LANXESS
Energizing Chemistry

LEVAPREN®

Ethylene Vinyl Acetate (EVM)

The cost-effective specialty rubber!

Edition 2007-02

Levapren® EVM

We have tomorrow's requirements in mind

As a worldwide leader in synthetic rubber production, LANXESS offers its customers a comprehensive range of synthetic rubbers.

Specialty rubbers such as Levapren® play an important role here. When conventional polymers come up against their limits, Levapren®, a polymer with very good heat and weathering resistance, is a suitable alternative. The Levapren® product range consists of rubbers that can cope with the continuously more demanding requirements of the following sectors:

- **automotive industry**
- **machinery industry**
- **construction industry**
- **wire and cable industry**
- **sporting goods**

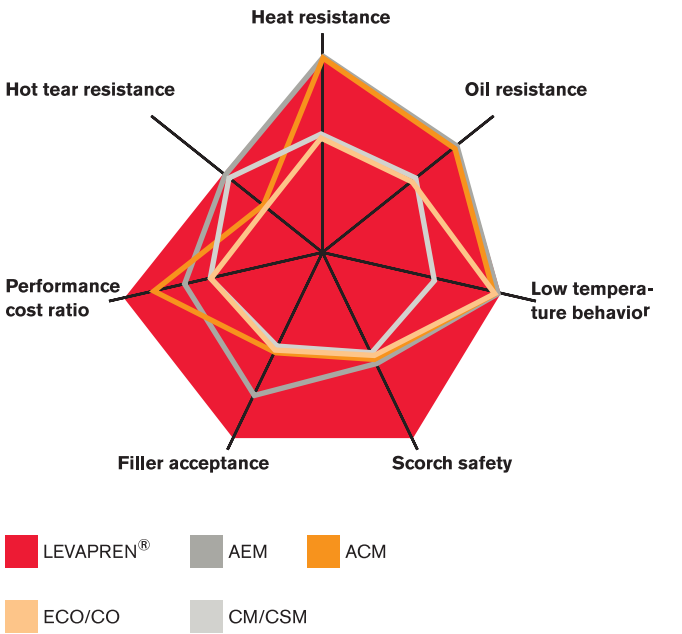
The aim of this brochure is to give a first impression of Levapren®, providing information on its many properties and advantages, and showing both processors and end users the solutions made available to them with it.

Our Levapren® experts will be happy to provide you with further technical information. Please find their contact data on page 22 of this brochure.
For immediate contact, complex questions or urgent requests you can also use our e-mail address at: **info@levapren.com**

LEVAPREN®
PROPERTIES & ADVANTAGES

A direct comparison shows that Levapren® is superior to many other elastomers and materials in several respects. This means that you can turn to Levapren® in applications where you previously needed less cost-effective elastomers.

Figure 1: Evaluation of Levapren®'s properties



AEM

Levapren® is superior to AEM (ethylene-acrylic elastomer) due to:
- better scorch safety
- no obligatory need for post-curing
- less odor
- less harmful crosslinking system

ACM

Levapren® is superior to ACM (acrylate elastomer) due to:
- better scorch safety
- mechanical properties
- better flow behavior
- higher filler acceptance

ECO/CO

Levapren® is superior to ECO/CO (epichlorohydrin) due to:
- better heat resistance
- better scorch resistance
- being halogen-free
- better corrosion resistance
- lead-free crosslinking system

CM/CSM

Levapren® is superior to CM/CSM (chlorinated/chlorosulfonated polyethylene) due to:
- better heat resistance
- better low temperature flexibility
- being halogen-free
- better corrosion resistance

HNBR

Levapren® is superior to HNBR (hydrogenated NBR) due to:
- better heat resistance
- better flow behavior
- higher filler acceptance

Levapren® rubber is formed by copolymerizing ethylene and vinyl acetate. Thus, Levapren® consists of methylene units forming a saturated main chain with pendant acetate groups. These rubber-like polymers are designated as EVM[1] according to ISO 1629: 1995 (E).
The fully saturated main chain leads to Levapren® being a particularly stable polymer. Any deterioration generally only occurs at very high temperatures and even then very slowly.

Table 1: Chemical structure of Levapren®

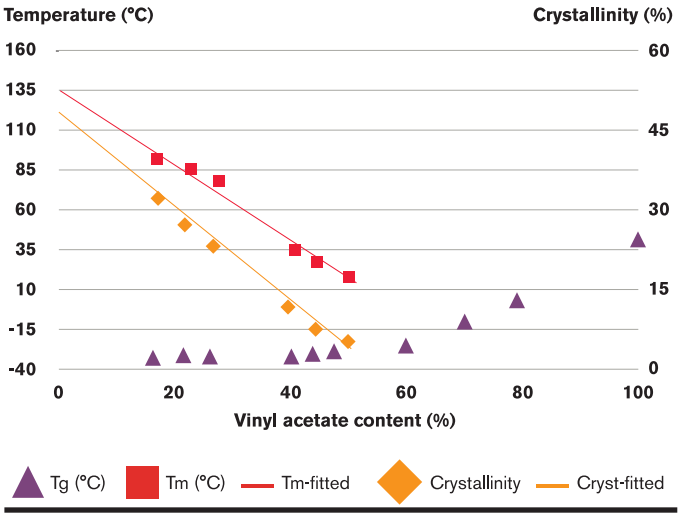
Ethylene	Vinyl acetate	Ethylene/Vinyl acetate Copolymer
$CH_2 = CH_2$	+ $CH = CH_2$	$\longrightarrow$ $-CH_2-CH_2-CH-CH_2-$
	O	O
	$C = O$	$C = O$
	CH_3	CH_3

These polymers are used as synthetic rubbers, as adhesive raw materials or as modifiers in thermoplastics, specifically PVC. The adhesive raw materials are marketed under the name Levamelt®, while the grades used for the modification of plastics are distributed under the name Baymod® L.

The grades are classified by the vinyl acetate content.

The general property profile of the copolymers produced from ethylene and vinyl acetate is determined in the first instance by the ratio of the two components. The reactivity of the two monomers is so similar that they are statistically distributed throughout the polymer chain, this being ideal for rubber applications.

Figure 2: Influence of VA content on morphology



The higher the proportion of vinyl acetate in the copolymer, the more the regularity of the ethylene chain is disturbed. Crystallization is increasingly hampered and is entirely absent from a copolymer with a vinyl acetate content of approx. 55 %. Copolymers with a high vinyl acetate content are therefore amorphous.

[1] In accordance with ISO 1043-1: 1987, the abbreviation E/VAC is to be used for thermoplastics. The abbreviation EVA is also frequently used.

VULCANIZATE PROPERTIES

General

As a result of vulcanization – the three-dimensional crosslinking of the polymers – the raw compound is converted from the thermoplastic, viscous state to the elastic state. This takes place in a one-stage process, with no need for any post-curing. For certain applications or technical reasons, however, post-curing may be applied to some advantage.

