Black building profiles according to DIN 7863 and RAL-GZ 716/1

Alternatives to carbon black: Aktisil VM 56

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4 Summary

1 Introduction

Typical formulations for black window sections and glazing profiles are based on EPDM, carbon black and paraffinic mineral oil. This means the major part of the raw materials is petroleum based *(Table 1 and fig. 4).*

According to the crude oil price, the raw material prices are subject to considerable variations. The long term trend is clearly pointing upwards *(Fig. 1).*

The price of mineral fillers is only marginally affected by the crude oil price; over the long term there will be a slight increase, and this without big variations *(Fig. 1).*

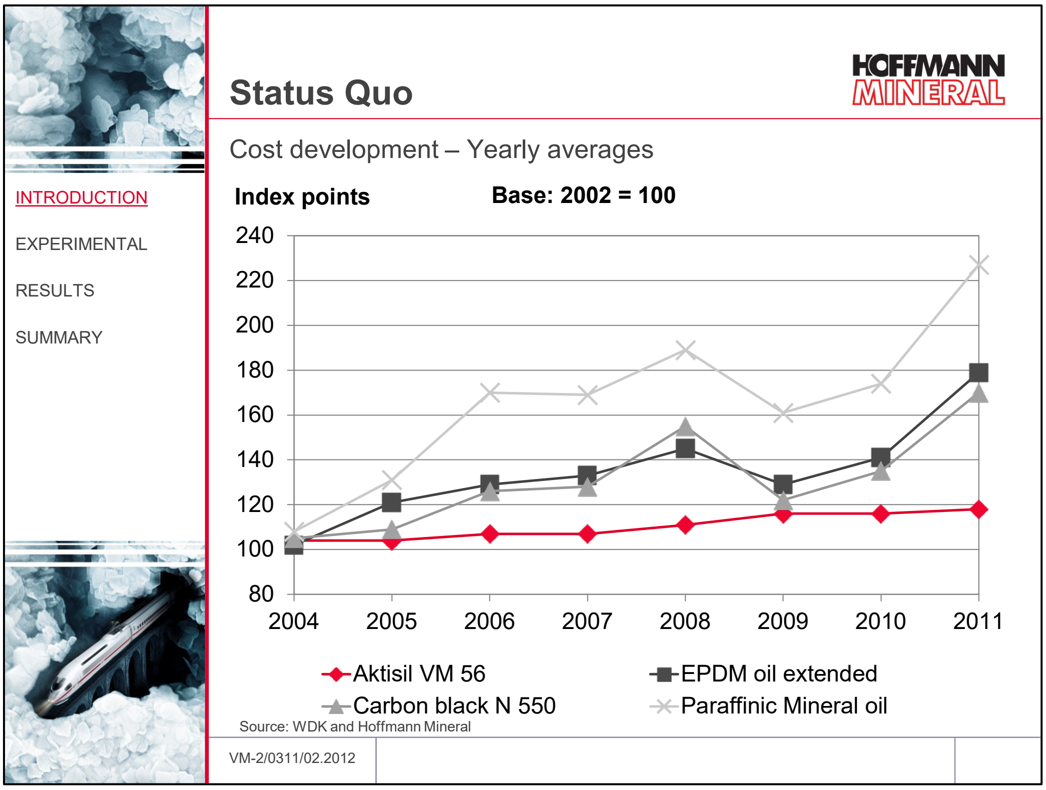

Fig. 1

As evident from *Figure 2*, it is hardly possible to obtain at equal hardness a further cost reduction via the carbon black and plasticizer loading. As a cost optimized starting point, a carbon black / plasticizer loading of 180 / 80 phr was selected.

