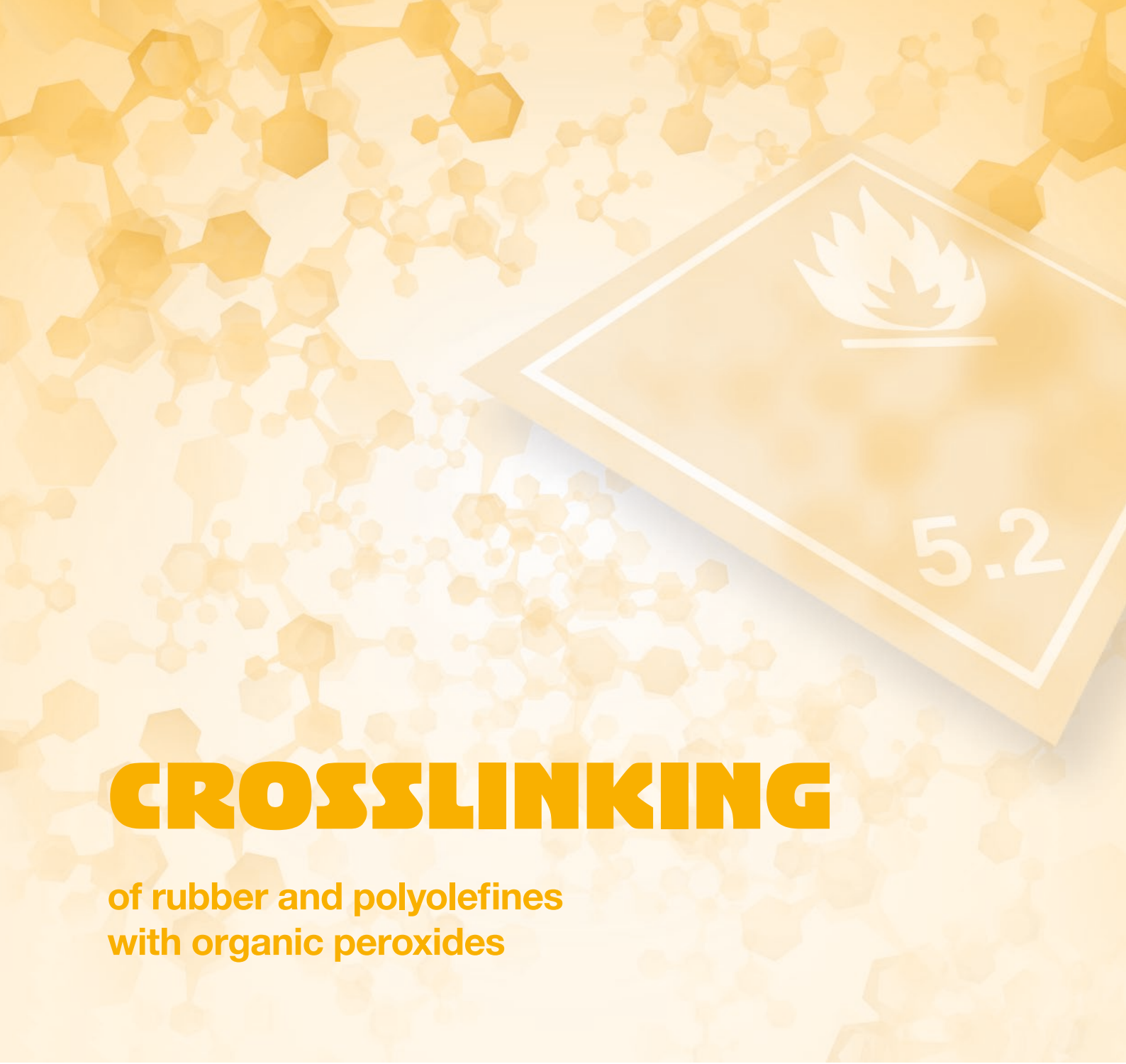

CROSSLINKING

of rubber and polyolefines with organic peroxides

PERGAN
The Peroxide Company

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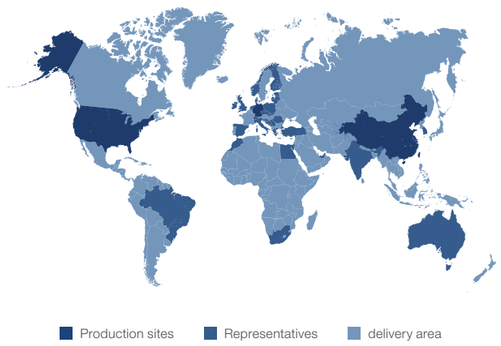
Reliable, competent, flexible - for 35 years your partner for organic peroxides.
Since its foundation in 1981, Pergan has established itself in the national and international market as a manufacturer of organic peroxides.

Our business activities are conducted from two production facilities in Germany, one production facility in the United States, through a network of more than 30 representatives worldwide and a joint venture company in China. We foster constructive and trusting business connections with our national and international partners.



Organic peroxides

The main stress of our business activity is put on the production and trade of organic peroxides. These are more or less stable chemical compounds which exclusively consist of carbon, hydrogen and oxygen. They are used as initiators and reaction substances in the plastics and rubber industry, because they easily decay in extremely active radicals.

Organic peroxides are used for:

- polymerization of monomers for plastics manufacture
- crosslinking and modification of polymers,
- as the curing of unsaturated polyester-, vinylester- and acrylic resins

Organic peroxides are furthermore used as oxidation materials for medical preparations and for complicated chemical synthesis.

Safety and environmental conservation out of responsibility

Organic peroxides are highly reactive chemicals. The manufacturing, transport, storage, handling and last but not least the disposal of organic peroxides requires strict precautions. We have effected considerable investments into safety to eliminate risks, to avoid faults and to protect people and environment from becoming endangered. Naturally, we provide our customers support in any kind of safety, handling, or storage issue.

Customer orientation – a recipe for success

Reliable