Table 2 compares the physical properties of Levapren® vulcanizates with those of other elastomers. The property profile obtained is strongly influenced by the composition of the rubber compound and its processing. It should be noted that the maximum values cannot be all achieved simultaneously.

Table 2: Typical properties of Levapren® vulcanizates compared with other elastomers

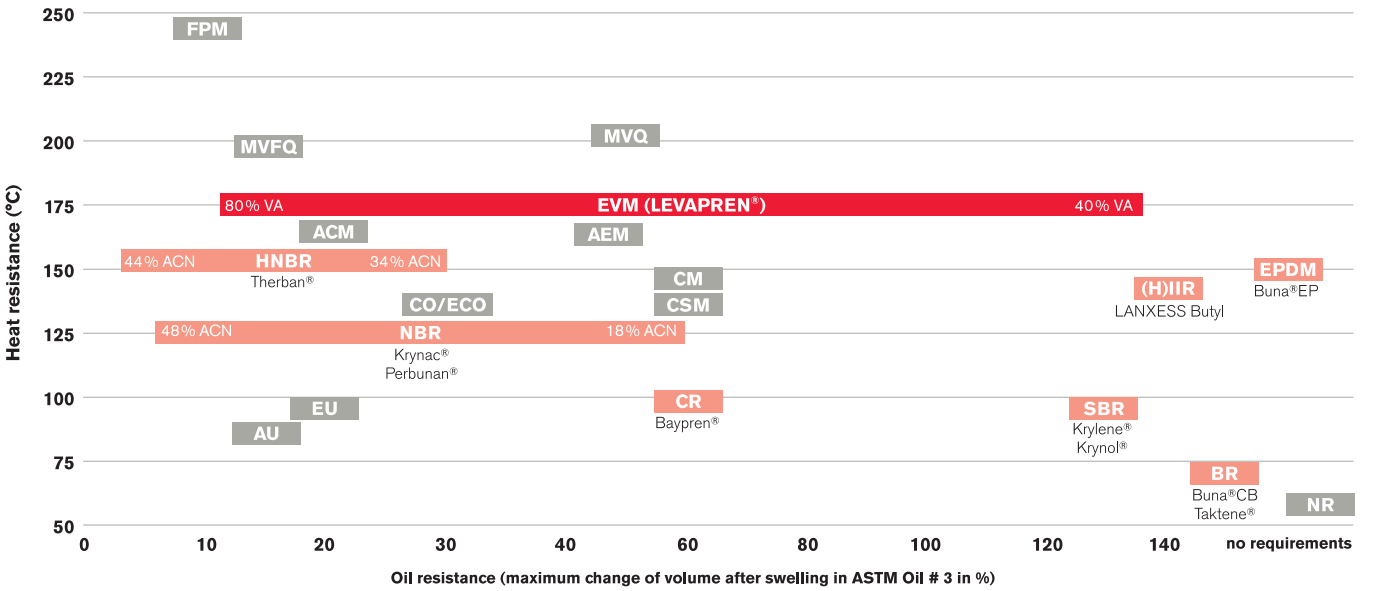
	Levapren®	AEM	ACM	ECO/CO	CM/CSM	HNBR
Tensile strength (MPa)	up to 24	up to 20	up to 18	up to 15	up to 20	up to 38
Hardness (Shore A)	50-90	50-90	50-90	50-90	50-90	50-90
Abrasion resistance	B	B	B	C	A	A
Tear propagation resistance	C	C	C	C	C	A
Rebound resilience	A-D	C	C	C	C	B-C
Hot air resistance; temperature limit under long-term stress, 1,000 hrs (°C)	175	175	175	135	135	150
Low temperature resistance	C	C	D	C	D	C
Weathering and ozone resistance	A	A	A	A	A-B	A-B
Combustion behavior	A	A-B	C	D	D	A-B

A: Excellent, B: Very good, C: Good, D: Moderate

VULCANIZATE PROPERTIES

Hot air and oil resistance

Figure 4: Classification of elastomers based on their hot air and oil resistance (in accordance with ASTM D 2000/SAE J 200)

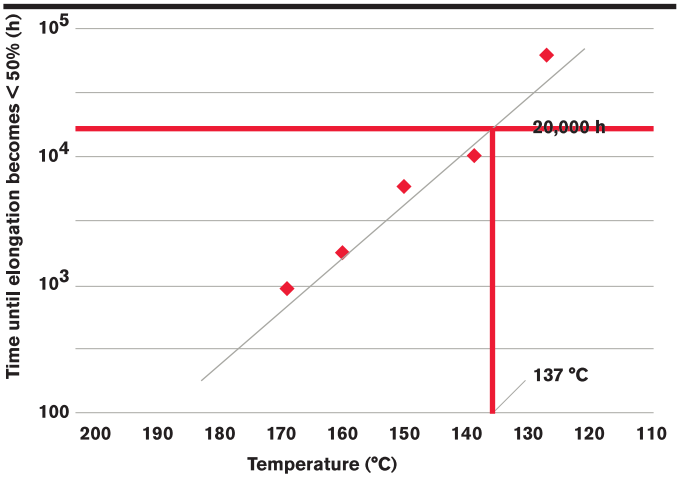


Levapren® vulcanizates in optimized compounds display excellent aging resistance and continue to function over long periods at elevated temperatures. The heat resistance of Levapren® vulcanizates is considerably better compared to most other common elastomers. This means that Levapren® vulcanizates bridge the gap between silicone rubber and ethylene-propylene rubber.
The very good heat resistance is only surpassed by that of silicone rubber and fluoro rubber and is equivalent to that of acrylate rubber.

Figure 4 based on ASTM D 2000/SAE J 200 shows how Levapren® can be classified in relation to other polymers. At 40 to 90 % vinyl acetate content, Levapren® covers the range from low to very good oil resistance.

Well protected Levapren® vulcanizates can serve up to 1,000 hrs at 175 °C. Even over a period of 20,000 hrs Levapren® can withstand temperatures of 137 °C, according to VDE 0304/IEC 216.

Figure 5: Determination of heat resistance of Levapren® (in accordance with VDE 0304)



Figures 6 to 8 show the oil resistance of Levapren® 600 HV and Levapren® 700 HV vulcanizates compared to commonly used elastomers in the automotive sector. These tests have been conducted in actually applied oils and therefore reflect the performance which can be achieved under real conditions. Although volume change and hardness reduction are slightly higher compared to the competitive products, the change of physical properties like elongation and especially tensile strength at break are superior to the other tested elastomers.