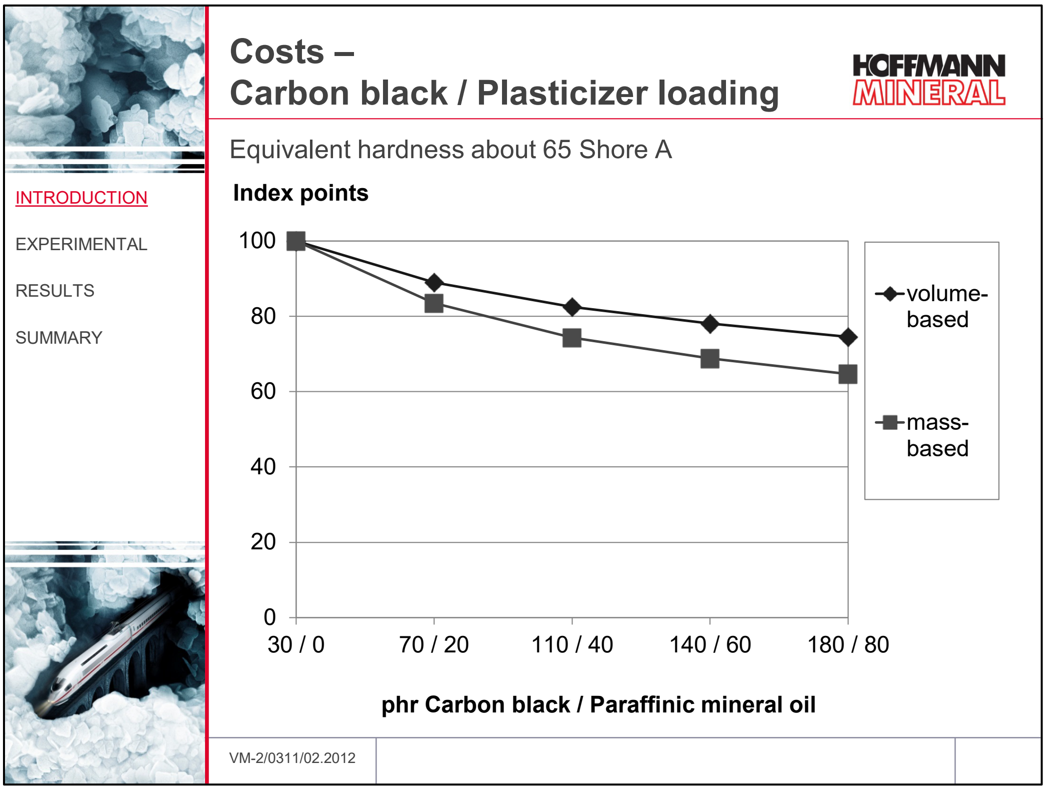

Fig. 2

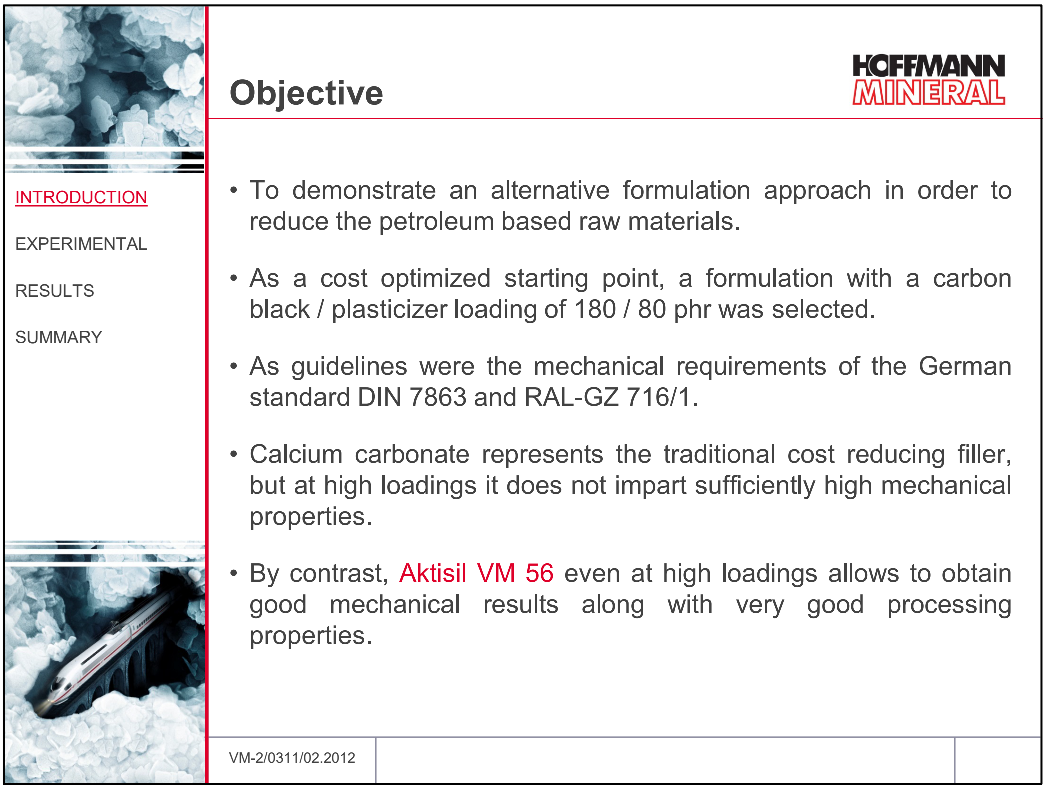

Fig. 3

2 <u>Experimental</u>

2.1 Compound Formulation

A typical formulation for black window sections and glazing profiles is based on EPDM, carbon black and paraffinic plasticizer oil. This way, the major portion for the raw materials is petroleum based, as is clearly visible in *Figures 4 – 6*.