Quality does not only mean reliability but also includes services such as consultation and support for our customers helping them to solve their problems. Quality results from the performance of all employees. We work towards strengthening quality awareness through the help of information, internal and external training and motivation.

Our company holds ISO 9001 and ISO 14001 certification

Competent

Part of our service also includes examining our customers' applications so that we can develop optimal product formulations and supply them with suitable peroxide- and other additive preparations for their process. Therefore we do not offer only products but moreover solutions to problems. The positive feedback from satisfied customers motivates us to keep continuing along this line.

Flexible

As a medium sized company flexibility is one of our greatest strengths. We are able to react quickly, competently and efficiently to the individual wishes and requirements of our customers. In recognition of exceptional business achievements PERGAN was awarded the jury award „Company of the Year 2010" by Stadtsparkasse Bocholt.

CROSSLINKING

of rubber and polyolefins with organic peroxides

Chemical crosslinking agents such as sulphur and organic peroxides are able to link polymer chains creating a three-dimensional network. This crosslinking reaction changes several material characteristics. The material characteristics of a crosslinked polymer are superior to the equivalent characteristics of the sulphur cured polymers.

Peroxide crosslinking of elastomers has the following advantages over the sulphur cure:

- simple formulation
- long storage time of the peroxide containing compound without scorching
- high processing temperature
- rapid vulcanization without reversion
- high temperature resistance of final product
- crosslinked products do not change colour through contacts with metals and PVC
- most peroxides do not cause blooming
- co-vulcanization of saturated and unsaturated rubbers
- co-vulcanization of rubbers with polyethylene and other polyolefins
- co-polymerisation with polymerisable plasticisers or other co-agents to achieve a controlled hardness and stiffness coupled with easy processing

In comparison to sulphur cure there are following disadvantages:

