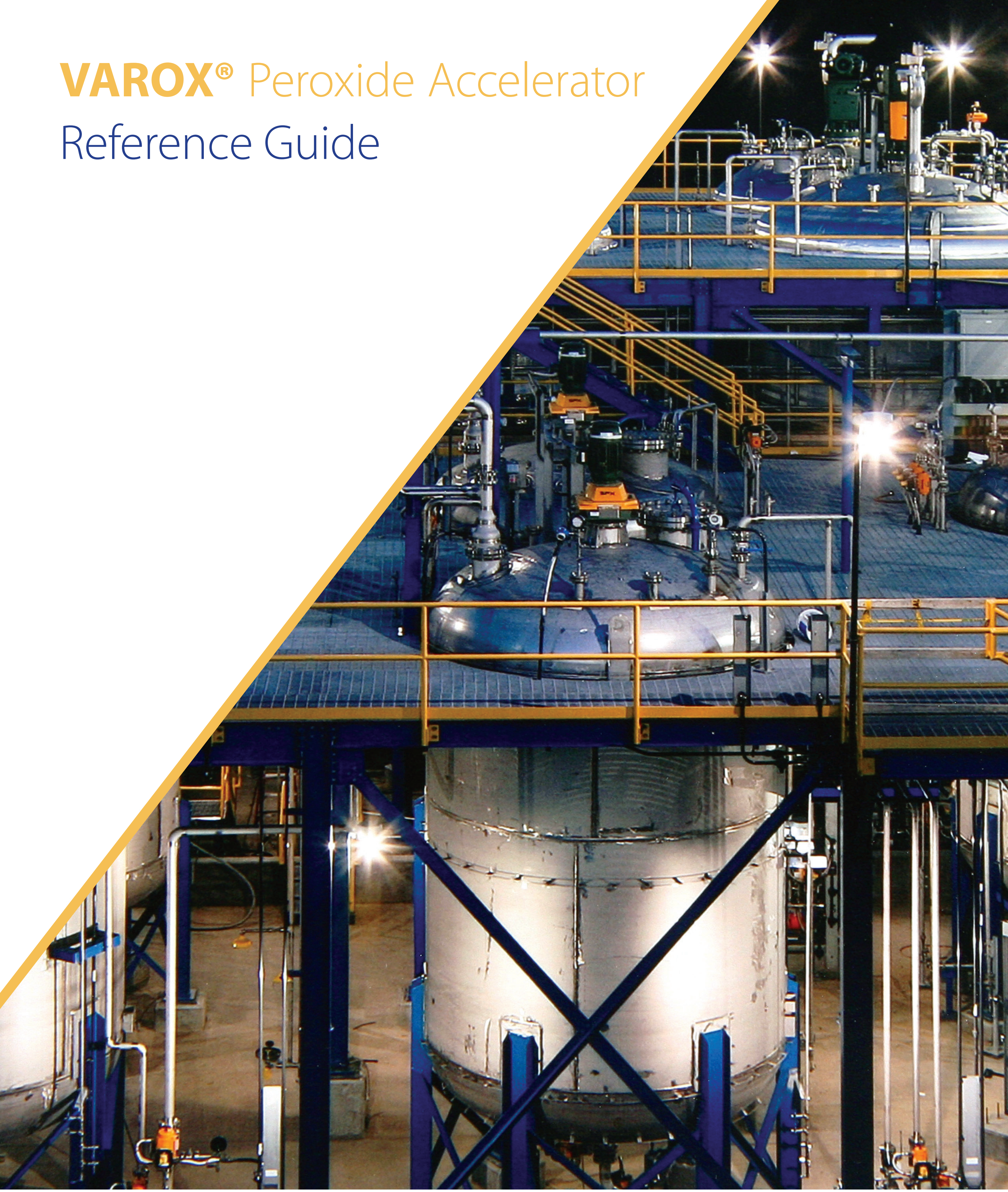
VAROX® Peroxide Accelerator

Reference Guide



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Vanderbilt Chemicals, LLC
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PEROXIDE CROSSLINKING of ELASTOMERS

Crosslinking and/or vulcanization are defined as a process for converting a thermoplastic material or elastomer into a thermoset or vulcanizate. This process converts unbound polymer molecular chains into a single network which retains many desirable physical and chemical properties of the base polymer. The two major chemical processes by which crosslinking occurs are peroxide and sulfur cure systems. Peroxide systems are more versatile since they can be used to crosslink both saturated and unsaturated polymers, thereby providing a wider selection of elastomers, and more opportunities for cost savings.

