Product information

ANCAMINE® 2432

Curing Agent

DESCRIPTION

Ancamine 2432 curing agent is a modified aliphatic amine intended for use with liquid epoxy resins. Ancamine 2432 imparts very rapid development of physical properties at ambient and low temperatures, while maintaining longer working life than conventional “fast cure“ hardeners. It yields formulations with outstanding chemical resistance. These properties make Ancamine 2432 curing agent ideal for formulating chemically resistant coatings and secondary containment linings. Ancamine 2432 curing agent is an effective accelerator for aliphatic and cycloaliphatic curing agents in civil engineering and coating formulations.

TYPICAL PROPERTIES

Property	Value	Unit	Method
Appearance	Yellow liquid		
Colour (Gardner)	<4	Gardner	ASTM D 1544-80
Viscosity @ 25°C	200-400	mPa.s	Brookfield RVTD, Spindle 4
Amine Value	350-380	mg KOH/g	Perchloric Acid Titration
Specific Gravity @ 21°C	1.10	g/ml	
Equivalent	88	Wt/{H}	
Recommended use Level	46	PHR	With Bisphenol A diglycidyl ether (EEW=190)

ADVANTAGES

- Very rapid cure and property development at ambient and low temperatures
- Outstanding chemical resistance to solvents, acids, and alcohols
- Good working life / cure speed balance

APPLICATIONS

- Chemically resistant coatings and mortars
- Accelerator for high solids coatings and flooring
- Secondary containment linings

SHELF LIFE

At least 24 months from the date of manufacture in the original sealed container at ambient temperature.

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PACKAGING AND HANDLING

Refer to the Safety Data Sheet for Ancamine 2432 curing agent.

TYPICAL HANDLING PROPERTIES

Property	Value	Unit	Method
Mixed Viscosity @ 25°C	2,100	mPa.s	Brookfield RVTD, Spindle 4
Gel Time (150g mix @ 25°C)	27	mins	Techne GT-3 Gelation Timer
Thin Film Set Time 25°C	2.0	h	BK Drying Recorder Phase I
Thin Film Set Time 5°C	8.0	h	BK Drying Recorder Phase I

TYPICAL PERFORMANCE PROPERTIES

Property	Value	Unit	Method
Following 7 days cure at 25°C			
Glass Transition Temperature	55	°C	ASTM D3418-82
Compressive Strength	81	MPa	ISO 604
Compressive Modulus	2.5	GPa	ISO 604
Tensile Strength	66	MPa	ISO 527
Tensile Modulus	3.3	GPa	ISO 527
Tensile Elongation at Break	4.8	%	
Flexural Strength	108	MPa	ISO 178
Flexural Modulus	3.6	GPa	ISO 178
Hardness	81	Shore D	ASTM D2240-86
60° Degree Specular Gloss (cured at 25°C)	109		ASTM D523-86
60° Degree Specular Gloss (cured at 5°C)	107		ASTM D523-86

SUPPLEMENTARY DATA

Immersion studies following ASTM D543 were performed using standard liquid bisphenol-A based (DGEBA, EEW=190) epoxy resin cured with Ancamine 2432 curing agent for 7 days at 25°C. Three samples were tested for each reagent. Table 1 shows the average percentage weight change after immersion at 25°C for 3 days, 7 days, and 28 days in various chemicals.

TABLE 1: CHEMICAL RESISTANCE FOR ANCAMINE 2432 CURING AGENT FORMULATION WITH BISPHENOL-A BASED (EEW=190) RESIN % WEIGHT CHANGE AS A FUNCTION OF TIME — CONTINUOUS IMMERSION

Reagent	After 3 days % wt. change	After 7 days % wt. change	After 28 days % wt. change
Deionized Water	0.33	0.51	1.11
Methanol	6.38	8.94	9.55
Ethanol	1.55	2.40	4.68
Toluene	0.17	0.43	0.99
Xylene	0.25	0.42	0.69
Butyl Cellosolve	0.31	0.48	1.18
MEK	9.35	13.48	11.19
10% Lactic Acid	1.10	1.64	3.24
10% Acetic Acid	1.23	1.94	3.85
70% Sulfuric Acid	0.10	0.10	0.13
50% Sodium Hydroxide	0.04	0.05	0.09
Bleach	0.27	0.45	0.93
1,1,1 Trichloroethane	0.18	0.26	0.43
10% Nitric Acid	0.55	0.92	2.05
30% Nitric Acid	2.04	2.74	4.17

Note: Samples cured for 7 days at 25°C before testing. Tested in accordance with ASTM D543-84.

