

## Centrifugal casting

### Application data and cure data

Nouryon is the world's leading producer of organic peroxides for the curing of thermoset resins, coatings and specialty monomers. We're home to the best known brands in the thermoset market, examples include Cadox<sup>®</sup>, Butanox<sup>®</sup>, Perkadox<sup>®</sup> and Trigonox<sup>®</sup>. We also have a whole range of specialty auxiliary products, such as cobalt free accelerators to meet specific production requirements.

This application guide provides an introduction to our thermoset product portfolio and can help you find a suitable curing system for your specific application. If you need more detailed information please contact your account manager or customer service representative. Sharing our thermoset experience is one of the biggest resources we offer.

#### Application

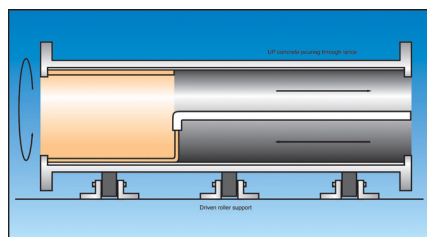
Centrifugal casting machine

#### Nouryon curing agents

**Main peroxides:** Butanox M-50, Cadox M-50a and Trigonox 44B  
Cadox M-50a (in TXIB) performance is equivalent to Butanox M-50 (in DMP)

#### Main products

- Pipes for sewer water transport and potable water transport
- Storage tanks



#### Reason for our products

- A guarantee of quality and reliability
- Outstanding technical and customer service
- Intensive safety research
- A global distribution network and security of supply
- Customized application research: special formulated products for an optimal performance in your application

### Cure of 4 mm laminates at 20°C

The speed of cure is expressed as the time to reach Barcol hardness of 25-30.

	GEL TIME (min.)	TIME TO PEAK (min.)	PEAK EXOTHERM (°C)
2 phr Trigonox 44B + 0.5 phr Accelerator NL-49PN	15	28	67
2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN	13	36	44
2 phr Trigonox 44B + 1.0 phr Accelerator NL-49PN	8	18	97
2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN	8	26	64

	BARCOL	RES. STYRENE	
	25-30 (h)	24 h 20°C (%)	+8 h 80% (%)
2 phr Trigonox 44B + 0.5 phr Accelerator NL-49PN	<1	4.4	0.1
2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN	15	6	0.3
2 phr Trigonox 44B + 1.0 phr Accelerator NL-49PN	<<1	0.9	0.2
2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN	1	5	0.1

### Cure of 10 mm laminates at 20°C

	GEL TIME (min.)	TIME TO PEAK (min.)	PEAK EXOTHERM (°C)
<b>10 mm</b>			
1 phr Trigonox 44B + 1.0 phr Accelerator NL-49PN	18	23	141
1 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN	16	33	111

	BARCOL	RES. STYRENE	
	25-30 (h)	24 h 20°C (%)	+8 h 80% (%)
<b>10 mm</b>			
1 phr Trigonox 44B + 1.0 phr Accelerator NL-49PN	<1	1.3	0.1
1 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN	<1	2.0	0.02

# Cure data

## Butanox M-50

Butanox M-50 is a general purpose methyl ethyl ketone peroxide (MEKP) for the curing of unsaturated polyester resins in the presence of a cobalt accelerator at room and elevated temperatures.

The curing system Butanox M-50/cobalt accelerator is particularly suitable for the curing of gelcoat resins, laminating resins, lacquers and castings; moreover, the manufacture of light resistant parts may be possible contrary to the curing system benzoyl peroxide/amine accelerator.

Practical experience throughout many years has proven that by the guaranteed low water content and the absence of polar compounds in Butanox M-50, this peroxide is very suitable in GRP products for e.g. marine applications.