Figure 6: Physical properties of elastomers after immersion in Engine Oil Helix 5W30 (1008 h at 150 °C)

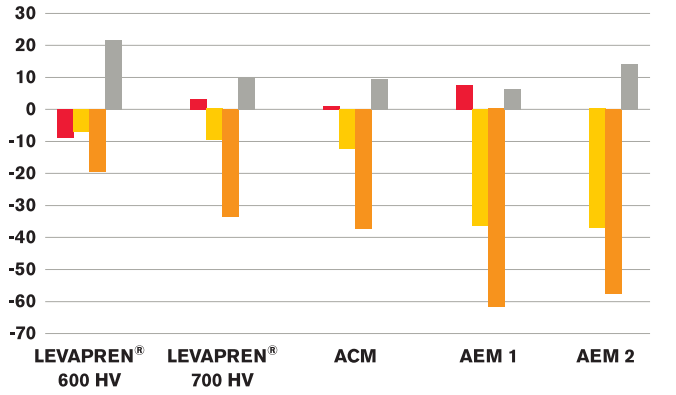


Figure 7: Physical properties of elastomers after immersion in Cecilia 20 (1008 h at 150 °C)

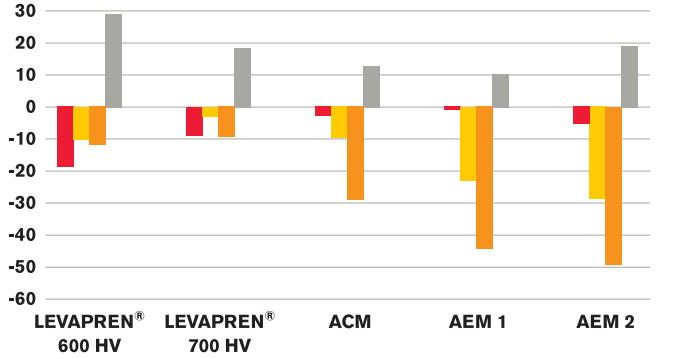
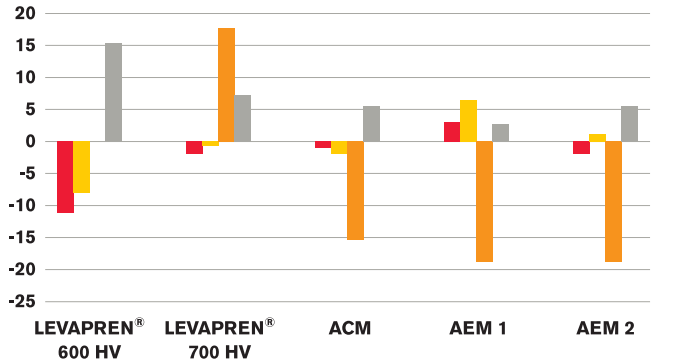
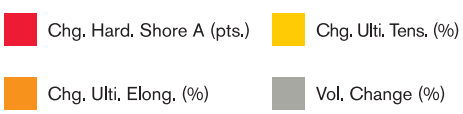


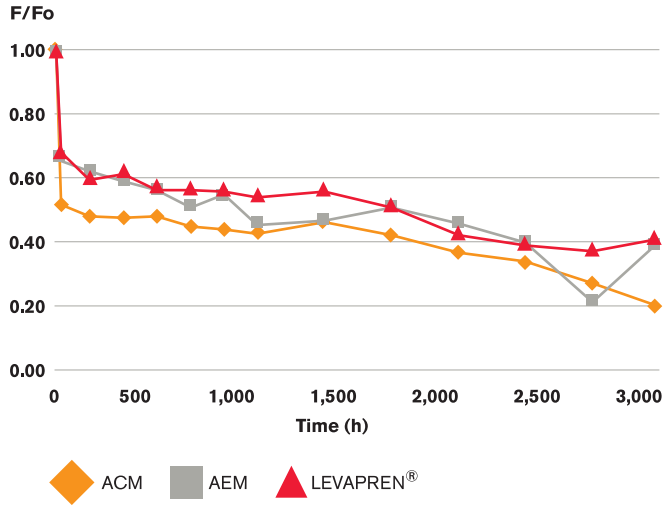
Figure 8: Physical properties of elastomers after immersion in ATF Gear Oil M 1375.4 (504 h at 130 °C)





As a higher swelling in oil might even be beneficial for sealing applications, only a more practical test like the CSR method (compressive stress relaxation) is able to determine the sealing force of the vulcanizate. Figure 9 shows the development of the sealing force after up to 3,000 hrs.

Figure 9: Compressive stress relaxation at 150 °C in SF 105G (Dyneon jigs)



Levapren® shows a superior sealing performance in comparison to the benchmarked materials. This makes Levapren® a material of choice for gaskets and seals used in a high temperature environment.

Another big advantage for Levapren® in sealing applications is the excellent processability, which will be shown later in this brochure.**

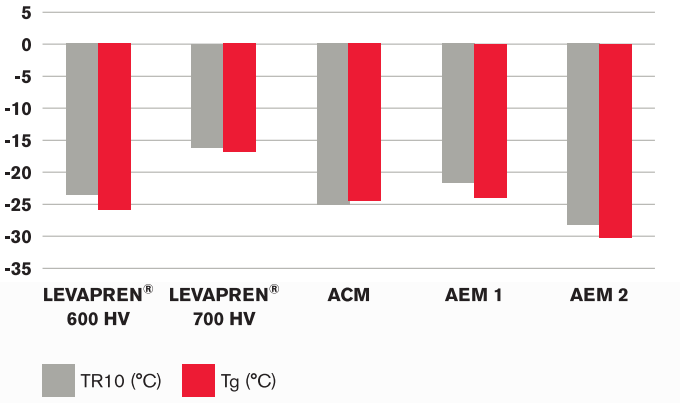
** See page 23

VULCANIZATE PROPERTIES

Low temperature performance

The low temperature performance of Levapren® depends significantly on the VA content. Decreasing VA contents result in a lower Tg (See also Figure 2). Depending on the application, the broad range of our Levapren® portfolio offers the possibility to select the right grade for the optimized solution regarding low temperature and oil resistance.

Figure 10: TR10 & T_g (measured by DMA) of representative vulcanizates



Levapren® is the material of choice wherever flame retardance has to be achieved. It presents the additional advantages of being halogen-free and of burning with non-corrosive emissions. Flame retardance is achieved by adding high amounts of specialized fillers, such as aluminium hydroxide or magnesium hydroxide, which additionally ensure the good processability of the compound.

Figure 11: Flame-retardant and chlorine-free fuel hose cover made of Levapren® by Veritas**

Based on small-scale laboratory flame tests, properly compounded, Levapren® gives lower smoke evolution than competitive materials. Smoke evolution during an actual fire may impair visibility and obscure escape routes. By proper compounding FRNC materials complying even with DIN 4102/Fire Class B1 can be produced.[1]

FRNC materials are particularly suitable for use in heavily frequented areas such as:

- department stores
- hospitals
- airports
- railway stations
- buses and trains, especially underground trains

and in buildings which contain high-value equipment and articles:

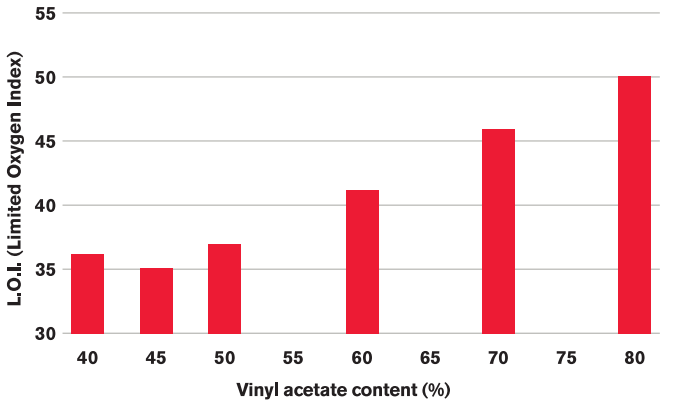
- computer centers
- museums

What's more, disposal of old halogen-free rubber products has less of an environmental impact.