These studies show that Ancamine 2432 curing agent imparts outstanding chemical resistance to all types of reagents (acids, solvents, and alcohol's).

Chemical resistance of Ancamine 2432 curing agent cured formulations can be optimized for specific chemicals using different resin blends. Tables 2 shows immersion study data for Ancamine 2432 curing agent with standard bisphenol-F resin and with a bisphenol-F/ multifunctional novolac resin blend. Ancamine 2432 curing agent imparts outstanding chemical resistance to all of the reagents with these resins. Resistance to methyl ethyl ketone (MEK) and 98% sulfuric acid is extraordinary with these resins, as most conventional epoxy formulations are destroyed by these reagents.

TABLE 2: CHEMICAL RESISTANCE FOR ANCAMINE 2432 CURING AGENT FORMULATIONS WITH BISPHENOL-F BASED RESIN AND BISPHENOL-F/NOVOLAC RESIN BLEND % WEIGHT CHANGE AS A FUNCTION OF TIME - CONTINUOUS IMMERSION

	Bisphenol-F Based Resin		
Reagent	**3 days**	**7 days**	**28 days**
Deionized Water	0.43	0.63	1.30
Methanol	6.79	9.71	4.15
Ethanol	1.26	1.76	3.47
Toluene	0.12	0.15	0.37
MEK	7.29	10.75	7.87
10% Acetic Acid	1.36	1.96	3.71
98% Sulfuric Acid	0.62	0.77	-0.01

	Bisphenol-F/Novolac Resin Blend		
Reagent	**3 days**	**7 days**	**28 days**
Deionized Water	0.48	0.70	1.43
Methanol	6.82	9.70	7.07
Ethanol	1.24	1.74	3.45
Toluene	0.15	0.15	0.36
MEK	6.40	9.35	6.74
10% Acetic Acid	1.57	2.23	4.19
98% Sulfuric Acid	0.72	1.23	0.45

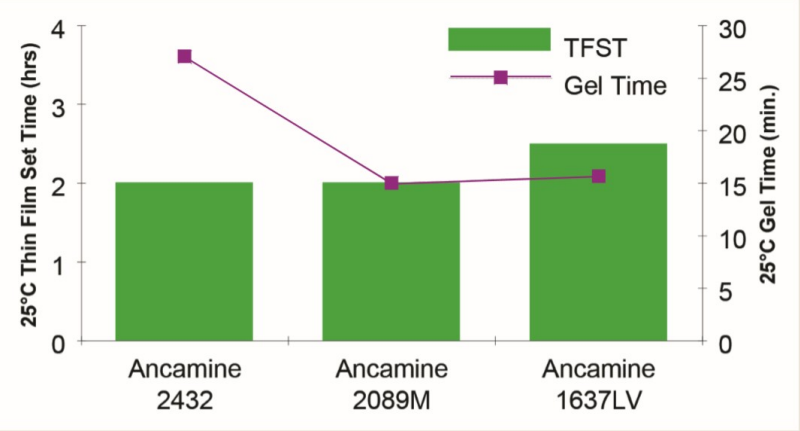
Note: Bisphenol-F resin tested is Epikote 862 (EEW=172). Bisphenol-F/Novolac Resin Blend tested is 60 Wt% Epikote 862 (EEW=172) and 40 Wt% DEN 431 (EEW=176). Samples cured for 7 days at 25°C before testing. Tested in accordance with ASTM D543-84.

The outstanding chemical resistance imparted by Ancamine 2432 curing agent makes it particularly useful in formulating chemically resistant coatings, mortars, and secondary containment linings.

CURE SPEED AND POT LIFE

Thin film set time of Ancamine 2432 curing agent with standard bisphenol-A resin (DGEBA, EEW=190) in a 6 mil film is 2.0 hours at 25 °C, and 8.0 hours at 5°C. Using a 90% bisphenol-A resin / 10% Epodil 748 reactive diluent blend, the thin film set time is 2.6 hours at 25°C and 9.5 hours at 5°C. Ancamine 2432 curing agent provides a fast cure with longer working life than other fast curing agents. Figure 1 compares the gel time and thin film set time (TFST) of Ancamine 2432 curing agent with Ancamine 2089M and Ancamine 1637LV curing agents when formulated with standard bisphenol-A resin.