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Base Formulation

HOFFMANN MINERAL

EPDM – 65 Shore A

	phr
Keltan 8340 A	100.0
PEG 4000	2.0
Processing aid	3.0
Carbon black N 550	180.0
Paraffinic mineral oil, Plasticizer	80.0
Calcium oxide	10.0
TAC GR 50 %	3.0
Perkadox 14/40 pd	8.0
Total	**386.0**

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Table 1

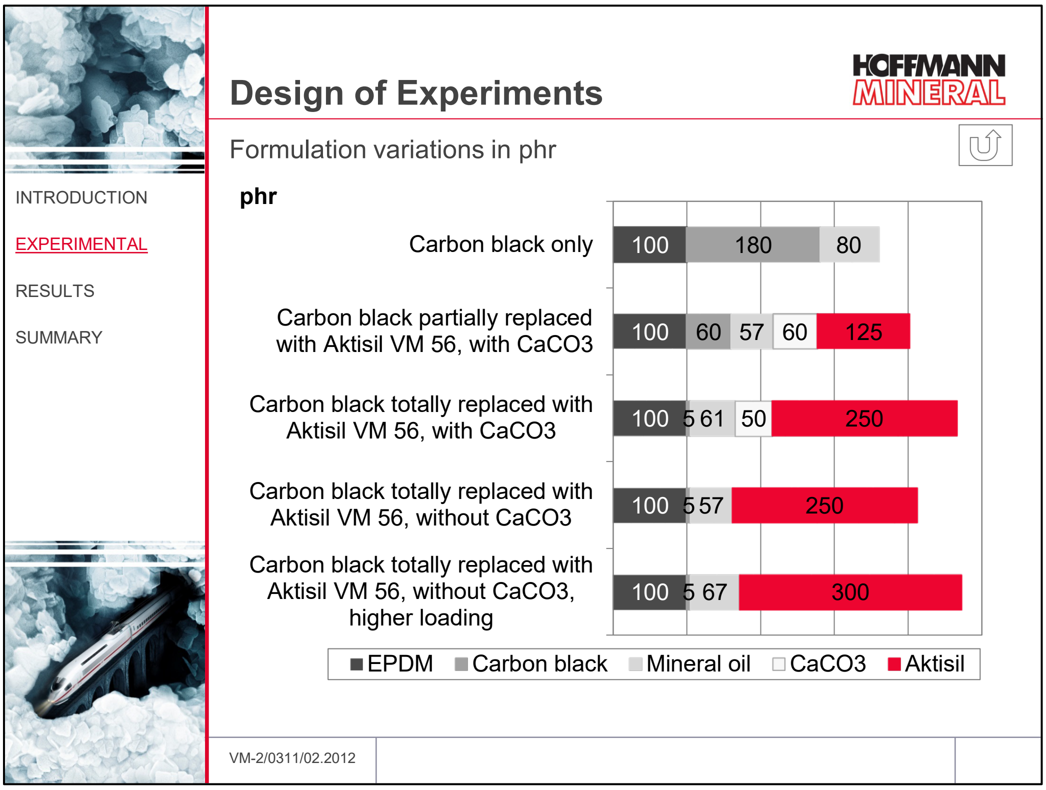

Fig. 4