- sensitivity to oxygen under curing conditions
- certain components of the rubber compound like extender oils, antioxidants and resins may consume peroxide free radicals under certain conditions
- usually tensile and tear strength properties are reduced by 15%

Peroxide crosslinking possible for:

NR	Natural rubber	**EPDM**	Ethylene propylene terpolymer
IR	Polyisoprene rubber	**POE**	Polyolefi n elastomer
BR	Polybutadiene rubber	**T**	Polysulphite rubber
CR	Polychloroprene rubber	**PE**	Polyethylene
SBR	Styrene butadiene rubber	**CM**	Chlorinated Polyethylene
NBR	Butadiene acrylonitrile rubber	**CSM**	Chlorosulphonyl polyethylene
HNBR	Hydrogenated butadiene acrylonitrile rubber	**ABS**	Acrylonitrile butadiene styrene copolymer
Q	Silicone rubber	**EVA**	Ethylene vinylacetate copolymer
AO/EO	Polyurethane rubber	**EBA**	Ethylene butylacrylate copolymer
EPM	Ethylene propylene copolymer	**FPM**	Fluoro rubber

Peroxide crosslinking possible with blends of:

NBR / EPDM	**SBR / EPDM**	**PE / EPDM**	**PE / EVA**
NBR / EVA	**EPDM / PP**	**POE / EP(D)M**	

Peroxide crosslinking limited or impossible for:

ACM	Polyacrylate rubber	**IIR**	Butyl rubber
CIIR	Chlorobutyl rubber	**CO**	Epichlorohydrin rubber
ECO	Epichlorohydrin copolymer	**PP**	Polypropylene
PB	Polybutene-1	**PIB**	Polyisobutene
PVC	Polyvinylchloride		

Peroxide formulation with improved scorch protection

PEROXAN BIB-40 GS+ is a new product which offers improved scorch protection as compared to **PEROXAN BIB-40 GS**. It offers significantly better scorch protection during mixing and compounding which results in increased productivity.

Advantages during mixing:

- increased mixing speeds which result in shorter mixing times
- makes one step mixing a possibility
- improves the dispersibility of components

Advantages during processing:

- higher processing temperatures which results in shorter cycle times
- faster filling of moulds
- higher speeds during the extrusion process

Azo-Initiators as a blowing agent

PEROXAN AZDN-Paste 50 SI is used as a chemical blowing agent for the production of silicone foams and other expanded elastomeric products. When 2,2`-Azodiisobutyronitril decomposes it releases Nitrogen gas and forms a homogeneous sponge structure within the elastomer. The physical form as a paste facilitates the dust-free incorporation into silicone rubber and other low viscous elastomeric compounds.

Typical amounts of organic peroxides required for crosslinking of various polymers

Additions of the important peroxides for the crosslinking of different types of polymers are listed on the next page. Satisfactory mechanical properties can be obtained at the lowest peroxide dosage levels. Compression set properties improve with higher peroxide amounts. The highest values should not be surpassed, otherwise the remaining mechanical properties will decrease. However, higher peroxide levels are necessary when the compound contains free radical consuming materials such as sulphur, certain antioxidants and non-paraffinic mineral extender oils.