TABLE 1: THIN FILM SET AND GEL TIME COMPARISON



Note: Formulated with standard bisphenol-A (DGEBA, EEW=190) resin.

Thin film set time (TFST), which is an indicator of the time for an applied coating to set, is about the same for the three curing agents in Figure 1. However, gel time, which is an indicator of pot life in a mixing container, is almost twice as long with Ancamine 2432 curing agent. Ancamine 2432 curing agent allows a faster return to service while giving the applicator more time to apply the formulated product after mixing.

HARDNESS DEVELOPMENT

Gel time and thin film set time define well the development of cure, but often do not accurately predict development of hardness. König pendulum hardness was measured as a function of cure time at 25°C for 10 mil coatings formulated with Ancamine 2432 curing agent and bisphenol-A resin. Shore D hardness development was also measured as a function of 25°C and 5°C cure for a 75mm diameter by 6.5mm thick casting. Results are presented below:

ANCAMINE 2432 CURING AGENT FORMULATION HARDNESS DEVELOPMENT

	With bisphenol-A based (EEW=190) resin		
Number of Days Cure	**1 day**	**3 days**	**7 days**
25°C Cure König Pendulum Hardness	127	132	134
25°C Cure Shore D Hardness*	81	81	81
5°C Cure Shore D Hardness*	60	72	78

	With 90% bisphenol-A resin/10% Epodil 748 reactive diluent blend		
Number of Days Cure	**1 day**	**3 days**	**7 days**
25°C Cure König Pendulum Hardness	78	90	93
25°C Cure Shore D Hardness*	80	80	81
5°C Cure Shore D Hardness*	30	69	78

*ASTM D 2240-86

The fast cure and rapid hardness development of formulations cured with Ancamine 2432 curing agent make it ideal for flooring, linings, mortars and grouts applied at ambient or low temperatures. Even at temperature as low as 5°C, Ancamine 2432 curing agent gives a Shore D hardness of 60 within 24 hours. This indicates that it is possible to formulate a coating with Ancamine 2432 curing agent that gives less than a one day walk on time at a cure temperature as low as 5°C.

PERFORMANCE IN CIVIL ENGINEERING APPLICATIONS

Ancamine 2432 curing agent has been compared with Ancamine 2089M in three start formulations:

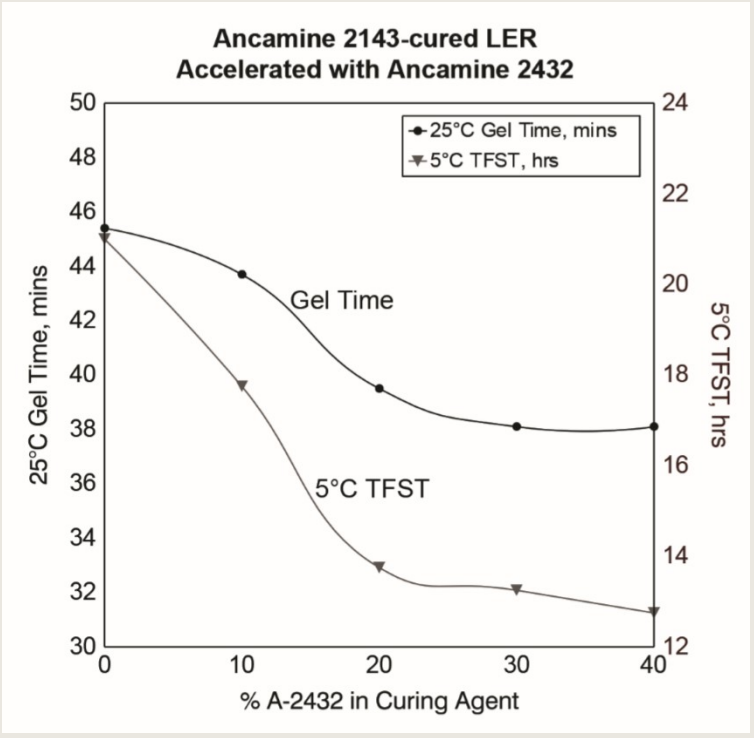
- **Self-leveling floor**
- **Mortar floor**
- **Machinery grout**

