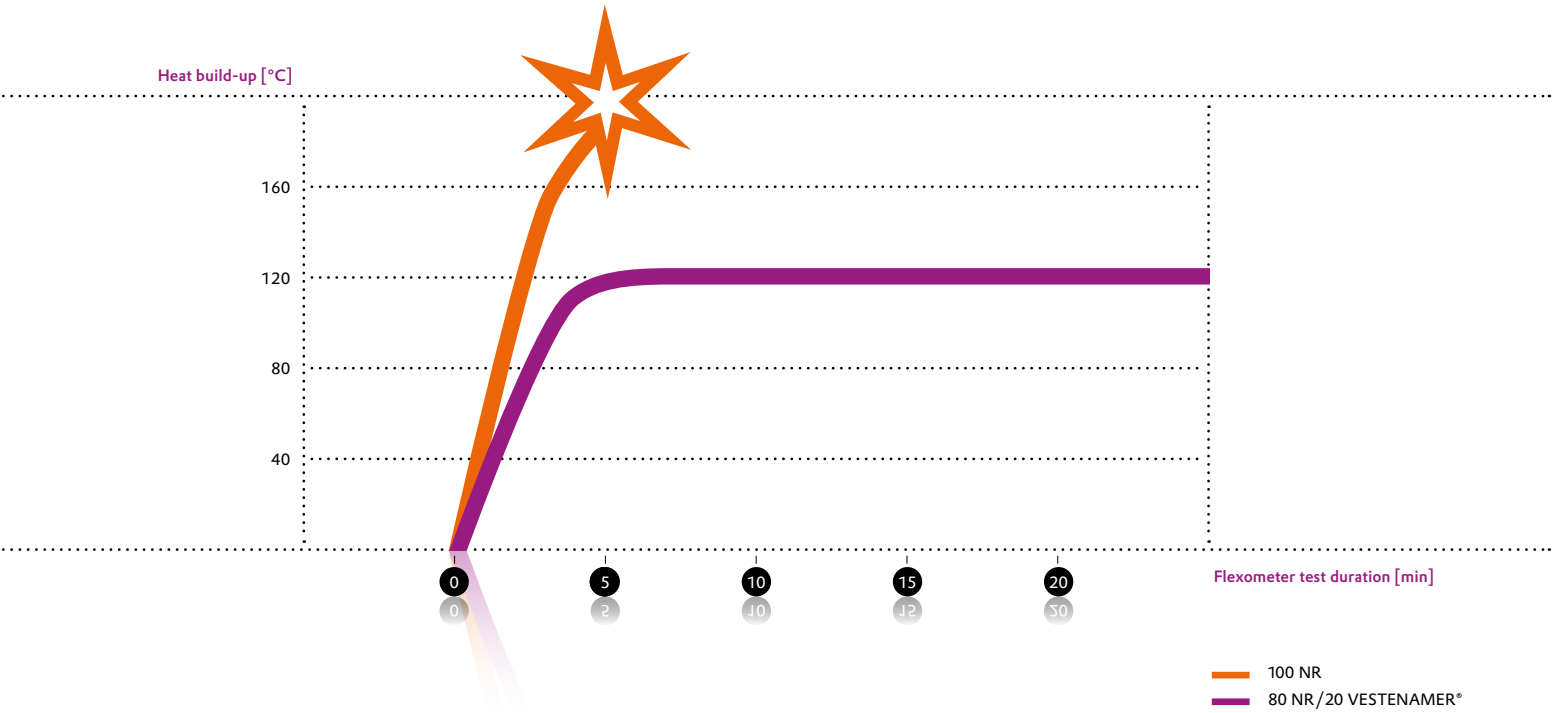
NATURAL RUBBER COMPOUNDS

VESTENAMER®

EVONIK
POWER TO CREATE



VESTENAMER®
in natural rubber compounds

The results which are described below relate to

- influencing the degradation of natural rubber during break down, mixing and further processing,
- improving the reversion behavior of natural rubber
- and improving important vulcanizate properties, for example the dynamic behavior and abrasion resistance.