For room temperature application it is necessary to use Butanox M-50 together with a cobalt accelerator (e.g. Accelerator NL-49PN)

### Dosing

Depending on working conditions, the following peroxide and accelerator dosage levels are recommended:

**Butanox M-50**

**1 - 4 phr \***

**Accelerator NL-49PN**

**0.5 - 3 phr**

\*(parts per hundred resin)

### Cure characteristics

In a high reactive standard orthophthalic resin in combination with Accelerator NL-49PN (= 1% cobalt) the following application characteristics were determined:

### Gel times at 20°C

2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN	12 minutes
2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN	7 minutes

### Cure of 1 mm pure resin layer at 20°C

The speed of cure is expressed as the time to reach a Persoz hardness of respectively 30, 60 and 120 s.

	Persoz	30	60	120	s
2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN		2.4	4.1	13	h
2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN		1.7	3.0	9.5	h

### Cure of 4 mm laminates at 20°C

4 mm laminates have been made with a 450 g/m<sup>2</sup> glass chopped strand mat. The glass content in the laminates is 30% (w/w).

The following parameters were determined:

- Time-temperature curve.
- Speed of cure expressed as the time to achieve a Barcol hardness (934-1) of 0-5 and 25-30 respectively.
- Residual styrene content after 24 h at 20°C and a subsequent postcure of 8 h at 80°C.

	GEL TIME (min.)	TIME TO PEAK (min.)	PEAK EXOTHERM (°C)
2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN	13	36	44
2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN	8	26	64

	BARCOL		RESIDUAL STYRENE	
	0-5 (h)	25-30 (h)	24 h 20°C (%)	+8 h 80°C (%)
2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN	3	15	6	0.3
2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN		1	5	0.1

### Pot life at 20°C

Pot lives were determined of a mixture of Butanox M-50 and a non-preaccelerated UP resin at 20°C.

2 phr Butanox M-50	12 h
4 phr Butanox M-50	7 h

### Solubility

Butanox M-50 is miscible with phthalates and slightly miscible with water.

### Colors

Butanox M-50 is available in vanishing red and red.



# Trigonox 44B

Trigonox 44B is an acetyl acetone peroxide formulation for the curing of unsaturated polyester resins in the presence of a cobalt accelerator at room and elevated temperatures.

With the curing system Trigonox 44B/cobalt accelerator a much faster speed of cure may be achieved than with curing systems based on a MEKP plus cobalt accelerator, at room and elevated temperatures. Normally the gel times with Trigonox 44B are comparable to those with Butanox M-50.

Trigonox 44B is particularly suitable in those applications where a fast mold-turnover is required, e.g. for the cold press molding or resin injection molding techniques.

The system Trigonox 44B/cobalt accelerator will give a higher peak exotherm than a standard MEKP/cobalt accelerator system. Due to this fact, it is recommendable to avoid the production of too thick laminates in one operation. At low temperatures a reasonable speed of cure is still obtained when Trigonox 44B is used in combination with large amounts of cobalt accelerator possibly in combination with N,N Dimethylaniline as promotor.

## Dosing

Depending on working conditions, the following peroxide and accelerator dosage levels are recommended:

**Trigonox 44B**

**1 - 2 phr \***

**Accelerator NL-49PN**

**0.5 - 3 phr**

\*(parts per hundred resin)

In a high reactive standard orthophthalic resin in combination with Accelerator NL-49PN (= 1% cobalt) the following application characteristics were determined:

## Gel times at 20°C

2 phr Trigonox 44B + 0.5 phr Accelerator NL-49PN 15 minutes

2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN 12 minutes

2 phr Trigonox 44B + 1.0 phr Accelerator NL-49PN 8 minutes

2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN 7 minutes

## Cure of 1 mm pure resin layer at 20°C

The speed of cure is expressed as the time to reach a Persoz hardness of respectively 30, 60 and 120 s.

	Persoz	30	60	120	s
2 phr Trigonox 44B + 0.5 phr Accelerator NL-49PN		<1	1.5	5	h
2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN		2.4	4.1	13	h
2 phr Trigonox 44B + 1.0 phr Accelerator NL-49PN		<<1	1	4	h
2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN		1.7	3	10	h

**Cure of 4 mm laminates at 20°C**

4 mm laminates have been made with a 450 g/m<sup>2</sup> glass chopped strand mat. The glass content in the laminates is 30% (w/w).