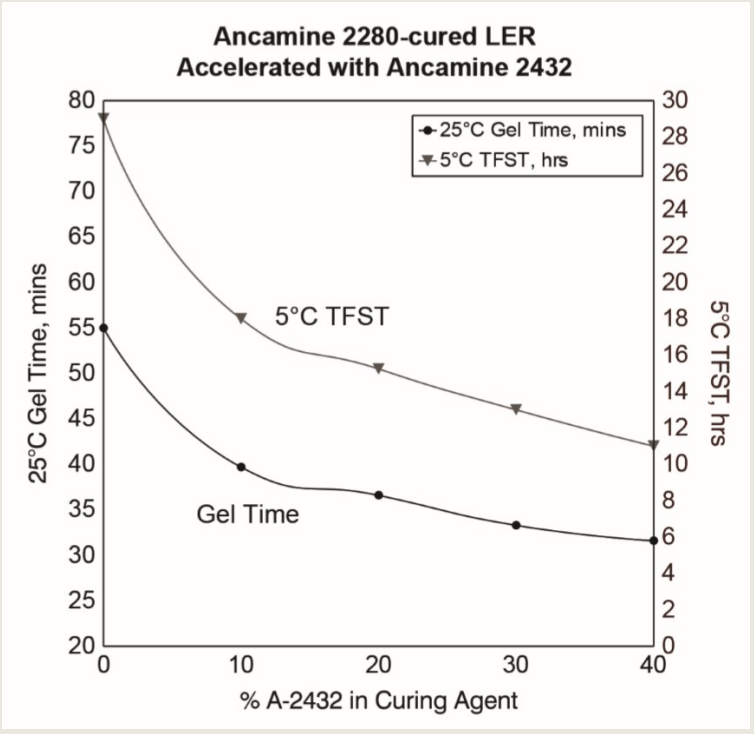
*See Appendix 1 for start formulations and performance data.

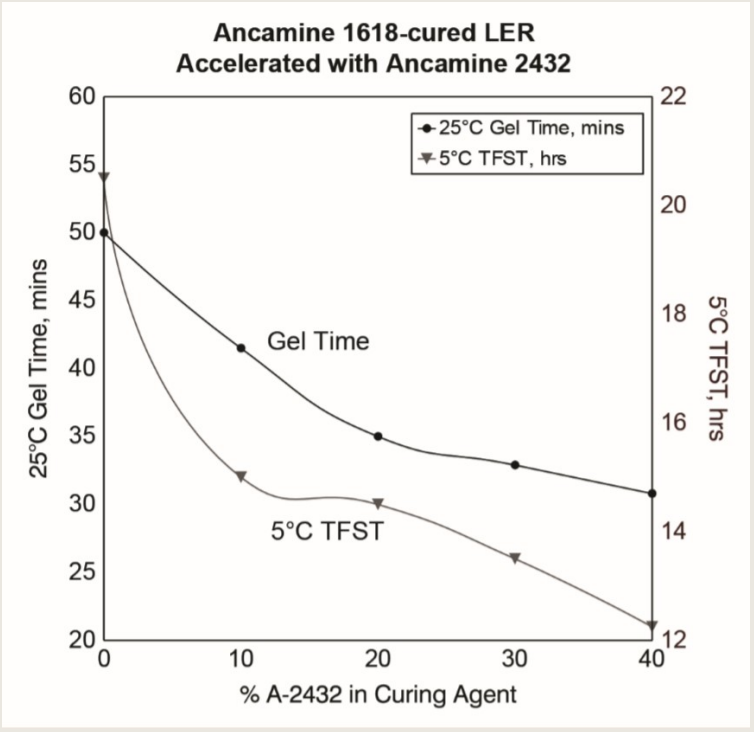
In each case, the formulations based on Ancamine 2432 curing agent show more rapid development of mechanical properties, as measured by development of compressive strength. Furthermore, in the self-leveling floor Ancamine 2432 curing agent offers better abrasion resistance and in the machinery grout it gives lower exotherm; this flatter exotherm profile will generate less thermal stress and tendency to crack in larger-scale grouts and patch repair applications.