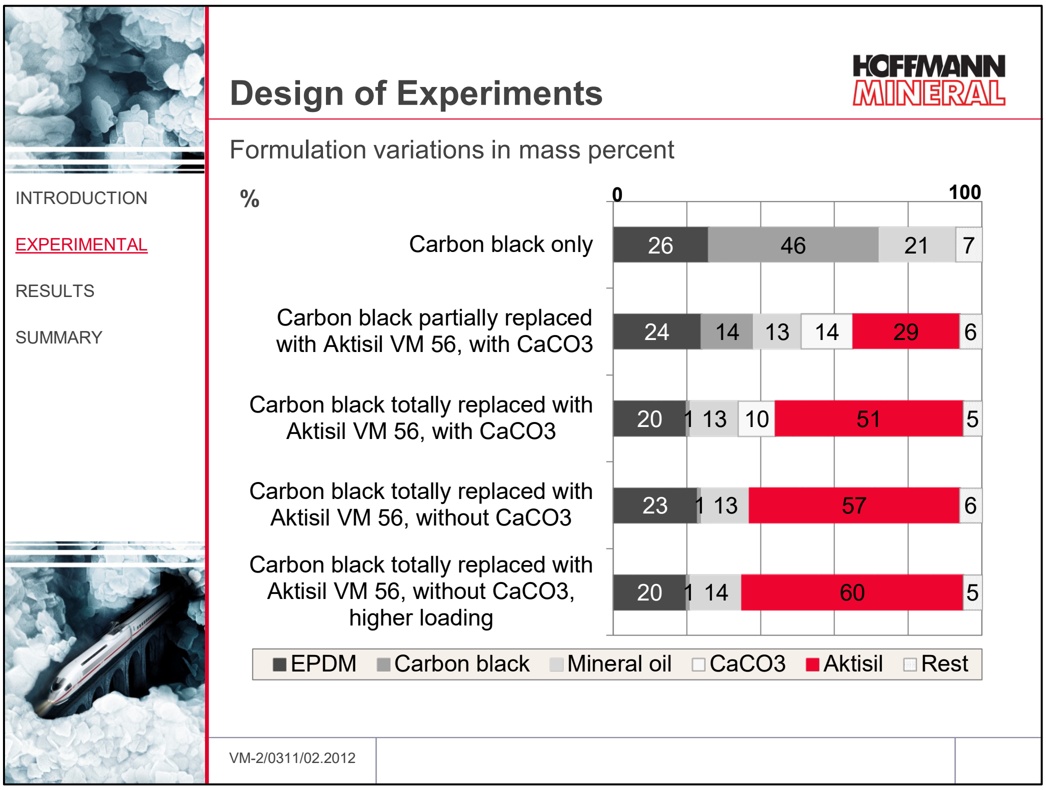

Fig. 5

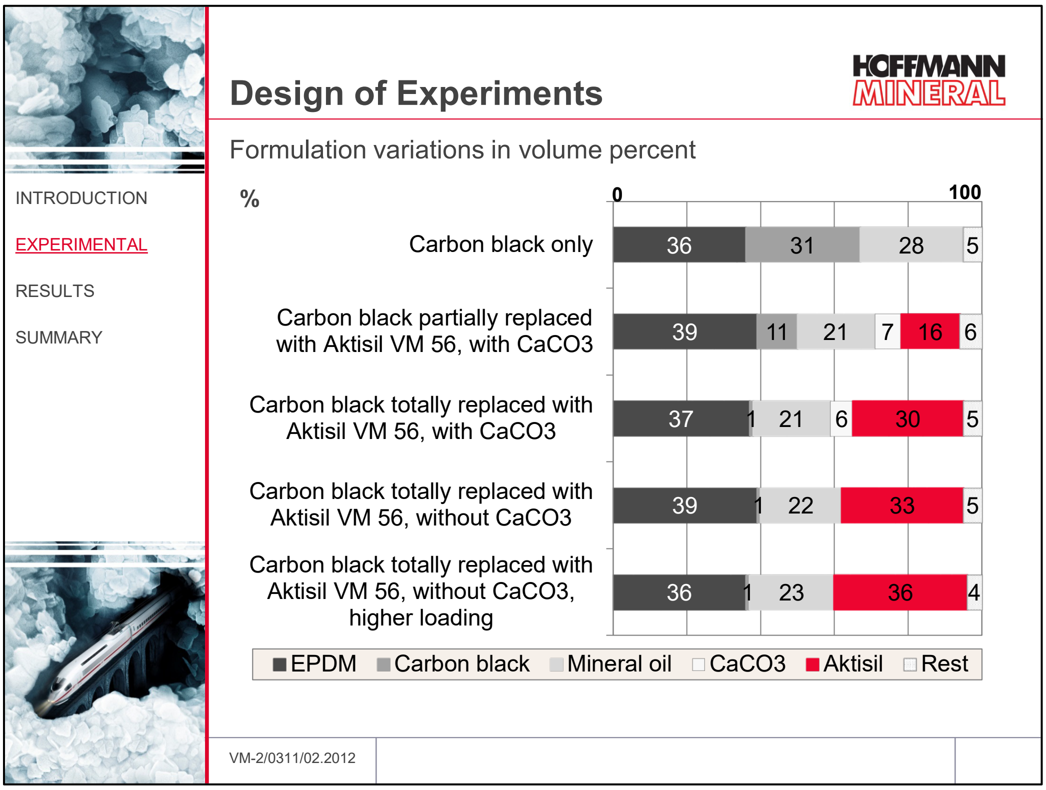

Fig. 6

The petroleum based raw materials are shown in different red shades. As evident from *Figures 4 – 6*, the portion of petroleum based raw materials is decreasing with an increasing part of mineral fillers, which are shown in green and yellow. As a result, the variations of compound costs caused by crude oil price changes are minimized.

