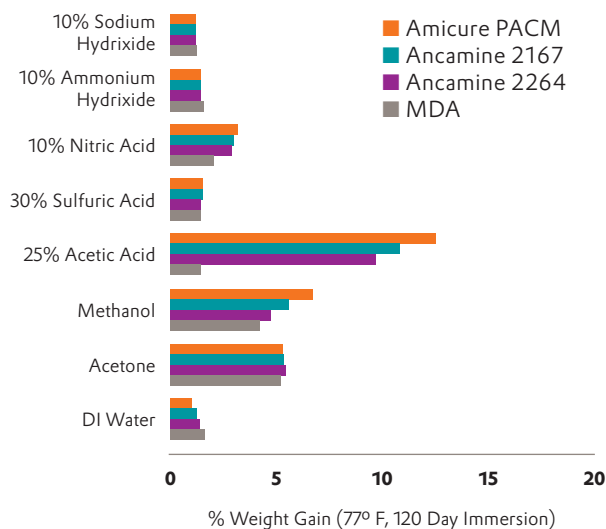
MECHANICAL AND THERMAL PERFORMANCE: Formulations of Ancamine 2264 and Ancamine 2167 curing agents can exhibit the high strength and modulus characteristic of aromatic diamine-cured systems, combined with the ductility and toughness characteristic of cycloaliphatic diamine-cured systems. The strength, modulus and ductility of systems cured with Ancamine 2264- and Ancamine 2167 curatives are further enhanced in presence of toughening agents.

Product	Resin	Cure Schedule	Tensile Strength (MPa)	Tensile Modulus (MPa)	Tensile Elongation @ Break (%)	Fracture Toughness K1C (MPa*m ^{1/2})	Tg°C (DSC second scan)
	DGEBA (EEW=180)	2 hr at 80°C then 3 hrs at 150°C	2,310	79	5.5	710	158
Ancamine 2167	DGEBA (EEW=180)	2 hr at 80°C then 3 hrs at 150°C	2,560	76	6.9	710	163
Ancamine 2264	DGEBA (EEW=180)	2 hr at 80°C then 3 hrs at 150°C	2,670	72	4.9	680	162
Ancamine DL-50 (MDA)	DGEBA (EEW=180)	2 hr at 80°C then 3 hrs at 150°C	2,620	73	4.4	660	160
Amicure PACM	DGEBA (EEW=180)	0.5 hr at 80°C then 2 hrs at 170°C	2,400	79	6.6	--	162
Ancamine 2167	DGEBA (EEW=180)	0.5 hr at 80°C then 2 hrs at 170°C	2,620	76	6.2	--	155
Ancamine 2264	DGEBA (EEW=180)	0.5 hr at 80°C then 2 hrs at 170°C	2,740	74	4.8	--	156

TABLE 6**Amicure PACM: Cured DGEBF Epoxy Resin Can Exhibit Improved Performance vs. DGEBA Epoxy Resin (Cast Panel)**

Product	Resin	Cure Schedule	Tensile Strength (MPa)	Tensile Modulus (MPa)	Tensile Elongation @ Break (%)	Tg°C (DSC second scan)
Ancamine 2167	DGEBF	2 hr at 80°C then 3 hrs at 150°C	2,740	86	8.5	130
Ancamine 2167	DGEBA	2 hr at 80°C then 3 hrs at 150°C	2,560	76	6.9	163
Ancamine 2264	DGEBF	2 hr at 80°C then 3 hrs at 150°C	3,020	92	6.9	130
Ancamine 2264	DGEBA	2 hr at 80°C then 3 hrs at 150°C	2,675	72	4.9	162

CHEMICAL RESISTANCE: DGEBA epoxy resin cured with Ancamine 2264 and Ancamine 2167 curatives exhibits chemical resistance superior to common cycloaliphatic diamine-cured resins. In the case of Ancamine 2264-cured DGEBA epoxy resin, the chemical resistance approaches that exhibited by aromatic amine-cured epoxy resins. The chemical resistance of a system cured with Ancamine 2264 curative can be further enhanced using multifunctional novolac epoxy resins.

FIGURE 4**Polycycloaliphatic Polyamine Curing Agents Exhibit Superior Chemical Resistance****TABLE 7****Amicure PACM: Cured DGEBF Epoxy Resin Can Exhibit Improved Performance vs. DGEBA Epoxy Resin (Cast Panel)**

Reagent	Formulations with DGEBA Epoxy Resin: % Weight Change @ 120 Days, 77° C of Immersion			
	Amicure PACM	Ancamine 2167	Ancamine 2264	MDA
10% Sodium Hydroxide	1.5	1.4	1.5	1.5
10% Ammonium Hydroxide	1.8	1.7	1.8	1.9
10% Nitric Acid	3.8	3.7	3.4	2.5
30% Sulfuric Acid	1.9	1.8	1.8	1.8
25% Acetic Acid	15.0	13.0	11.5	1.8
Methanol	8.0	7.0	5.7	5.0
Acetone	6.4	6.9	6.5	6.2
Toluene	0.7	0.3	0.6	-
Ethanol	1.2	0.4	0.5	-
Deionized Water	1.2	1.6	1.7	1.9

MECHANICAL PROPERTIES OF COMPOSITE PANELS: In addition to the cure cycle and processing conditions used, the selection of an epoxy curing agent is a critical factor in determining the structural integrity of a composite part. Evonik offers a wide selection of amine based curing agents which can be used to maximize load-bearing capabilities, fatigue resistance, and fracture toughness in a fully formulated system. Ancamine 2167 curing agent typically provides 15% higher fracture toughness vs. Ancamine 2264 curative using cast panels. One benefit of Ancamine 2264 curative is that it provides better chemical resistance and a faster cure.

Composite Panel Fabrication
Method: Vacuum Assisted Resin Transfer Molding (VARTM)
Fiber Type: E-glass (275g/m ²) unidirectional
Fiber Volume: 60 ± 3%
Cure Schedule: 1 hr @ 80°C, then 3 hrs @ 150°C

Mechanical Performance Composite Panel	Ancamine 2167		Ancamine 2264	
	SI	English	SI	English
Flexural Strength 0° Longitude (ASTM D790)	1083 MPa	157.1 ksi	1040 MPa	150.8 ksi
Flexural Modulus 0° Longitude (ASTM D790)	50.0 GPa	7.25 Msi	48.0 GPa	6.96 Msi
Flexural Ultimate Strain (ASTM D790)	2.5%		2.4%	
ILSS 0° Longitude (ASTM D2344)	73.0 MPa	10.59 ksi	78.0 MPa	11.31 ksi
ILSS 90° Transverse (ASTM D2344)	22.0 MPa	3.19 ksi	30.0 MPa	4.35 ksi
Compressive Strength 0° Longitude (ASTM D695)	330 MPa	48 ksi	310 MPa	45 ksi
Compressive Modulus 0° Longitude (ASTM D695)	13.5 GPa	2.0 Msi	12 GPa	1.74 Msi

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