The possibilities which are indicated here may be especially interesting for producers of bushings and damping components and of voluminous articles.

Table 1:

NR-Breakdown in NR/VESTENAMER® Blends

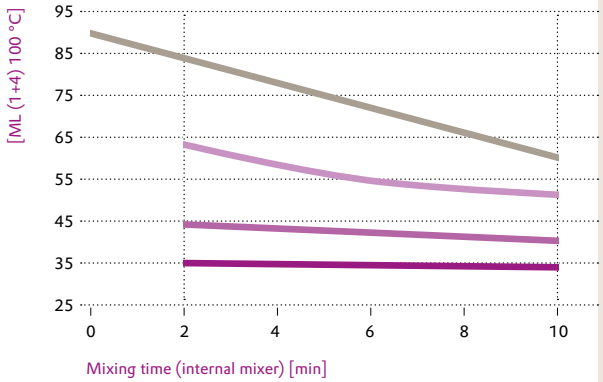
Compound Ingredients	phr
Sheets Defo 1500	100/90/80/70
VESTENAMER® 8012	0/10/20/30
Carbon Black N 220	50
Aromatic oil	10
ZnO RS	4
Stearic acid	1
Koresin	3
IPPD	1
6PPD	1
Sulfur	2.2
CBS	0.7
TMTD	0/0.1/0.2/0.3

Tabelle 2:

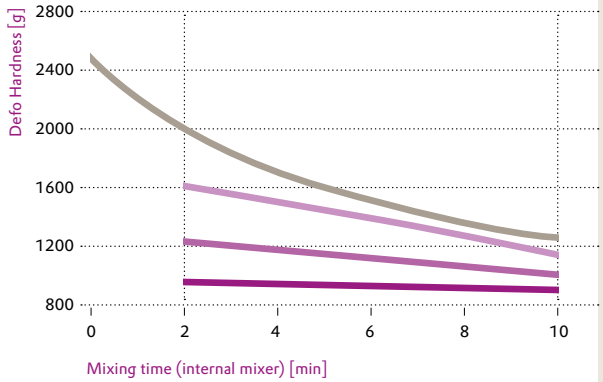
Flexometer tests

Compound Ingredients	phr
Sheets Defo 1000	100/80
VESTENAMER® 8012	0/20
Carbon Black N 330	50
ZnO RS	5
Stearic acid	2.5
Struktol WB 42	5
Koresin	2
IPPD	1,5
Sulfur	2,5
TBBS	1/1.2
TMTM	0.1/0.2
Modulus 100% [MPa]	3.7/4.0
Modulus 300% [MPa]	14.5/ 14.9

1a Influence of Mixing Time on Mooney Viscosity



1b Influence of Mixing Time on Defo Hardness



NR-BREAKDOWN OF NR/VESTENAMER® 8012 BLENDS

Figures 1a, 1b und 1c

Using VESTENAMER® for plasticizing

The investigations were conducted on pure polymer blends. The extent of polymer degradation, i.e. of break down, is well known to have a decisive influence on the processability of natural rubber. This degradation is reduced in the presence of VESTENAMER® or prevented at higher levels of addition of VESTENAMER®. The viscosity level of NR/VESTENAMER® blends is at the same time significantly reduced. This opens up the possibility of adjusting the viscosity of NR compounds by plasticizing with VESTENAMER® and reducing break down.