[1] Proper compounding assumed, flammability results are based on small-scale laboratory tests for purposes of relative comparison and are not intended to reflect the hazards presented by this or any other material under actual fire conditions.

The flame-retardant properties of Levapren® vulcanizates are not only affected by the amount and kind of filler in the compound, but also by the vinyl acetate content of the EVM grade used (see Figure 12). The higher the content of the vinyl acetate, the higher the limited oxygen index (LOI) of the resulting material and therefore the lower the likelihood of combustion.

Figure 12: Effect of the VA content/Aluminium hydroxide (ATH 190 phr) on the L.O.I. (in accordance with ASTM D 2663)



Other factors can significantly reduce the properties of elastomers, with ozone, UV radiation, rain and industrial waste gases proving particularly damaging. The effects are described according to their appearance as ozone cracking, crazing (non-oriented tear cracking), chalking, softening or hardening. Vulcanizates with light-colored fillers in particular are sensitive to these influences.

Levapren® vulcanizates show none of these effects after outdoor weathering tests conducted over 2-year periods. The samples were still usable at the end of the trial.

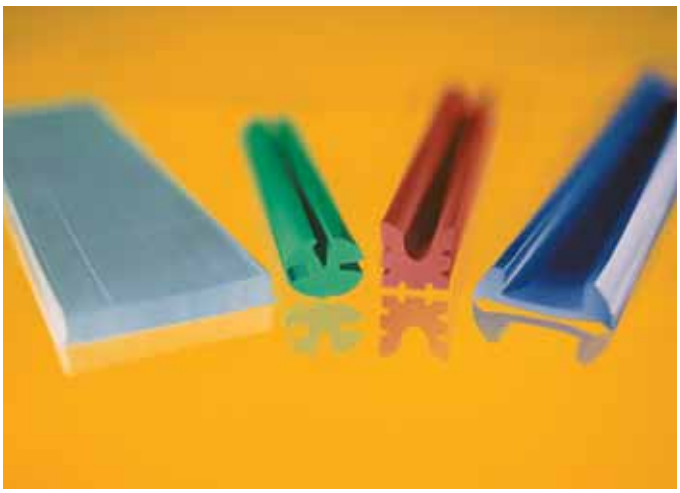
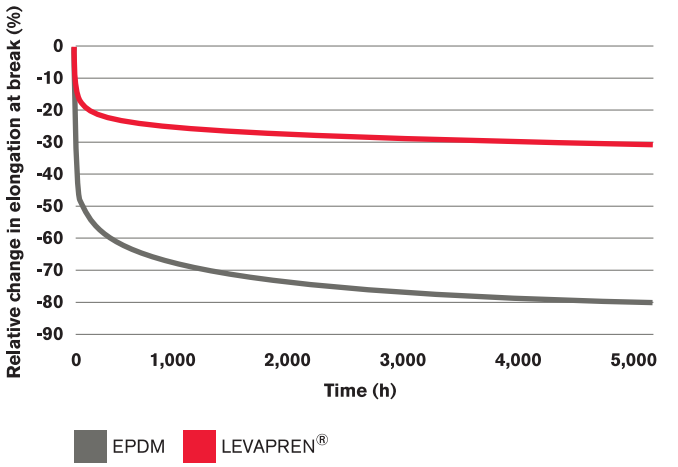


Figure 13: Colored profiles made of Levapren®

Similar positive results were obtained in the laboratory after trials involving UV radiation in a xenon tester.
A light-colored Levapren®-based FRNC (Flame-Retardant Non Corrosive) compound was protected with 10 phr titanium dioxide and 1 phr UV stabilizer. The changes in elongation at break are depicted in Figure 14 and are compared with the values obtained from a similar compound based on EPDM showing a clear advantage for Levapren®.

Figure 14: Relative change of elongation at break (%) of Levapren® compared to EPDM



Compared to AEM, Levapren® shows superior tear propagation resistance making it an ideal material for dynamic applications under severe environmental conditions.**

Figure 15a: Dynamic crack growth rate of Levapren® and other elastomers measured by tear analyzer at 80 °C in unaged and aged condition (aging: 7 days at 170 °C)

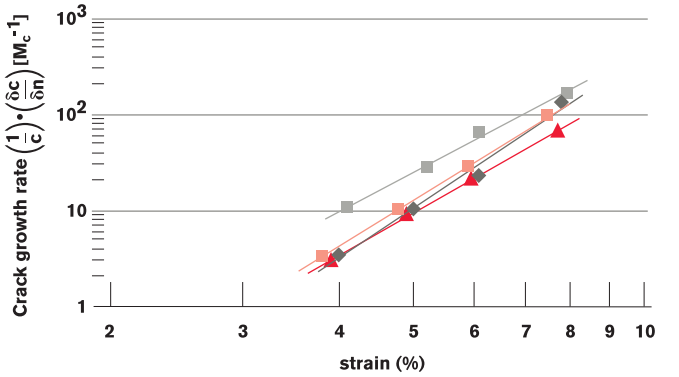
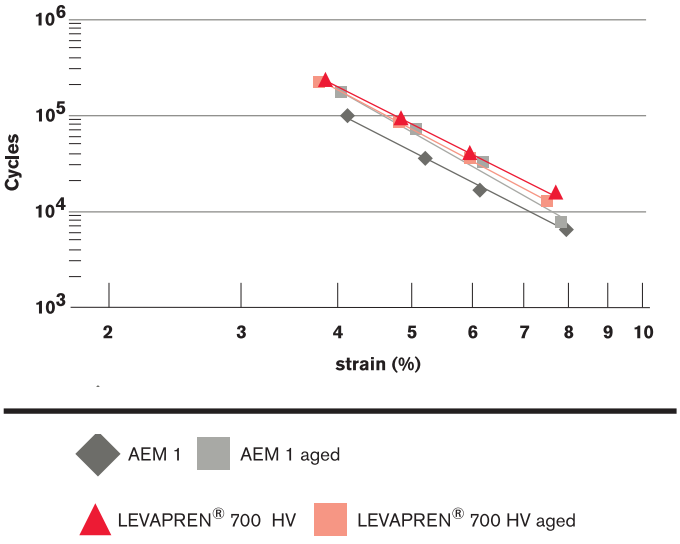


Figure 15b: Lifetime of Levapren® and other elastomers measured by tear analyzer at 80 °C in unaged and aged condition (aging: 7 days at 170 °C)



The high VA content Levapren® grades (Levapren® 800 HV and Levapren® VP 900 HV)(1) provide high damping at room temperature whereas the low VA content grades (Levapren® 400 HV and Levapren® 500 HV) show an extremely elastic behavior. This can be seen in Figures 16a and 16b.
Different Levapren® grades can be blended together, thus delivering an elegant way to produce materials with tailor-made dynamic mechanical properties.