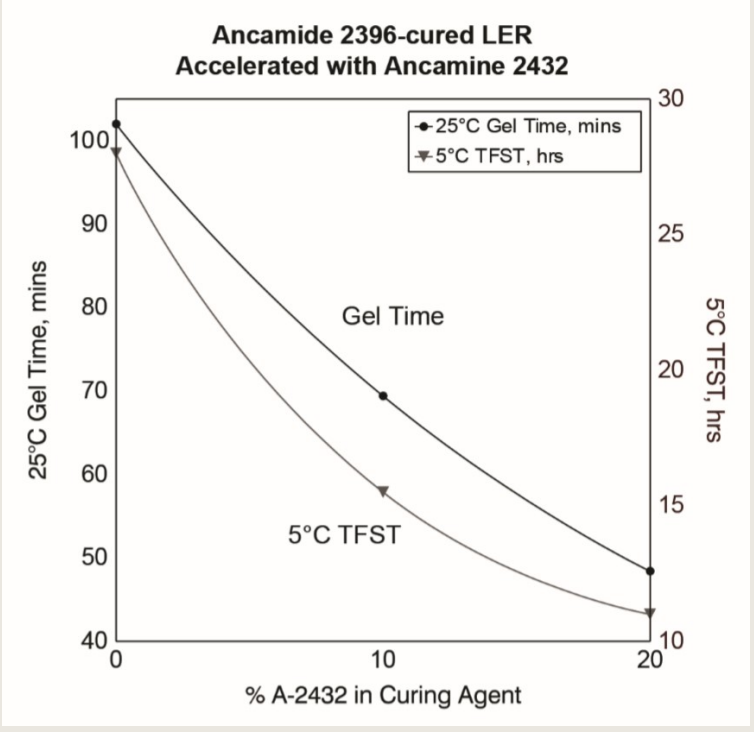
ACCELERATING WITH ANCAMINE 2432 CURING AGENT

Ancamine 2432 curing agent can be used with other curing agents to accelerate cure at ambient and low temperatures. It is an especially effective accelerator when used with cycloaliphatic and amidoamine curing agents. The following charts show the effect of Ancamine 2432 curing agent level (as a percentage of the total curing agent component) on 5°C thin film set time and 25°C gel time with standard bisphenol-A (DGEBA, EEW=190) resin. Charts are shown for cycloaliphatic curing agents Ancamine 2143, 2280, and 1618 as well as modified amidoamine curing agent Ancamide 2396. Ancamine 2432 curing agent is not recommended for acceleration of unmodified amidoamines or polyamides.


Ancamine 2143-cured LER
Accelerated with Ancamine 2432
25°C Gel Time, mins
5°C TFST, hrs
Gel Time
5°C TFST
25°C Gel Time, mins
5°C TFST, hrs
% A-2432 in Curing Agent


Ancamine 2280-cured LER
Accelerated with Ancamine 2432
25°C Gel Time, mins
5°C TFST, hrs
5°C TFST
Gel Time
25°C Gel Time, mins
5°C TFST, hrs
% A-2432 in Curing Agent


Ancamine 1618-cured LER
Accelerated with Ancamine 2432
25°C Gel Time, mins
5°C TFST, hrs
Gel Time
5°C TFST
25°C Gel Time, mins
5°C TFST, hrs
% A-2432 in Curing Agent


Ancamide 2396-cured LER
Accelerated with Ancamine 2432
25°C Gel Time, mins
5°C TFST, hrs
Gel Time
5°C TFST
25°C Gel Time, mins
5°C TFST, hrs
% A-2432 in Curing Agent

Adding Ancamine 2432 curing agent greatly improves set time, especially at low temperatures, while maintaining adequate working life (gel time). Typically, adding 20% Ancamine 2432 curing agent will significantly reduce thin film set time. Table 3 shows handling characteristics of 20% Ancamine 2432 curing agent and 80% base curing agent formulated with standard bisphenol-A (DGEBA, EEW=190) resin.

TABLE 3: HANDLING PROPERTIES AND HARDNESS DEVELOPMENT OF FORMULATIONS ACCELERATED WITH ANCAMINE 2432 CURING AGENT

	20% 2432/ 80% 2280	20% 2432/ 80% 2143	20% 2432/ 80% 1618	20% 2432/ 80% 2396	Method
25°C TFST (h)	4.5	4.5	4.6	6.4	BK Drying Recorder
5°C TFST (h)	15.3	13.8	14.5	11.0	BK Drying Recorder
25°C Gel Time (min.)	37	40	35	48	Techne GT-4 Gelation Timer
Mixed Viscosity (mPas)	2,200	2,500	2,240	4,300	ASTM D-445-83, Brookfield, RVTD, Spindle 4
60° Gloss (7 days at 25°C)	110	110	109	105	ASTM D 523-85
Hardness Development					
25°C Shore D Hardness					ASTM D 2240-86
after 1 day cure	72	71	78	79	
after 2 day cure	75	71	78	81	
after 3 day cure	78	73	80	81	
5°C Shore D Hardness					
1 day cure (Shore A)	60	77	74	N.M.	
2 day cure (Shore A)	83	87	87	84	
7 day cure (Shore D)	70	73	76	71	ASTM D 2240-86

Note: Curing agent blends formulated with standard bisphenol-A (DGEBA, EEW=190) resin.