Figure 2, Table 1

Reducing polymer degradation in NR during mixing and multistage processing, e. g. reprocessing of off-spec batches

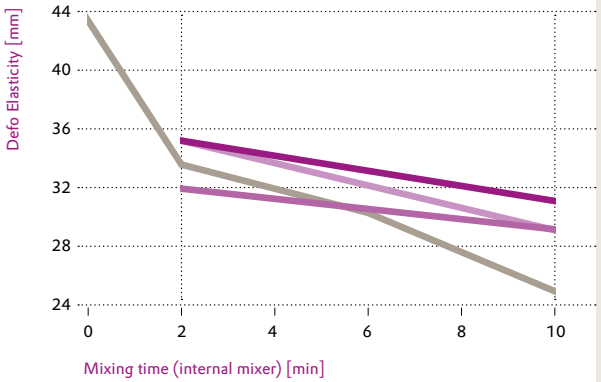
The compounds were prepared in an internal mixer in three stages with one remill stage; the NR sheets were masticated to the same degree of break-down (Defo ~ 1500) prior to the mixing process. A carefully prepared laboratory compound (batch preparation in one stage in a 2 l banbury, final mix on a roller mill) was used as reference. The recipes are shown in table 1. Each extrusion simulates one processing step. The figures show that in compounds containing VESTENAMER® the initial viscosity and the decrease of viscosity relative to pure NR compounds are reduced as the VESTENAMER® content increases.

Figures 3 und 4

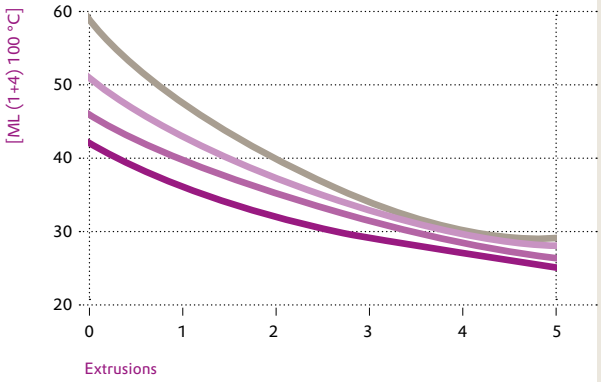
The vulcanization characteristics of NR/VESTENAMER blends

Rheological data show that the cure rate of blends is slightly reduced with in-creasing VESTENAMER® content. This effect is, however, less pronounced the higher the temperature of vulcanization. If necessary, these differences should be compensated by slightly increasing the level of accelerator (e.g. addition of about 0.05 parts thiuram per 10 parts VESTENAMER®).

1c Influence of Mixing Time on Defo Elasticity



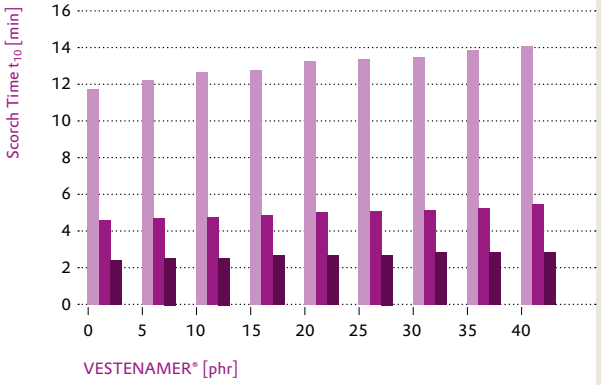
2 Influence of the Number of Extrusions on Mooney Viscosity



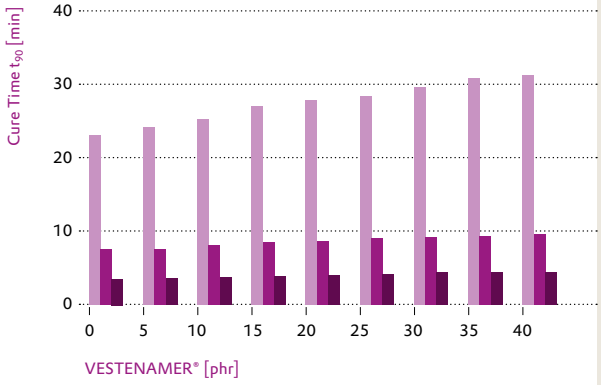
100 NR / 0 TOR
90 NR / 10 TOR
80 NR / 20 TOR
70 NR / 30 TOR