Figure 16a: Frequency dependence of the complex shear modules at 20 °C of raw polymers (Mettler DMA/ STDA861e and Rheometer Physica MCR300)

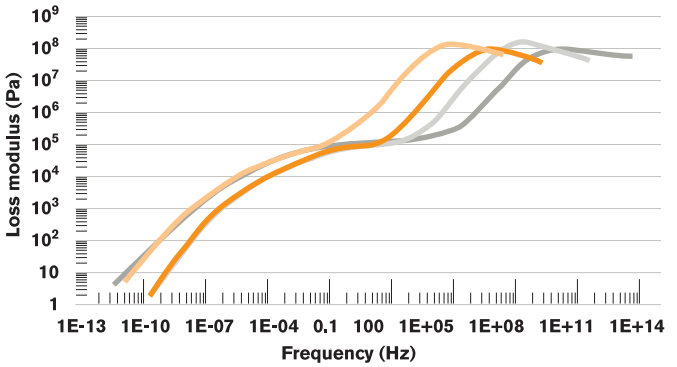
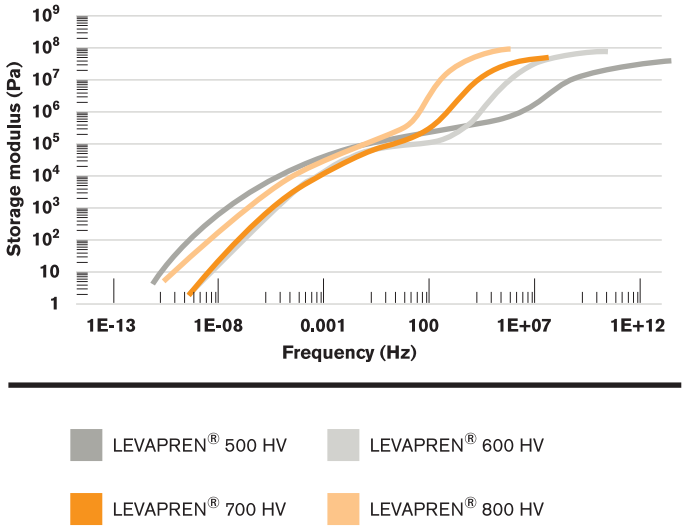


Figure 16b: Frequency dependence of the complex shear modules at 20 °C of raw polymers (Mettler DMA/ STDA861e and Rheometer Physica MCR300)



(1) formerly known as Levapren® VP KA 8939
** See page 23

All Levapren® grades are delivered as granules, allowing the material to be fed and therefore mixed continuously.
The low viscosity of Levapren® results in excellent flow properties which, combined with a very high scorch safety of Levapren® compounds (see Figure 17), enables the rubber manufacturer to produce highly sophisticated injection molded parts (see Figure 18). Post-curing is not necessary, though for certain applications or technical reasons it may be applied advantageously.

Figure 17: Scorch safety

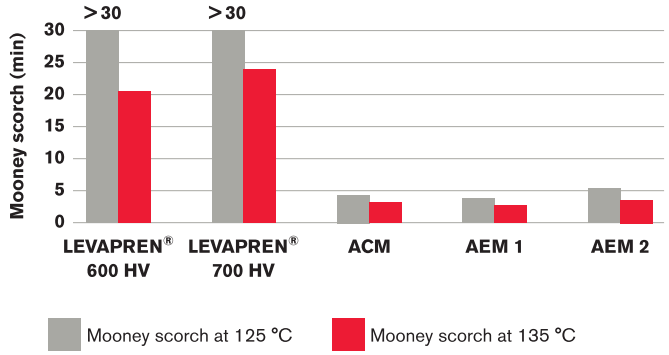
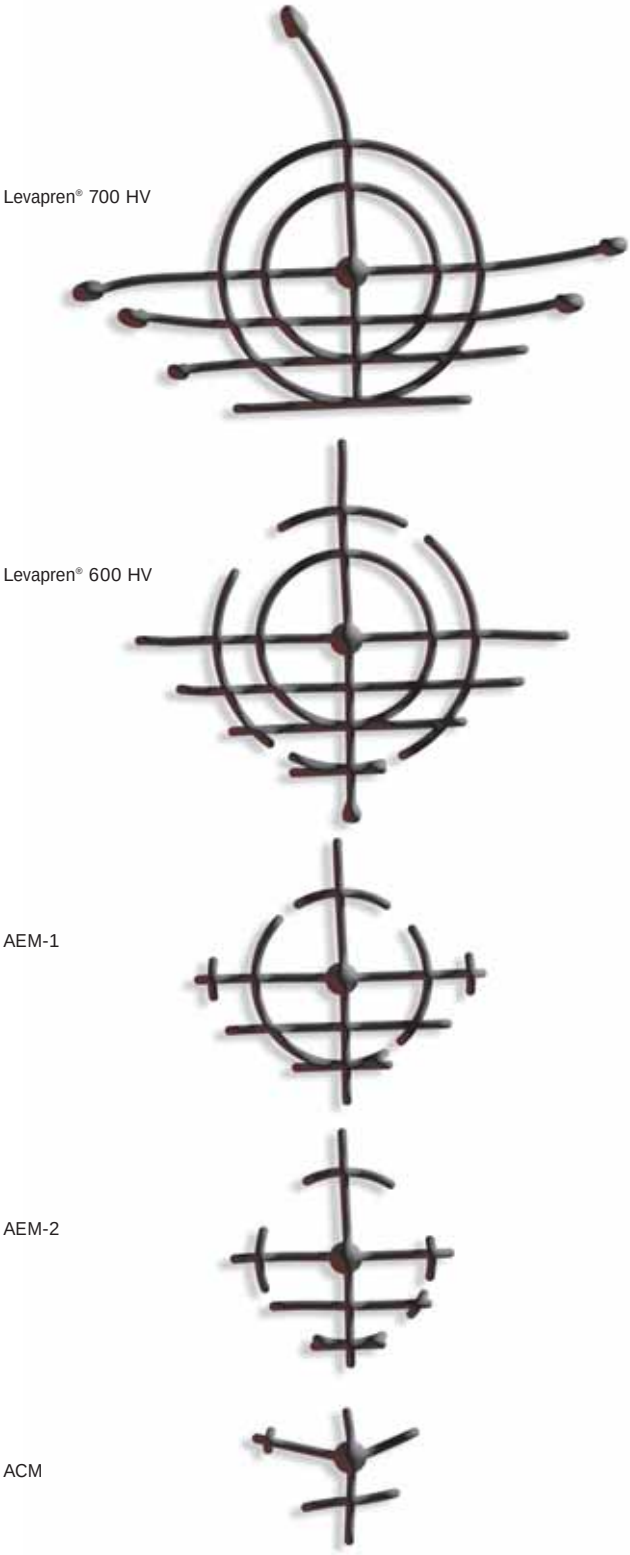