The typical conventional filler is carbon black N 550. In order to achieve a closer price control, the carbon black is replaced by calcium carbonate and Aktisil VM 56. As evident from the levels of oil number, specific surface area BET and DBP absorption, the carbon black is distinguished by a markedly higher surface area and structure compared to the calcium carbonate. Aktisil VM 56 presents itself within these extremes. In order to obtain an equivalent hardness of the compounds, the replacement loading had to be adjusted at appr. 1:2 phr *(Table 2 and fig. 4).*

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Fillers, Characteristics

HOFFMANN MINERAL

		Carbon black N 550	Calcium-carbonat surface treated	Aktisil VM 56
Density	[g/cm^3]	1.8	2.7	2.6
Particle size d_{50}	[µm]		2.7	2.0
Particle size d_{97}	[µm]		25	9
Sieve residue >40 µm	[mg/kg]	</= 300	14	4
Sieve residue 45 µm (Siev No. 325)	ppm	10		
Oil absorption	[g/100g]		19	50
DBP absorption	[ml/100 g]	121		
Specific surface area BET	[m²/g]	41	2.1	11
CTAB Surface area	[m²/g]	42		
Surface treatment		none	Stearate	vinyl functionalized

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Table 2

2.2 Compounding and Curing

All compounds were mixed on a laboratory roll mill (Ø 150 x 300 mm) at 20 rpm with a batch size of approx. 600 cm³. The mixing times were adjusted according to the incorporation characteristics of the filers, and were registered. The curing time in all cases was t_{90} + 10 % at 180 °C in an electrically heated press *(Fig. 7).*

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Preparation and Curing of the Compound

HOFFMANN MINERAL

- **Mixing**

  Open mill Ø 150 x 300 mm

  Batch volume: approx. 600 cm³

  Temperature: 50 °C

  Mixing time: approx. 20 min.

- **Curing**

  Press, 180 °C, t_{90} + 10 %

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Fig. 7

3 Results

3.1 Mooney Viscosity und Mooney Scorch Time

The reduction of the petroleum based raw materials caused a slight decrease of the Mooney viscosity *(Fig. 8)*.

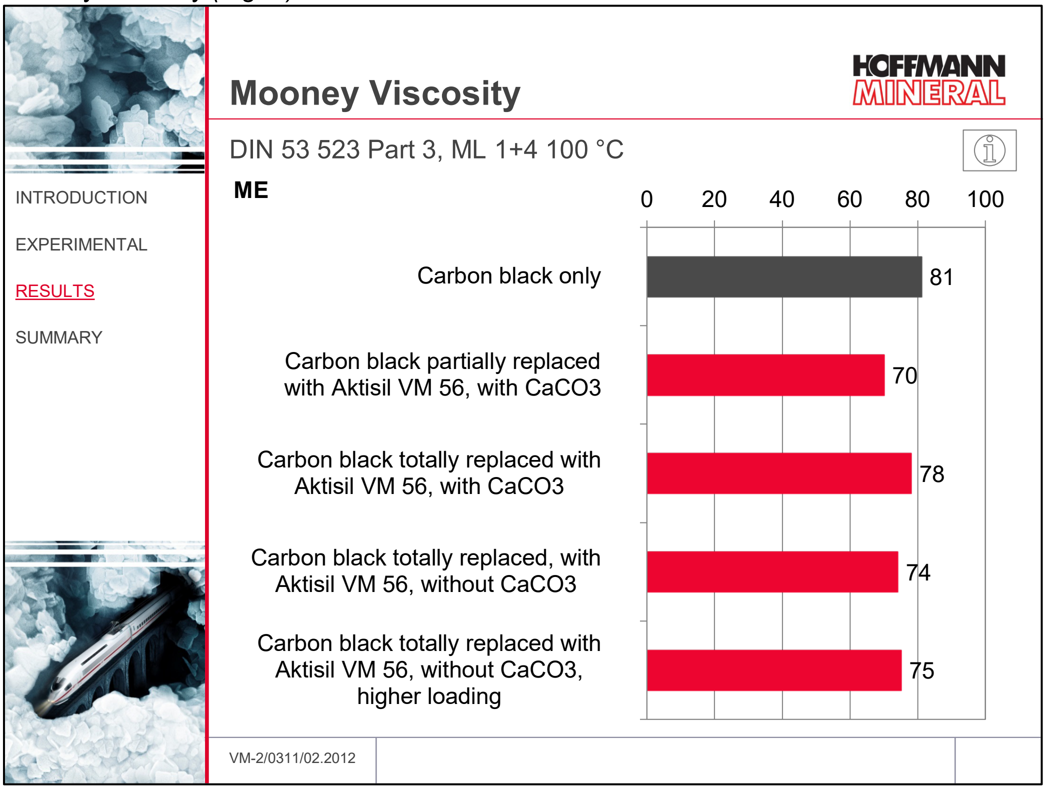

Fig. 8

The Mooney scorch time, an index for the onset of cure during processing, shows a marked increase with an increasing portion of mineral fillers. This means that the risk of scorch (onset of cure) during the processing steps is minimized *(Fig. 9)*.