VULCANIZATION CHARACTERISTICS OF NR/VESTENAMER BLENDS

3 Influence on the Scorch Time of NR Compounds

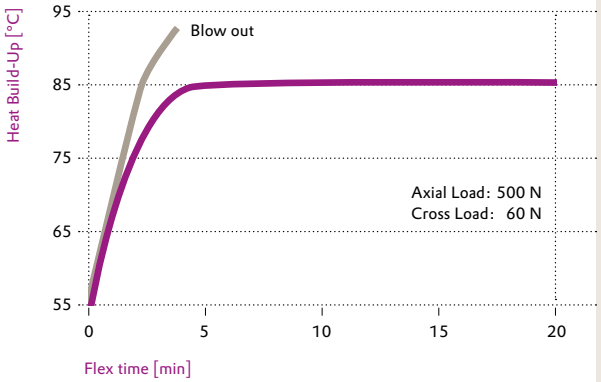


4 Influence on the Cure Time of NR Compounds

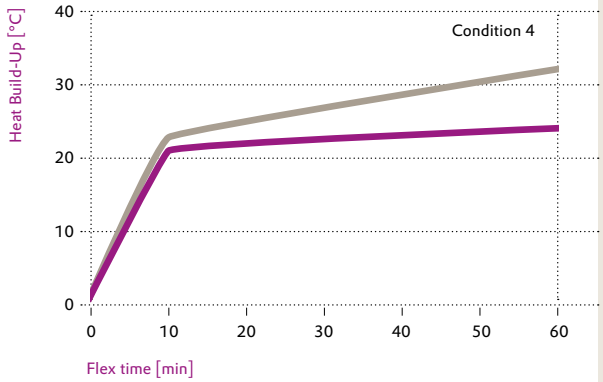


140 °C
160 °C
180 °C

5 Heat Build-Up in the Frank-Flexometer



6 Heat Build-Up in the Goodrich Flexometer



INFLUENCE OF VESTENAMER® 8012 ON VULCANIZATES AND ABRASION RESISTANCE

Figure 5, 6 and 7, Table 2

The effect of VESTENAMER on the static and dynamic properties of vulcanizates

In consequence of the higher molecular weight (less degradation) and of the reduced reversion some important properties of the vulcanizates are also enhanced. This is strongly dependent, of course, on the previous history of the compound with regard to break down, mixing and further processing. However, in many cases, valuable improvements in properties are found (increased modulus, improved compression set, lower heat build-up under dynamic load and so on). These effects are more pronounced, the greater the applied shear during the total processing is, and the greater the vulcanization temperature or time of vulcanization.

An example of the possibilities of improving the dynamic characteristics of NR vulcanizates is given in Figures 5 to 7. The results of flexometer testing using both the Frank and Goodrich methods show significant advantages for the 80/20 NR/ VESTENAMER® blend compared with the pure NR compound. The crosslinking density (modulus) of the blend was matched to that of the pure NR compound by a slight adjustment of the accelerator system (recipes see table 2).

Figure 8, Table 1

The effect of VESTENAMER® on the abrasion resistance of NR

VESTENAMER® considerably improves the abrasion resistance of natural rubber. This is shown by Figure 8. Figure 8 results from an investigation in which the level of accelerator was increased by 0.1 phr thiuram per 10 parts VESTENAMER® (compare in table 1).