Parts of peroxide per 100 parts of polymer

Polymer	PEROXAN PK295 P	PEROXAN BV-40 P	PEROXAN DC-40 P	PEROXAN BIB-40 P	PEROXAN HX-45 P
NR, IR	2,3 - 4,5	2,5 - 5,0	2,0 - 4,1	1,3 - 2,5	1,3 - 2,4
BR	1,0 - 2,1	1,1 - 2,3	0,9 - 1,9	0,5 - 1,2	0,8 - 1,2
CR	1,1 - 3,0	1,3 - 3,3	1,0 - 2,7	0,6 - 1,7	0,6 - 1,6
SBR	1,9 - 4,1	2,1 - 4,6	1,7 - 3,7	1,1 - 2,3	1,1 - 2,2
NBR	2,6 - 4,5	2,9 - 5,0	2,4 - 4,1	1,5 - 2,5	1,4 - 2,4
HNBR	6,8 - 11,3	7,5 - 12,5	6,1 - 10,1	3,8 - 6,3	3,7 - 6,1
EPM, EPDM	6,8 - 11,3	7,5 - 12,5	6,1 - 10,1	3,8 - 6,3	3,7 - 6,1
PE	1,5 - 7,6	1,7 - 8,4	1,4 - 6,8	0,8 - 4,2	0,8 - 4,0
CM	6,8 - 10,6	7,5 - 11,7	6,1 - 9,5	3,8 - 5,9	3,7 - 5,7
EVA	2,6 - 5,3	2,9 - 5,8	2,4 - 4,7	1,5 - 3,0	1,4 - 2,9
Q			1,0 - 2,0	0,4 - 0,8	0,4 - 0,8
t90 Crosslinking*	145°C	160°C	170°C	175°C	175°C
t2 Crosslinking	115°C	125°C	130°C	135°C	135°C

* Very short crosslinking times can be achieved by raising t90- temperatures to approximately 40°C above the mentioned temperature.

APPLICATIONS

Cable insulation

Cable insulation from peroxide cross-linked polyethylene (XLPE) are used in 1-380 kV range. Important after crosslinking are good dielectric properties and dimensional stability at higher temperatures. Mostly LDPE is crosslinked with Dialkylperoxides.

NBR & SBR

Butadiene acrylonitrile rubber (NBR) is produced by copolymerization of acrylonitrile (ACN) and 1,3-butadiene. Materials based on this synthetic rubber are suitable because of their good technological properties for many applications. In particular, radial shaft seals, sealing elements for hydraulic and pneumatic systems as well as O-rings.

Styrene butadiene rubber (SBR) is produced by the copolymerization of 1,3-butadiene and styrene. SBR is now the most widely used synthetic rubber and finds its application in the production of tires (tread), gaskets and conveyor belts.

Crosslinked Foamed Polyethylene

Crosslinked polyethylene foam is produced by crosslinking of polyethylene in the presence of foaming agents, such as e.g. Azo initiators. Crosslinked PE foam has a fine, regular and closed cell structure with low density. The closed cell structure provides excellent heat and cold insulation properties. In addition, cross-linked PE foam does not absorb water. Applications are noise protection, thermal insulation, seat cushions, gym mats or floats (swimming aids).

Crosslinked EVA

Ethylene vinyl acetate (EVA) is a class of copolymers. The crosslinking with organic peroxides is carried out in order to improve the elongation, the aging and the heat resistance. Applications are hot melt adhesives, films, electrical cables, solar panels, shoe soles and floor coverings.

Crosslinked EPM/EPDM

Ethylene-propylene copolymer (EPM) is a copolymer of ethylene and propylene, ethylene-propylene terpolymer (EPDM) is a terpolymer of ethylene, propylene and a diene component. Advantages are more enhanced temperature resistance, lower compression set and a better aging behavior. Applications are hoses, seals, profiles, cables, shoe soles and conveyor belts.

Crosslinked HDPE & Crosslinked LDPE

Crosslinked Polyethylene (PE-X) is produced by crosslinking of thermoplastic polyethylene (LDPE, LLDPE or HDPE) through organic peroxides. Due to the crosslinking the impact resistance, abrasion resistance, low-temperature and stress cracking resistance can significantly be increased. On the contrary the hardness and rigidity decreases. As PE-X does not melt it is more thermally resistant. With a higher crosslinking density the maximum shear modulus increases also. Crosslinking of PE is only applied to the finished or semi-finished product. Applications are rotationally sintered hollow bodies, underfloor heating pipes, medium and high voltage cable insulation or container linings.