Formulations accelerated with Ancamine 2432 curing agent have reduced cure times and maintain good working life (gel time) whilst providing low mixed viscosity and high gloss in the cured film. Systems accelerated with 20% Ancamine 2432 curing agent develop hardness quickly at both ambient and low temperatures. Rapid hardness development makes Ancamine 2432 curing agent an effective accelerator for flooring and lining formulations where fast return to service is important.

CHOICE OF RESIN AND REACTIVE DILUENTS

In applications where speed of cure and rate of property development is important the choice of epoxy resin is critical to achieve optimum performance from Ancamine 2432 curing agent. In order to provide some guidelines in resin choice Ancamine 2432 curing agent has been tested with a series of resins.

Resin	Description	EEW	Loading (phr)	Method
DER 331/Ep 828	Standard bis A liquid epoxy resin	190	46	
DER 324/Ep 215	Alkyl glycidyl ether diluted 331/828	200	44	Epodil 748 reactive diluent: C_{12}-C_{14} alkyl glycidyl ether.
DER 321/Ep 213	Alkyl glycidyl ether diluted 331/828	185	48	Epodil 742 reactive diluent: o-cresyl glycidyl ether.
DER 358/Ep 246	Alkyl diglycidyl ether diluted bis A/F epoxy resin	195	45	Epodil 748 reactive diluent: C_{12}-C_{14} alkyl glycidyl ether.
DER 353/Ep 240	Alky glycidyl ether diluted bis A/F epoxy resin	175	50	
Resin Z	10 parts Epodil 746 reactive diluent; 90 parts DER 331/ Ep 235	179	49	Epodil 746 reactive diluent: 2-ethyl hexyl glycidyl ether.

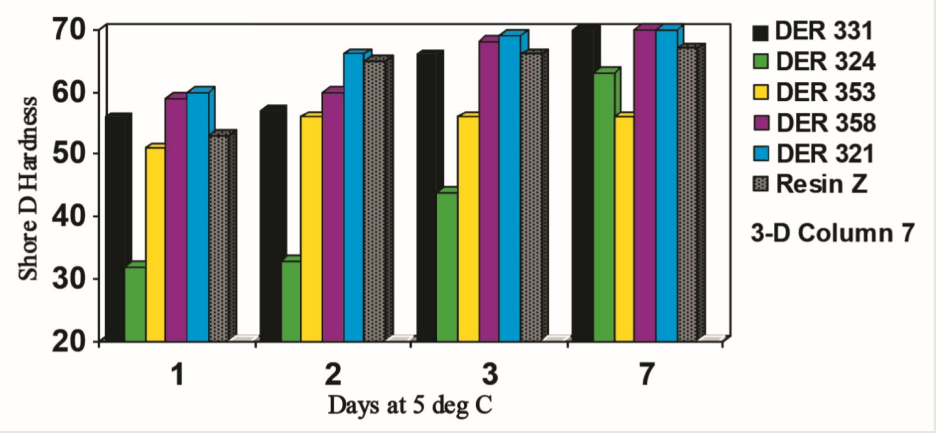
Each resin was tested with Ancamine 2432 curing agent for handling properties and reactivity as measured by thin film set time (Table 4) and hardness build (Figure 2).