The following parameters were determined:

- Time-temperature curve.
- Speed of cure expressed as the time to achieve a Barcol hardness (934-1) of 25-30.
- Residual styrene content after 24 h at 20°C and a subsequent postcure of 8 h at 80°C.

	GEL TIME (min.)	TIME TO PEAK (min.)	PEAK EXOTHERM (°C)
2 phr Trigonox 44B + 0.5 phr Accelerator NL-49PN	15	28	67
2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN	13	36	44
2 phr Trigonox 44B + 1.0 phr Accelerator NL-49PN	8	18	97
2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN	8	26	64

	BARCOL	RESIDUAL STYRENE	
	25-30 (h)	24 h 20°C (%)	+8 h 80°C (%)
2 phr Trigonox 44B + 0.5 phr Accelerator NL-49PN	<1	4.4	0.1
2 phr Butanox M-50 + 0.5 phr Accelerator NL-49PN	15	6	0.3
2 phr Trigonox 44B + 1.0 phr Accelerator NL-49PN	<<1	0.9	0.2
2 phr Butanox M-50 + 1.0 phr Accelerator NL-49PN	1	5	0.1

**Pot life at 20°C**

Pot lives were determined of a mixture of Trigonox 44B and a non-preaccelerated UP resin at 20°C.

2 phr Trigonox 44B	20 h
4 phr Trigonox 44B	11 h



# Accelerator NL-49PN

The curing of unsaturated polyester resins at ambient temperatures can in general not be performed by an organic peroxide alone. The radical formation, which is necessary to start the polymerization reaction, is at ambient temperatures with most generally applied organic peroxides too slow. To speed up the radical formation in a controllable way organic peroxides must therefore be used in combination with a so called accelerator.

For ketone peroxides like methyl ethyl ketone peroxides, cyclohexanone peroxides and acetylacetone peroxide a cobalt accelerator must be used.

For this purpose the following formulations of cobalt 2 ethylhexanoate also called cobalt octoate are available:

Accelerator NL-49PN	1% cobalt in aliphatic ester
Accelerator NL-51PN	6% cobalt in aliphatic ester
Accelerator NL-53N	10% cobalt in white spirit

The reactivity of the various cobalt accelerators is directly correlated with the cobalt content. The use of a lower concentrated version increases the dosage accuracy. However, when the dosage level of e.g. Accelerator NL-49PN must be higher than approx. 3% to achieve the required cure performance, it is advised to use a higher concentrated cobalt accelerator e.g. 0.5% Accelerator NL-51PN.

The cure characteristics of an unsaturated polyester resin/ketone peroxide mixture can, apart from the choice of the ketone peroxide, very effectively be influenced by the dosage level of the cobalt accelerator. The dosage level of the cobalt accelerator expressed as Accelerator NL-53N (10% cobalt) can for this purpose be varied between e.g. 0.025% up to approximately 0.6% calculated on the UP resin.

When the right peroxide has been chosen and still the required gel time and Cure characteristics cannot be obtained with the cobalt accelerator alone, it is possible to increase the reactivity of the cobalt accelerator by the extra addition of a promoter like N,N-Dimethylaniline or Promotor D (N,N Diethylacetoacetamide).

This adaptation of the accelerator system may be necessary when:

- a very short gel time and/or a very fast cure is required e.g. for resin transfer molding or the production of polymer concrete
- highly inhibited and/or low reactive resins must be cured e.g.
- bisphenol A/fumarate and vinylester resins.

The cure system ketone peroxide/cobalt accelerator can further be characterized by:

- the relatively low color, related to the cobalt dosage, of the cured molding
- a very good UV light resistance of the molded parts
- the long pot life of the cobalt accelerator in the polyester resin
- A possible disadvantage may be that the cure system is more sensitive for moisture, pigments and fillers than the cure system dibenzoyl peroxide/ amine accelerator.