Peroxide crosslinking systems can:

- Δ Offer a truly nitrosamine-free finished product with predictable cure rates and cured physical properties.
- Δ Provide a stable factory stock elastomer compound, as opposed to a sulfur-cured compound with a short shelf life (sometimes days).
- Δ Be made equivalent, and in many cases superior, to sulfur systems, by varying the ratio of many common additives.
- Δ Produce thermosets and vulcanizates having better heat aging properties, lower compression set, less color, no reversion, reduced (if any) bloom, and lower odor levels than compounds cured by sulfur systems.

HALF-LIFE TIME and HALF-LIFE TEMPERATURE

Decomposition rates of organic peroxides are reported in terms of half-life time or half-life temperature. The half-life time of a peroxide, at any specified temperature, is the time in which 50% of the peroxide has decomposed. Correspondingly, the half-life temperature at any specified time is the temperature at which 50% of the peroxide has decomposed in the specified time.

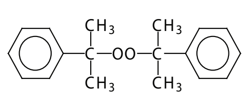
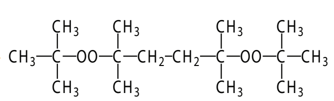
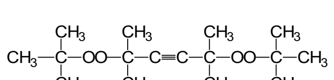
The rate of crosslinking produced by a free radical initiator is determined by its rate of thermal decomposition. Half-life data are essential in the selection of the optimum initiator for specific time/temperature applications.

Since crosslinking is directly related to the amount of peroxide decomposed, at least 6 to 10 half-lives of peroxide decomposition are recommended for crosslinking operations. One mole of crosslinked peroxide equates to one mole of decomposed peroxide. The t´90 (min) value is the time necessary to achieve 90% of the final cure. Thus, the t´90 (min) is equivalent to 90% peroxide decomposed, or approximately 3.33 half-lives. The percent of peroxide decomposed can be calculated by using the number of peroxide half-lives in the equation:

Percent of Peroxide Decomposed = $(1 - 0.5^{N}) \times 100$
(Where 'N' is the number of peroxide half-lives)

- Δ At N = 3.33 half-lives, approximately 90% of the peroxide is decomposed.
- Δ At N = 6 half-lives, the peroxide is 98.4% decomposed.
- Δ At N =10 half-lives, the peroxide is almost completely decomposed at 99.9%.

Specifications

Commercial Product	Peroxide Class & CAS #	Generic Name Peroxide Structure Molecular Weight	Assay (%)	Active Oxygen (%)	Physical Form	Diluent, Filler, or Binder	Specific Gravity [g/cm³ at °C] and/or Bulk Density	Typical Decomposition Products in Inert Media
VAROX® DCP PURE	Dialkyl 80-43-3	 Dicumyl Peroxide M.W. 270.37	99.0 min	5.86 min	Free Flowing Powder	—	N/A	– Methane – Acetophenone – Cumyl Alcohol
VAROX DBPH	Dialkyl 78-63-7	 2,5-dimethyl-2,5-Di-(t-butylperoxy)hexane M.W. 290.44	93.0 min	10.25 min	Liquid	—	0.8650 @ 25°C	– Ethane – Methane – Acetone – t-Butyl Alcohol – Mixture of Aromatic Hydrocarbons
VAROX DBPH-50	Dialkyl		45.0 - 48.0	4.96 - 5.29	Free Flowing Powder	$CaCO_3$ Silica	N/A	
VAROX DBPH-50-EZD	Dialkyl		45.0 - 48.0	4.96 - 5.29	Free Flowing Powder	Silica	N/A	
VAROX DBPH-50 SG	Dialkyl		45.0 - 51.0	4.56 - 5.28	Paste	Silicone Polymer	1.09 ± 0.10	
VAROX DBPH-P20	Dialkyl		19.0 - 21.0	2.09 - 2.31	Free Flowing Beads	Poly-Propylene	N/A	
VAROX 130-XL	Dialkyl 1068-27-5	 2,5-dimethyl-2,5-Di-(t-butylperoxy)hexyne-3 M.W. 286.41	45.0-48.0	5.03-5.36	Free Flowing Powder	$CaCO_3$ Silica	1.26 @ 20°C	– Methane – Acetone – t-Butyl Alcohol
VAROX 130 LIQUID	Dialkyl		94.0 min	10.50 min	Liquid	—	0.89	