Crosslinked Silicone Rubber

Silicones (poly (organo) siloxanes) is a group of synthetic polymers in which silicon atoms are linked via oxygen atoms. As silicone rubber is referred to the compositions of the poly (organo) siloxanes transferred into a rubber-elastic state. Silicone rubber differs in two types according to the required curing temperature: a cold- (RTV) and a hot-crosslinked (HTV) silicone rubber. Both types can, in addition to the silane or platinum crosslinking, be crosslinked with organic peroxides. Crosslinked silicone rubber has a good cold-/heat- and aging resistance and can be used for hoses, rollers, conveyor belts, cable sheathing, gaskets and for pharmaceutical and medical products. As crosslinkers we recommend our peroxide formulations based on silicone oil or silicone rubber.

Safe processing- and crosslinking times

Safe processing temperature t2

The raw materials (polymer, additives, peroxide) have to be homogenized before the crosslinking reaction can take place. Although the temperature sensitive peroxide will be the last raw material which is added for homogenization, one has to take care to avoid temperatures at which the peroxide decomposes and the crosslinking reaction starts. This maximum processing temperature of the peroxides is called the scorch temperature. The safe processing temperature t2 is defined as the temperature, at which the scorch time is longer than 20 minutes.

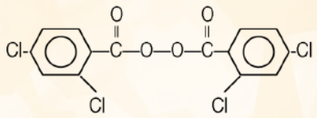
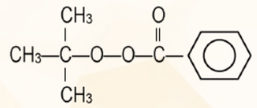
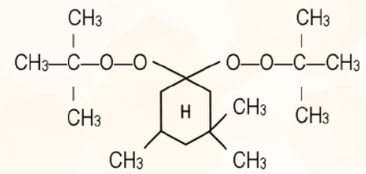
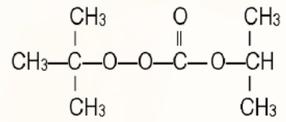
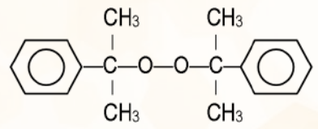
Typical crosslinking temperature t90

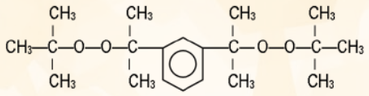
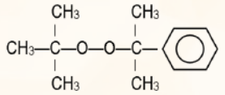
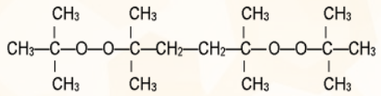
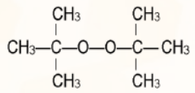
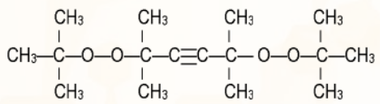
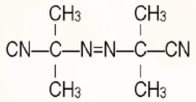
The typical crosslinking temperature t90 is defined as the temperature at which 90% of the crosslinks in the compound are formed within about 12 minutes.

Storage temperatures

Crosslinking peroxides can be stored and handled without risk providing certain precautions are taken. Please refer to our MSDS and product labels for precise information and keep products at recommended storage temperature.

PEROXAN BD	°C	70	80	90	100	110	120	130	140	150	160	170	180	190	200
Safe processing time	min	47	12	2											
Crosslinking time	min			10	4	2									
PEROXAN PB															
Safe processing time	min			29	20	11									
Crosslinking time	min						61	30	12	5					
PEROXAN PK295															
Safe processing time	min					35	11								
Crosslinking time	min							50	16	7					
PEROXAN BV															
Safe processing time	min						35	12							
Crosslinking time	min								72	30	11	5			
PEROXAN DC															
Safe processing time	min						77	24							
Crosslinking time	min									65	25	10	4		
PEROXAN BIB															
Safe processing time	min							58	19						
Crosslinking time	min										46	22	7	3	
PEROXAN BU															
Safe processing time	min							57	19						
Crosslinking time	min										46	19	6	3	
PEROXAN HX															
Safe processing time	min							45	15						
Crosslinking time	min										60	24	8	3	
PEROXAN DB															
Safe processing time	min								54	18					
Crosslinking time	min										86	34	12	5	2
PEROXAN HXY															
Safe processing time	min								43	14					
Crosslinking time	min											63	22	8	4