Figure 18: Filling level of injection molded parts at 180 °C mold temperature, 50 bar injection pressure and 15 sec injection time

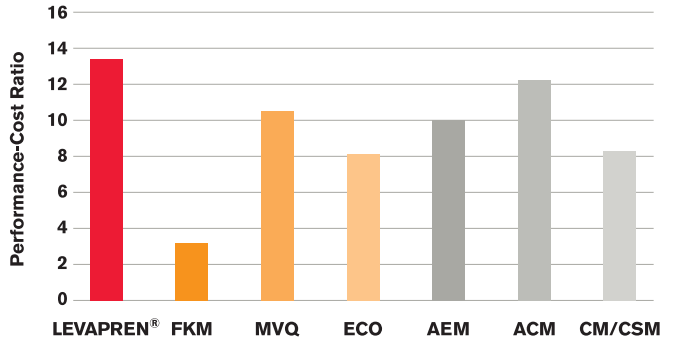


The combination of properties of Levapren® with respect to:

- high temperature resistance
- low temperature resistance
- oil resistance
- weather and ozone stability
- being halogen-free
- processability

offers the best performance-cost ratio within the range of specialty elastomers.

Figure 19: Performance-Cost Ratio of Levapren® compared to other specialty elastomers(1)



(1) Performance based on oil resistance, high temperature and low temperature properties. Cost based on typical compound compositions in EUR/liter (Source: LANXESS customer intelligence).

(1) Performance based on oil resistance, high temperature and low temperature properties. Cost based on typical compound compositions in EUR/liter (Source: LANXESS customer intelligence).

LEVAPREN®
APPLICATIONS

Seals

Due to its long-term heat stability and its good resistance to automotive fluids, Levapren® is used in seals, e.g., for rocker head covers.**

Figure 20: Rocker head cover seal based on Levapren®

Hoses

Levapren® is used as base material for flame-retardant and chlorine-free hose covers like in the fuel hoses for AUDI produced by Veritas.**

Figure 21: Flame-retardant and chlorine-free fuel hose cover made of Levapren®

** See page 23

Foams

Interep produces sponges out of Levapren® which are formulated for more favorable combustion behavior than competitive materials; that is, improved flame retardance and reduced smoke formation. These sponges are used in many applications where human safety has highest priority or where significant material assets exist. Typical applications are in ships, railways and buses.**

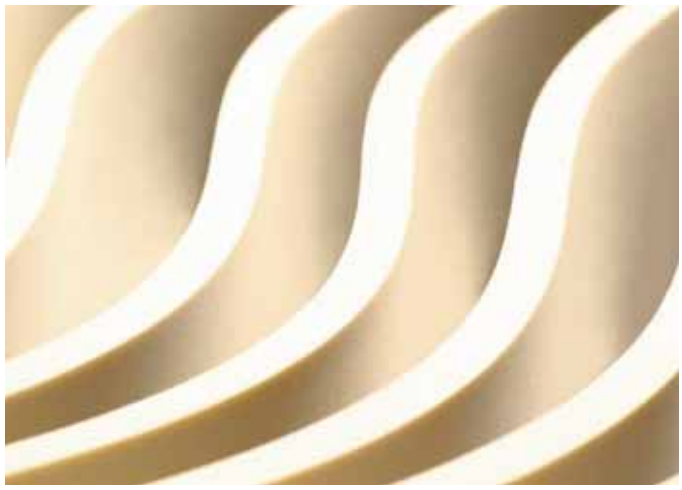


Figure 22: Levapren® sponge with more favorable combustion behavior

Floor coverings

Floor coverings based on Levapren® can not only fulfill FRNC requirements(1), they also give other benefits like:

- good resistance to wear and abrasion
- good resistance to ozone and weathering
- outstanding color stability.**

Figure 23: Floor coverings made of Levapren®

(1) Proper compounding assumed, flammability results are based on small-scale laboratory tests for purposes of relative comparison and are not intended to reflect the hazards presented by this or any other material under actual fire conditions.

Sensor cables

Due to its polymerization process, Levapren®'s molecular weight is particularly widely distributed. That is why it is a gel-free product, which has a positive effect on the processability of the material and the quality of the end product such as the sensor cables produced by Facab Lynen. Gel particles would impact the function of the cables and therefore cause safety problems. Larger particles would tear open the insulation in the course of extrusion with consequential electrical breakdown and short-circuiting.

For instance, Levapren® compounds satisfy the stringent requirements of such applications in terms of thermal stability, flame retardance, and good resistance to ozone, UV light and industrial waste gases.**

Figure 24: Sensor cables produced by Facab Lynen

Cables

Due to the high flame retardance and the heat and fluid resistance of FRNC Levapren® vulcanizates, cables are one of the key applications of Levapren®. Many cables in buildings, ships and other transport vehicles like the TGV are made of FRNC Levapren® compounds.**

Figure 25: FRNC Levapren® vulcanizates are used for the French high-speed train TGV

Vitroflex®(1)

Flexibility in design without compromising on properties is one of the common challenges in the industry. Levapren® enables designers to create translucent articles with very good weather and UV resistance which in most cases can only be achieved with carbon-black-filled rubber articles. Reinforced with glass fibers, this material, called Vitroflex®, is used, for example, for the bellows in buses, allowing more light to pass inside.**

Figure 26: Vitroflex® made of Levapren® (© ContiTech AG)

(1) Vitroflex® is a registered trademark of ContiTech Elastomer-Beschichtung GmbH.