Half-Life Temperatures

Compounding Information

Commercial Product	1 Min Half-Life Temp °F (°C)	10 Min Half-Life Temp °F (°C)	1 Hr Half-Life Temp °F (°C)	Suggested Cure Temps °F (°C)	Suggested Maximum Compounding Temp* °F (°C)	CPE	CR	EPM/ EPDM	EVA	FKM	HDPE	HNBR	LDPE	PP	NBR	NR or IR	Q	SBR
VAROX® DCP PURE	352°F (178°C)	315°F (157°C)	279°F (137°C)	310-390°F (154-199°C)	266°F (130°C)	2.4 - 3.8	0.8 - 1.6	2.4 - 5.4	1.2 - 2.0	—	—	2.2 - 4.2	1.5 - 2.5	—	0.9 - 1.7	0.8 - 1.6	0.4 - 0.8	0.7 - 1.5
VAROX DBPH	358°F (181°C)	315°F (157°C)	284°F (140°C)	320-400°F (160-204°C)	293°F (145°C)	2.5 - 4.0	0.5 - 1.4	1.7 - 3.4	1.0 - 2.0	0.5 - 1.2	0.5 - 1.2	2.5 - 4.7	1.4 - 2.0	0.1 - 1.0	1.0 - 2.0	0.8 - 1.6	0.4 - 0.8	0.4 - 1.5
VAROX DBPH-50	358°F (181°C)	315°F (157°C)	284°F (140°C)	320-400°F (160-204°C)	293°F (145°C)	5.6 - 8.9	1.0 - 3.0	3.8 - 7.6	2.0 - 5.0	1.2 - 2.5	—	5.5 - 10.5	—	—	2.4 - 4.4	2.0 - 4.0	0.5 - 1.0	1.6 - 2.7
VAROX DBPH-50-EZD	358°F (181°C)	315°F (157°C)	284°F (140°C)	320-400°F (160-204°C)	293°F (145°C)	5.6 - 8.9	1.0 - 3.0	3.8 - 7.6	2.0 - 5.0	1.2 - 2.5	—	5.5 - 10.5	—	—	2.4 - 4.4	2.0 - 4.0	0.5 - 1.0	1.6 - 2.7
VAROX DBPH-50 SG	358°F (181°C)	315°F (157°C)	284°F (140°C)	320-400°F (160-204°C)	293°F (145°C)	5.6 - 8.9	1.0 - 3.0	3.8 - 7.6	2.0 - 5.0	1.2 - 2.5	—	5.5 - 10.5	—	—	2.4 - 4.4	2.0 - 4.0	0.5 - 1.0	1.6 - 2.7
VAROX DBPH-P20	358°F (181°C)	315°F (157°C)	284°F (140°C)	320-400°F (160-204°C)	293°F (145°C)	—	—	—	—	—	1.5 - 3.0	—	4.0 - 8.0	1.0 - 2.0	—	—	—	—
VAROX 130-XL	381°F (194°C)	336°F (169°C)	306°F (152°C)	340-420°F (171-215.5°C)	305.6°F (152°C)	5.6 - 8.9	1.0 - 3.0	7.5 - 13.0	3.5 - 6.5	—	—	7.5 - 13.0	—	3.0 - 5.5	3.0 - 5.5	2.5 - 5.0	0.9 - 2.0	2.0 - 4.5
VAROX 130 LIQUID	381°F (194°C)	336°F (169°C)	306°F (152°C)	340-420°F (171-215.5°C)	305.6°F (152°C)	5.6 - 8.9	1.0 - 3.0	7.5 - 13.0	3.5 - 6.5	—	—	7.5 - 13.0	—	3.0 - 5.5	3.0 - 5.5	2.5 - 5.0	0.9 - 2.0	2.0 - 4.5

*The suggested maximum compounding temperature is the temperature at which the scorch time is equal to 5 minutes

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