TABLE 4: EFFECT OF REACTIVE DILUENTS ON ANCAMINE 2432 CURING AGENT REACTIVITY HANDLING PROPERTIES

Property	DER 331	DER 331	DER 331	DER 331	DER 331	Resin Z
Mix Viscosity @ 25°C (mPas)	1110	360	380	360	420	410
Gel time @ 25°C (min)	20	28	22	20	24	23
Thin film set time @ 25°C (h)	1.5	2.3	2.0	1.8	2.0	2.0
Thin film set time @ 5°C (h)	5.8	9.0	7.5	7.3	9.0	7.3

Ancamine 2432 curing agent provides good all-round low temperature performance with all resins tested. However, the test results confirm the importance of resin choice where the highest performance at low temperature is required. In general, best performance is achieved with bisphenol A/F resin diluted with the minimum level of diluent to achieve application viscosity. Choice of reactive diluent is also critical — standard diluent of choice is typically the C_{12}-C_{14} glycidyl ether (Epodil 748 reactive diluent) which provides good dilution and maintains good reactivity at ambient temperature, but significantly retards cure rate at 5°C. The best diluent for maintaining cure rate at low temperature is o-cresyl glycidyl ether (Epodil 742 reactive diluent) but much higher addition levels are needed to achieve the same dilution as Epodil 748 reactive diluent. The optimum choice of reactive diluent for dilution efficiency and maintenance of cure rate at low temperature is Epodil 746 reactive diluent.

FIGURE 2: EFFECT OF REACTIVE DILUENTS ON ANCAMINE 2432 CURING AGENT REACTIVITY HARDNESS BUILD



Civil Engineering — Self-levelling floor		Ancamine 2432 Start Formulation	
		Ancamine 2432	Ancamine 2089M
Binder (by weight)			
Liquid DGEBA (EEW 190)		90.0	90.0
Epodil 748 reactive diluent	Evonik	10.0	10.0
Byk 333 flow additive		0.3	0.3
Ancamine 2432	Evonik	45.0	-
Ancamine 2089M	Evonik	-	38.0
		145.3	**138.3**
Aggregate (by weight)			
75µ silica flour		94	94
125µ silica flour		47	47
150µ silica sand		94	94
300µ silica sand		142	142
500µ silica sand		-	-
		377	**377**

TECHNICAL DATA

Property	Unit	Ancamine 2432	Ancamine 2089M
Filler : binder ratio:-		2.6:1	2.6:1
Flow diameter	mm	100	95
24 h compressive strength	mPa	40	29
7 day compressive strength		50	34
Abrasion resistance @ 1000 cycles — weight loss	mg	108	159
Bulk exotherm — 1kg mass	ºC	-	-
Time to peak exotherm	mins	-	-

Civil Engineering — Mortar		Ancamine 2432 Start Formulation	
		Ancamine 2432	Ancamine 2089M
Binder (by weight)			
Liquid DGEBA (EEW 190)		90.0	90.0
Epodil 748 reactive diluent	Evonik	10.0	10.0
Byk 333 flow additive		0.3	0.3
Ancamine 2432	Evonik	45.0	-
Ancamine 2089M	Evonik	-	38.0
		145.3	**138.3**
Aggregate (by weight)			
75µ silica flour		-	-
125µ silica flour		-	-
150µ silica sand		254	254
300µ silica sand		181	181
500µ silica sand		290	290
		725	**725**

TECHNICAL DATA

Property	Unit	Ancamine 2432	Ancamine 2089M
Filler : binder ratio:-		5.0:1	5.0:1
Flow diameter	mm	-	-
24 h compressive strength	mPa	55	31
7 day compressive strength		60	32
Abrasion resistance @ 1000 cycles — weight loss	mg	-	-
Bulk exotherm — 1kg mass	ºC	-	-
Time to peak exotherm	mins	-	-

Civil Engineering — Machinery Grout		Ancamine 2432 Start Formulation	
		Ancamine 2432	Ancamine 2089M
Binder (by weight)			
Liquid DGEBA (EEW 190)		90.0	90.0
Epodil 748 reactive diluent	Evonik	10.0	10.0
Byk 333 flow additive		0.3	0.3
Ancamine 2432	Evonik	45.0	-
Ancamine 2089M	Evonik	-	38.0
		145.3	**138.3**
Aggregate (by weight)			
75µ silica flour		-	-
125µ silica flour		191	191
150µ silica sand		191	191
300µ silica sand		268	268
500µ silica sand		307	307
		957	**957**

TECHNICAL DATA

Property	Unit	Ancamine 2432	Ancamine 2089M
Filler : binder ratio:-		6.6:1	6.6:1
Flow diameter	mm	-	-
24 h compressive strength	mPa	66	59
7 day compressive strength		73	60
Abrasion resistance @ 1000 cycles — weight loss	mg	-	-
Bulk exotherm — 1kg mass	ºC	26	35
Time to peak exotherm	mins	28	65

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