Figure 9 and 10

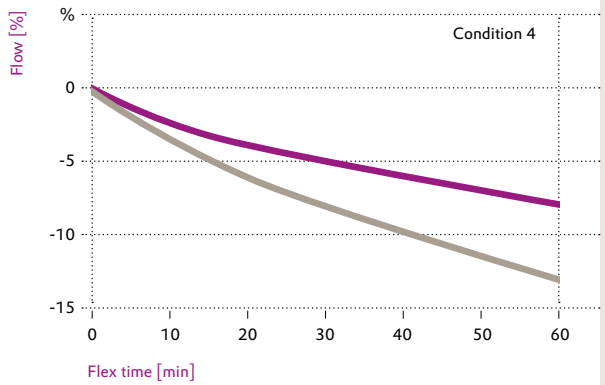
The effect of VESTENAMER on the reversion of natural rubber

In these investigations the differences in cure rates were not leveled out by adjustment of the TMTD dosages (compare table 1), because reference was made to the maximum crosslinking level (F at t_{100}). The figures show the effect of different contents of VESTENAMER® at five different vulcanization temperatures. In each case, after reaching the maximum level of crosslinking (Ft_{100}) vulcanizing was carried on for 20 minutes. The ratio

$$\frac{\text{F at } t_{100} + 20 \text{ min}}{\text{F at } t_{100}}$$

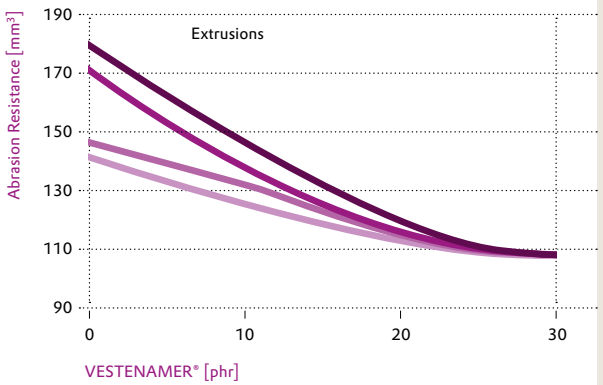
was evaluated for different concentrations of VESTENAMER® (Figure 9 and 10) or for different vulcanization temperatures at a VESTENAMER® content of 30 parts (Figure 10). The results show that VESTENAMER® considerably improves the reversion stability of natural rubber, especially at higher vulcanization temperatures.

7 Flow in the Goodrich Flexometer



100 NR / 0 TOR
80 NR / 20 TOR

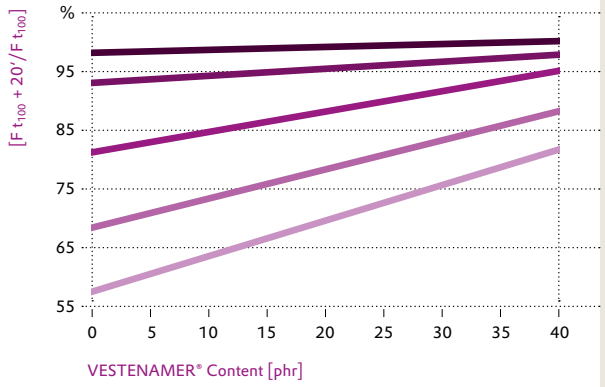
8 Abrasion Resistance (acc. DIN)



5 x
3 x
1 x
0 x

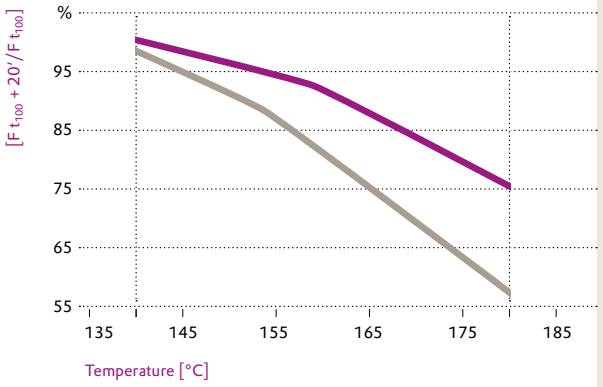
REVERSION OF NR/VESTENAMER® 8012 BLENDS

9 VESTENAMER® Reversion with Increasing Cure Temperature



140 °C
150 °C
160 °C
170 °C
180 °C

10 Reversion of NR at different Temperatures



100 NR / 0 TOR
VESTENAMER® 8012
70 NR / 30 TOR

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