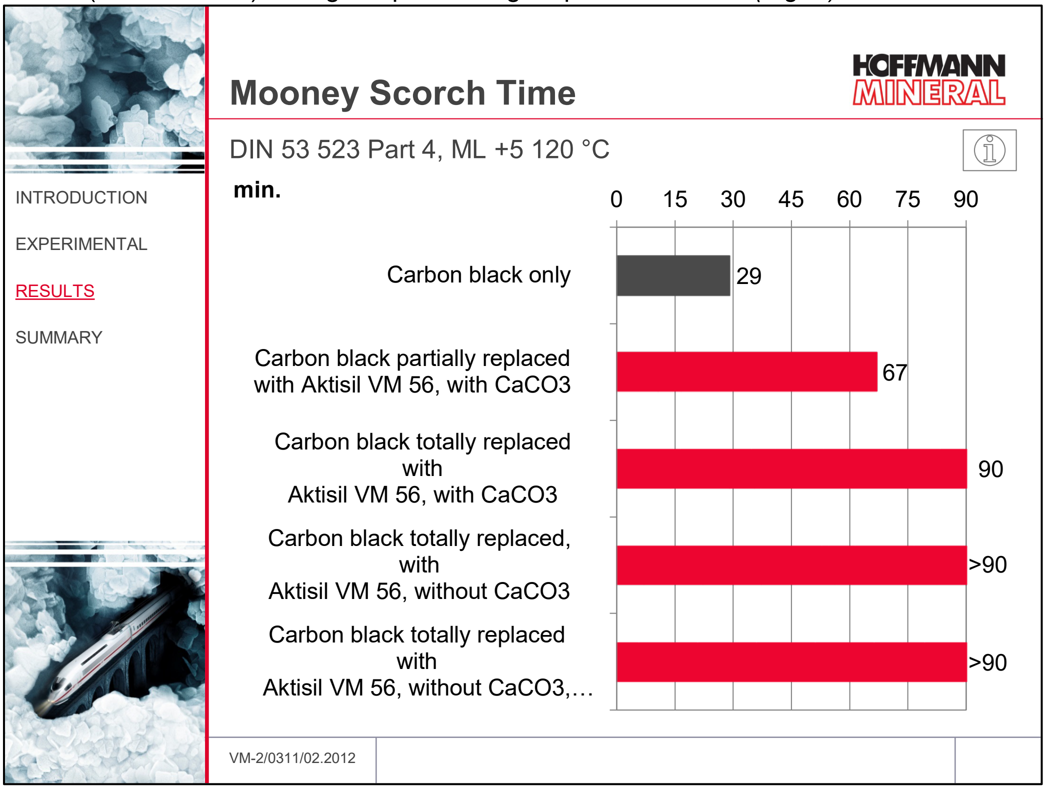

Fig. 9

3.2 Curing Properties

With an increasing loading of mineral fillers, the minimum torque will slightly go down, while the torque maximum shows a certain increase. This result indicates a better yield of cure *(Fig. 10 and 11)*.