** See page 23

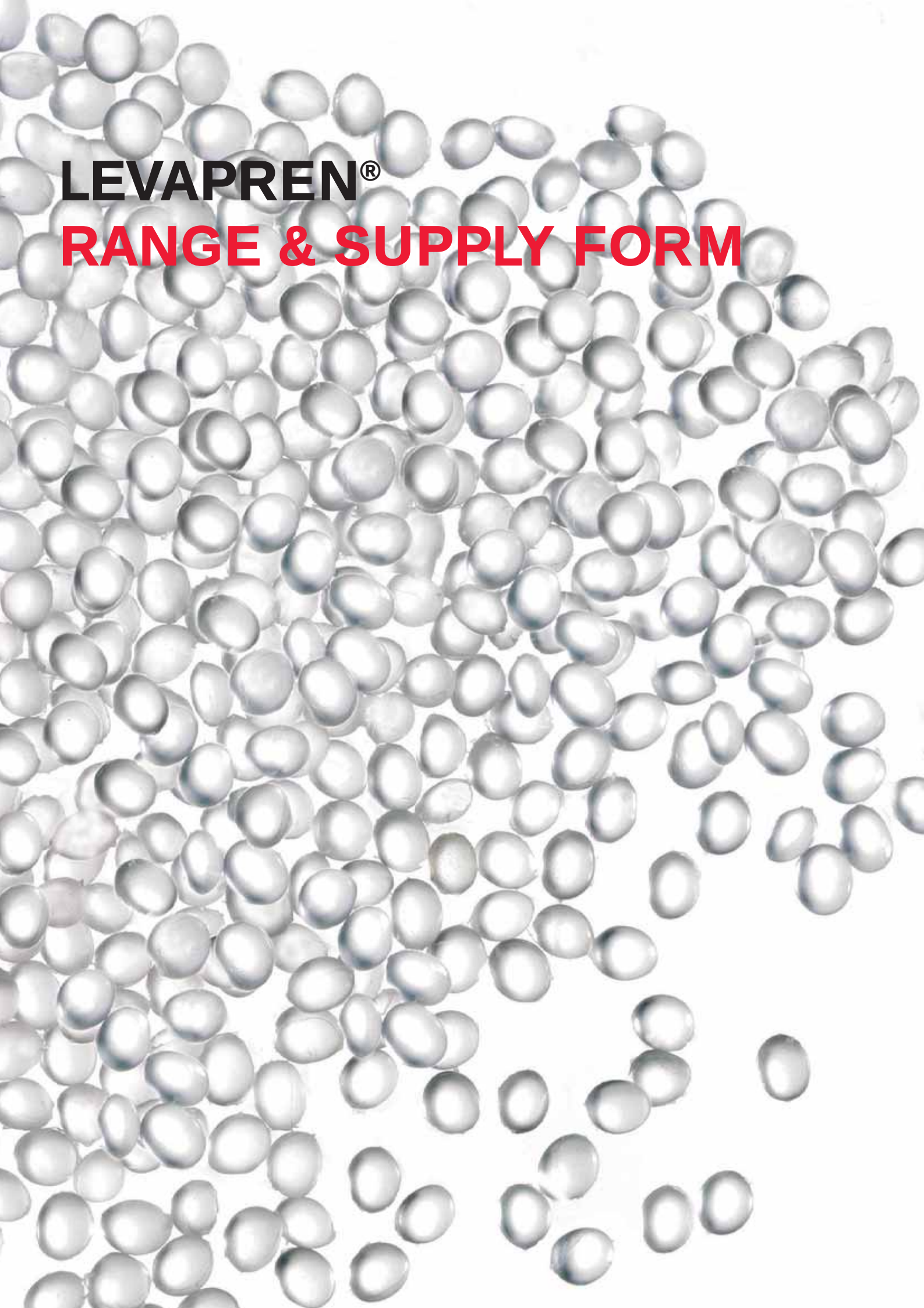
HeliMax®(1)

The properties mentioned before, in combination with the low gas permeability of Levapren®, make it an optimal choice for translucent materials such as the cover of the so-called HeliMax® which, when filled with helium and lit up by strong halogen lights is used to illuminate big areas during the night. This has proven to be of great use for sports events, salvage work, etc.**

Figure 27: Powermoon HeliMax® made of Levapren®

(1) HeliMax® is a registered trademark of Jürgen Nölle, Rheinberg.
** See page 23

LEVAPREN®
RANGE & SUPPLY FORM



The numbers of the Levapren® nomenclature are used to differentiate the grades. The first two digits relate to the vinyl acetate content, while the high-viscosity grades are designated HV.
With regard to trial products (identified by VP = Versuchsprodukt in German), the number has no real significance other than to identify the product. Some products are pre-crosslinked in a controlled manner in an additional process stage.

Table 3: Levapren® product range

	Vinyl acetate content, weight (%)	Viscosity ML (1+4) at 100 °C
Standard grades:		
Levapren® 400	40 ± 1.5	20 ± 4
Levapren® 450	45 ± 1.5	20 ± 4
Levapren® 500 HV	50 ± 1.5	27 ± 4
Levapren® 600 HV	60 ± 1.5	27 ± 4
Levapren® 700 HV	70 ± 1.5	27 ± 4
Levapren® 800 HV	80 ± 2.0	28 ± 6
Levapren® VP 900 HV	90 ± 2.0	38 ± 6
Pre-crosslinked grades:		
Levapren® VP KA 8857*	50 ± 1.5	approx. 55
Levapren® VP KA 8815*	60 ± 1.5	approx. 55
Levapren® VP KA 8784*	70 ± 1.5	approx. 60
Levapren® VP KA 8936*	80 ± 2.0	approx. 55

Levapren® is dispatched in 25-kg sacks on pallets or in big bags. The sacks are made from transparent PE and should always be removed if the compounding temperature does not significantly exceed their softening point.
Under suitable conditions (dry, max. temp. of 25 °C), Levapren® can be stored for 36 months from the date of manufacture. Higher temperatures or pressure may cause the granules to agglomerate, with the result that free-flowing properties cannot be guaranteed.

Table 4: Levapren® packaging

	Pallet, 40 sacks 25-kg PE sack in a box	Pallet, 40 sacks 25-kg PE sack	Pallet, 35 sacks 25-kg PE sack in a box
Standard grades:			
Levapren® 400	–	●	–
Levapren® 450	–	●	–
Levapren® 500 HV	–	●	–
Levapren® 600 HV	●	–	–
Levapren® 700 HV	●	–	–
Levapren® 800 HV	●	–	–
Levapren® VP 900 HV	●	–	–
Pre-crosslinked grades:			
Levapren® VP KA 8857*	–	–	●
Levapren® VP KA 8815*	–	–	●
Levapren® VP KA 8784*	–	–	●
Levapren® VP KA 8936*	–	–	●

CONTACT DATA & SERVICE

United States

LANXESS Corporation
111 RIDC Park West Drive
Pittsburgh, PA 15275-1112
USA
E-mail: terry.farver@lanxess.com
Phone: +1 (412) 809-4762
www.us.lanxess.com

Germany

LANXESS Deutschland GmbH
Technical Rubber Products
Global Product Management EVM
51369 Leverkusen, Germany
E-mail: harry.zumaque@lanxess.com
Phone: (+49) 214/30 54 865
www.lanxess.com

Asia

LANXESS Chemical (Shanghai) Co., Ltd
Technical Rubber Products, APAC
Building 8, No. 899 Zu Chong Zhi Road
Zhangjiang High-Tech Park
Shanghai, 201203
P.R. China
E-mail: martin.hoch@lanxess.com
Phone: +86 21 51317888-231
www.lanxess.cn

Internet

www.lanxess.com
www.us.lanxess.com
www.levapren.com
Sales offices worldwide: www.sales-offices-trp.lanxess.com

Make use of our experience!

Further information on Levapren® is available on the Internet at **www.levapren.com.**

For direct information, please contact our technical support service. Our Levapren® experts look forward to answering your questions.

Inventing the future together

Research and development plays a key role at LANXESS. The Technical Rubber Products Business Unit has research and technical centers with testing facilities on almost every continent. Whether you are looking for better compounding ideas or are thinking about developing a new product, our experts will be happy to assist you.

* = Trial product
(VP = Versuchsprodukt = trial product). The information contained herein is merely preliminary data. Testing as to properties and applications is not final. Further information, including data which could change or add hazards with use, may be developed. Such information may be needed to properly evaluate or use this product. Use is undertaken at the sole risk of the user.