Cobalt accelerators can also be used to increase the reactivity of organic peresters, which are applied for the cure of unsaturated polyester resins at elevated temperatures. Moreover, the use of a cobalt accelerator gives in general a lower residual styrene content in the cured molding. For this application peresters like Trigonox C, Trigonox 21S, Trigonox 42S and the special mixture Trigonox 93 can be used.

## Dosage

Depending on working conditions the following accelerator dosage level is recommended:

**Accelerator NL-49PN**

**0.25 - 3.0 phr \***

\*(parts per hundred resin)

## Cure characteristics

In the following cure experiments the performance of cobalt 2 ethylhexanoate as accelerator will be demonstrated.

### Gel times at 20°C

in a standard orthophthalic resin with various ketone peroxides

ACCELERATOR NL-49PN (PHR)	0.25	0.5	1
2 phr Butanox M-60	22	12	7
2 phr Butanox LPT-IN	65	31	20
2 phr Cyclonox LE-50	20	11	6
2 phr Trigonox 44B	24	14	8

in various resins with Dimethylaniline, 100% as promoter

### standard orthophthalic resin

2 phr Butanox M-60 + 1 phr Acc. NL-49PN	7 min.
2 phr Butanox M-60 + 1 phr Acc. NL-49PN + 0.05 phr Dimethylaniline, 100%	4 min.
2 phr Butanox M-60 + 1 phr Acc. NL-49PN + 0.10 phr Dimethylaniline, 100%	2 min.
2 phr Trigonox 44B + 1 phr Acc. NL-49PN	8 min.
2 phr Trigonox 44B + 1 phr Acc. NL-49PN + 0.05 phr Dimethylaniline, 100%	5 min.
2 phr Trigonox 44B + 1 phr Acc. NL-49PN + 0.10 phr Dimethylaniline, 100%	3 min.

### bisphenol A/fumarate resin

2 phr Butanox LPT-IN + 3 phr Acc. NL-49PN	145 min.
2 phr Butanox LPT-IN + 3 phr Acc. NL-49PN + 0.05 phr Dimethylaniline, 100%	65 min.
2 phr Butanox LPT-IN + 3 phr Acc. NL-49PN + 0.10 phr Dimethylaniline, 100%	34 min.

### bisphenol A/vinylester resin

2 phr Butanox LPT-IN + 3 phr Acc. NL-49PN	32 min.
2 phr Butanox LPT-IN + 3 phr Acc. NL-49PN + 0.05 phr Dimethylaniline, 100%	22 min.
2 phr Butanox LPT-IN + 3 phr Acc. NL-49PN + 0.10 phr Dimethylaniline, 100%	16 min.

### Time-temperature curves at elevated temperatures (70°C and 90°C)

	CURE TEMP (°C)	GEL TIME (min.)	TIME TO PEAK (min.)	PEAK EXOTHERM (°C)
1 phr Trigonox 21S	70	916	233	
1 phr Trigonox 21S + 1 phr Accelerator NL-49PN	70	35	214	
1 phr Trigonox 21S	90	16	258	
1 phr Trigonox 21S + 1 phr Accelerator NL-49PN	90	0.3	1.5	240
1 phr Trigonox C	90	925	236	
1 phr Trigonox C + 1 phr Accelerator NL-49PN	9	26	258	

### Pot life at 20°C

The pot life has been determined of Accelerator NL-49PN in a standard orthophthalic polyester resin at 20°C.

1 phr Accelerator NL-49PN	6 months
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# Contact us

For product inquiry and ordering information, please contact your Nouryon account manager or regional Nouryon sales office.

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## Additional information

Product Data Sheets (PDS) and Safety Data Sheets (SDS) for our polymerization initiators are available at [www.nouryon.com](http://www.nouryon.com)

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# Nouryon

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[nouryon.com](https://www.nouryon.com)