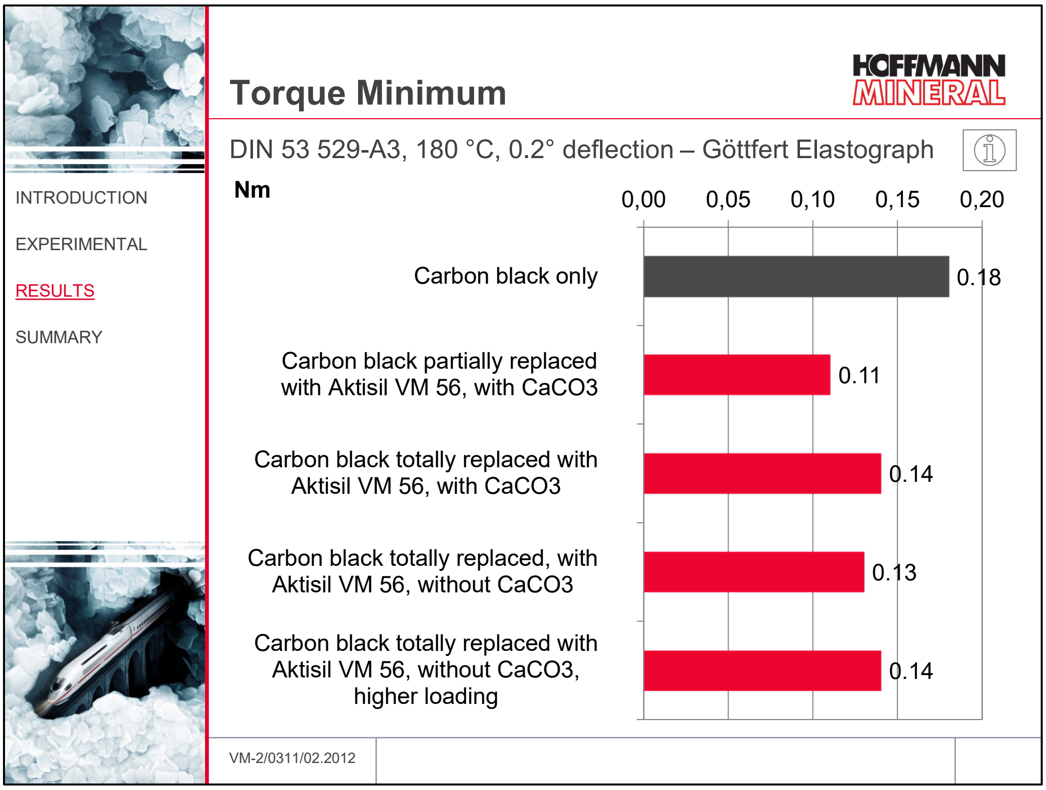

Fig. 10

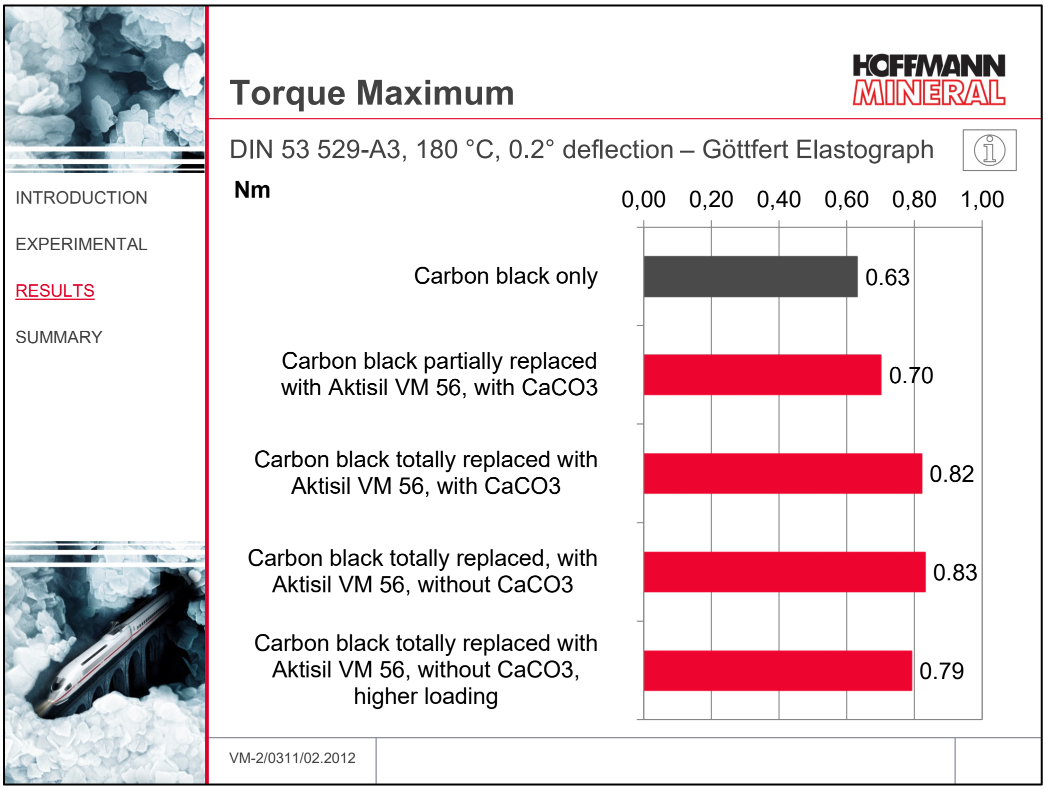

Fig. 11

The conversion time t_{90} will somewhat increase with a higher portion of mineral fillers *(Fig. 12)*.