** As with any product, use of the products mentioned in this publication in a given application must be tested (including field testing, etc.) by user in advance to determine suitability.

Health and Safety Information:
Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling the LANXESS products mentioned in this publication. For materials mentioned which are not LANXESS products, appropriate industrial hygiene and other safety precautions recommended by their manufacturers should be followed. Before working with any of these products, you must read and become familiar with the available information on their hazards, proper use and handling. This cannot be overemphasized. Information is available in several forms, e.g., material safety data sheets, product information and product labels. Consult your LANXESS representative in Germany or contact the Health, Safety, Environment and Quality Department (HSEQ) of LANXESS Germany or - for business in the USA - the LANXESS Product Safety and Regulatory Affairs Department in Pittsburgh, PA.

Regulatory Compliance Information:
Some of the end uses of the products described in this publication must comply with applicable regulations, such as the FDA, BfR, NSF, USDA, and CPSC. If you have any questions on the regulatory status of these products, contact your LANXESS Corporation representative, the LANXESS Regulatory Affairs Manager in Pittsburgh, PA or the Health, Safety, Environment and Quality Department (HSEQ) of LANXESS Deutschland GmbH in Germany.

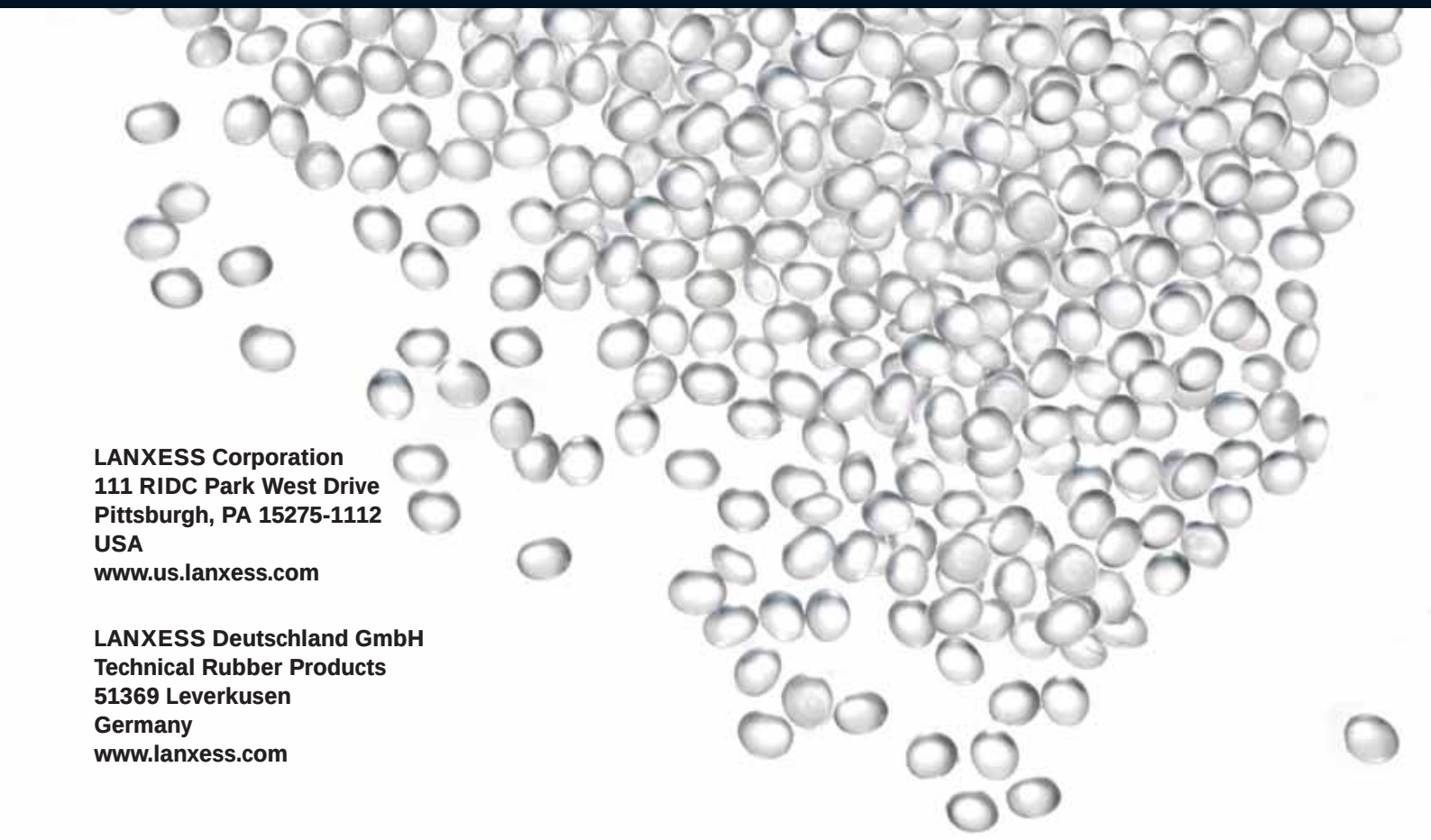
The manner in which you use and the purpose to which you put and utilize our products, technical assistance and information (whether verbal, written or by way of production evaluations), including any suggested formulations and recommendations are beyond our control. Therefore, it is imperative that you test our products, technical assistance and information to determine to your own satisfaction whether they are suitable for your intended uses and applications. This application-specific analysis must at least include testing to determine suitability from a technical as well as health, safety, and environmental standpoint. Such testing has not necessarily been done by us. Unless we otherwise agree in writing, all products are sold strictly pursuant to the terms of our standard conditions of sale. All information and technical assistance is given without warranty or guarantee and is subject to change without notice. It is expressly understood and agreed that you assume and hereby expressly release us from all liability, in tort, contract or otherwise, incurred in connection with the use of our products, technical assistance, and information.

Any statement or recommendation not contained herein is unauthorized and shall not bind us. Nothing herein shall be construed as a recommendation to use any product in conflict with patents covering any material or its use. No license is implied or in fact granted under the claims of any patent.

Levapren®, Levamelt®, Therban®, Krynac®, Krynol®, Perbunan®, Krylene® and Taktene® are Registered Trademarks of LANXESS Deutschland GmbH.
Baymod® and Baypren® are Registered Trademarks of Bayer AG.

Note: The information contained in this publication is current as of February 2007. Please contact your LANXESS representative to determine if this publication has been revised.

Order no.: LXS-KA 017e
Edition: 2007-02
Printed in Germany



LANXESS Corporation
111 RIDC Park West Drive
Pittsburgh, PA 15275-1112
USA
www.us.lanxess.com

LANXESS Deutschland GmbH
Technical Rubber Products
51369 Leverkusen
Germany
www.lanxess.com

LANXESS

LANXESS
Energizing Chemistry

LEVAPREN®

Ethylene Vinyl Acetate (EVM)

The cost-effective specialty rubber!

Edition 2007-02