Trade name	Chemical name / Chemical structure	CAS number / Physical form	Peroxide assay	Active oxygen assay	Standard package	Storage temperatures max.	Storage temperatures min.	Half life temperatures 10h	Half life temperatures 1h	Half life temperatures 0,1h	Processing temperatures t2	Processing temperatures t90	Regulatory Recommendations FDA	Regulatory Recommendations BfR	UN-No.
	Di-(2,4-dichlorobenzoyl)-peroxide	133-14-2						47°C	65°C	80°C	75°C	90°C			
PEROXAN BD-Paste 50 SI		Paste in silicone oil	50%	2,11%	20kg pail	30°C	5°C						177.2600	XV	3106
	tert-Butyl peroxybenzoate	614-45-9						87°C	110°C	136°C	100°C	140°C			
PEROXAN PB		Liquid	98%	8,07%	25kg container	30°C	10°C							XLVI	3103
PEROXAN PB-50 P		Powder with chalk	50%	4,12%	25kg cardboard box	30°C									3106
	1,1-Di-(tert-butylperoxy)-3,3,5-trimethylcyclohexane	6731-36-8						91°C	117°C	138°C	115°C	145°C			
PEROXAN PK295 P		Powder with chalk	40%	4,23%	25kg cardboard box	30°C									3110
PEROXAN PK295 GS		Granules with chalk	40%	4,23%	25kg cardboard box	30°C									3110
PEROXAN PK295 MB		Granules with EPM	40%	4,23%	25kg cardboard box	30°C									3110
	Butyl-4,4-di-(tert-butylperoxy) valerate	995-33-5						104°C	130°C	152°C	125°C	160°C			
PEROXAN BV-40 P		Powder with chalk	40%	3,83%	25kg cardboard box	30°C									3108
PEROXAN BV-40 GS		Granules with chalk	40%	3,83%	25kg cardboard box	30°C									3108
	Dicumyl peroxide	80-43-3						112°C	138°C	162°C	130°C	170°C			
PEROXAN DC		Fine granules	98%	5,80%	20kg cardboard box	30°C							177.2600	XV,	3110
PEROXAN DC-P		Powder	98%	5,80%	20kg cardboard box	30°C								XXXIX	3110
PEROXAN DC-P+		Powder	98%	5,80%	20kg cardboard box	30°C									3110
PEROXAN DC-Paste 50 SI/3		Paste in silicone oil	50%	2,96%	25kg pail	30°C	5°C								3110
PEROXAN DC-40 GS		Granules with chalk	40%	2,37%	25kg cardboard box	30°C									3077
PEROXAN DC-40 MB		Granules with EPM	40%	2,37%	25kg cardboard box	30°C									3077
PEROXAN DC-40 PE-G		Granules with PE	40%	2,37%	20kg cardboard box	30°C									3077
PEROXAN DC-40 PK		Powder with clay	40%	2,37%	20kg cardboard box	30°C									3077
PEROXAN DC-40 P		Powder with chalk	40%	2,37%	25kg cardboard box	30°C									3077
PEROXAN DC-20 PE-MB		Masterbatch with PE	20%	1,18%	20kg cardboard box	30°C									none

Trade name	Chemical name / Chemical structure	CAS number / Physical form	Peroxide assay	Active oxygen assay	Standard package	Storage temperatures max.	Storage temperatures min.	Half life temperatures 10h	Half life temperatures 1h	Half life temperatures 0,1h	Processing temperatures t2	Processing temperatures t90	Regulatory Recommendations FDA	Regulatory Recommendations BfR	UN-No.
	Di-(2-tert-butyl-peroxyisopropyl)-benzene	25155-25-3						117°C	146°C	169°C	135°C	175°C			
PEROXAN BIB-1		Powder	95%	8,98%	20kg cardboard box	30°C								XXXIX,	3106
PEROXAN BIB-40 EV-G		Granules with EVA	40%	3,78%	20kg cardboard box	30°C								XLVI,	none
PEROXAN BIB-40 GS		Granules with chalk	40%	3,78%	25kg cardboard box	30°C								XXI	none
PEROXAN BIB-40 GS+		Granules with chalk	40%	3,78%	25kg cardboard box	30°C									none
PEROXAN BIB-40 MB		Granules with EPM	40%	3,78%	25kg cardboard box	30°C									none
PEROXAN BIB-40 PE-G		Granules with PE	40%	3,78%	20kg cardboard box	30°C									none
PEROXAN BIB-40 PK		Powder with clay	40%	3,78%	20kg cardboard box	30°C									none
PEROXAN BIB-40 P		Powder with chalk	40%	3,78%	20kg cardboard box	30°C									none
	tert-Butylcumylperoxide	3457-61-2						117°C	146°C	169°C	135°C	175°C			
PEROXAN BU		Liquid	94%	7,22%	25kg container	30°C	15°C							XV	3107
	2,5-Dimethyl-2,5-di-(tert-butylperoxy)-hexane	78-63-7						118°C	147°C	171°C	135°C	175°C			
PEROXAN HX		Liquid	92%	10,14%	25kg container	40°C	10°C						177.2600	XV,	3103
PEROXAN HX-Paste 75 SI		Paste in silicone oil	75%	8,27%	25kg pail	40°C	10°C							XXXV,	3108
PEROXAN HX-Paste 70 SH		Paste with fillers	70%	7,71%	25kg pail	40°C	10°C							XLVI	3108
PEROXAN HX-50 PS		Powder with silica	50%	5,51%	25kg cardboard box	40°C	10°C								3108
PEROXAN HX-Paste 45 SI		Paste in silicone oil	45%	4,96%	25kg pail	40°C	10°C								3108
PEROXAN HX-45 SP		Paste in silicone rubber	45%	4,96%	18kg pail	40°C	10°C								3108
PEROXAN HX-45 GS		Granules with chalk	45%	4,96%	25kg cardboard box	40°C									3108
PEROXAN HX-45 MB		Granules with EPM	45%	4,96%	25kg cardboard box	40°C									3108
PEROXAN HX-45 P		Powder with chalk	45%	4,96%	20kg cardboard box	40°C	10°C								3108
PEROXAN HX-26 TA		Powder with chalk and TAIC	26%	2,87%	25kg cardboard box	40°C	10°C								3108
	Di-tert-butylperoxide	110-05-4						120°C	154°C	176°C	145°C	180°C			
PEROXAN DB		Liquid	98%	10,72%	20kg container	40°C							177.2600	XXXV, XLVI	3107
	2,5-Dimethyl-2,5-di(tert-butylperoxy)hexyne-3	1068-27-5						127°C	157°C	182°C	145°C	185°C			
PEROXAN HXY-85 W		Solution in white oil	85%	9,50%	25kg container	30°C	10°C							XLVI	3103
PEROXAN HXY-45 P		Powder with chalk	45%	5,03%	25kg cardboard box	30°C									3106
Blowing agent	2,2'-Azodiisobutyronitril	78-67-1		**Assay**				**Application**							
PEROXAN AZDN-Paste 50 SI		Paste in silicone oil		50%	25kg pail	20°C		**PEROXAN AZDN-Paste 50 SI** is a blowing agent for the production of silicone foams. The physical form as a paste facilitates the dust-free incorporation into silicone rubber.							3234

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