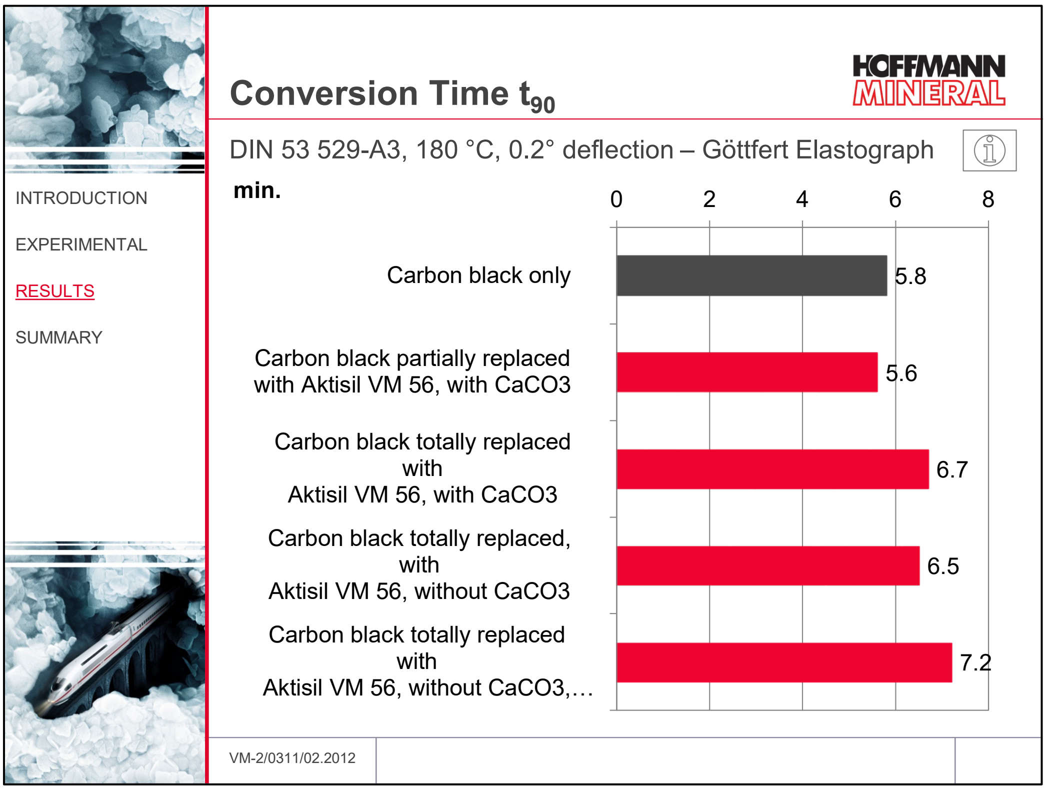

Fig. 12

3.3 Mechanical Properties

All compounds were adjusted to a Shore A hardness of approx. 65 *(Fig. 13)*.

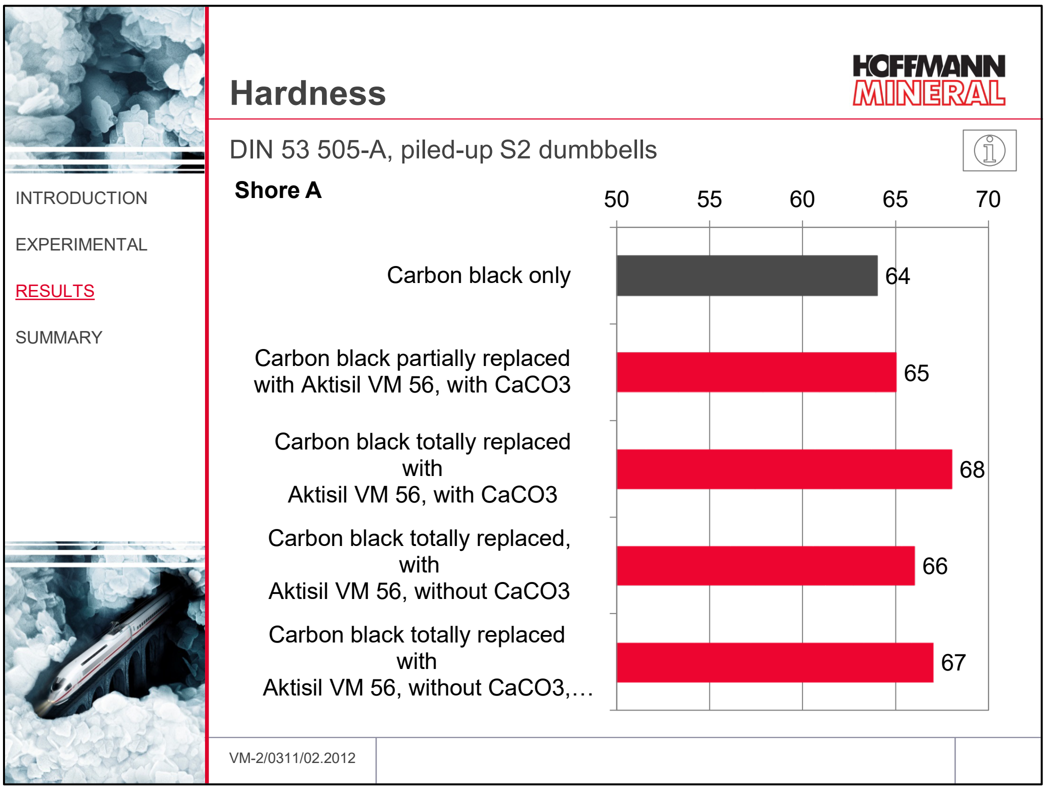

Fig. 13

The guideline for the mechanical properties are the German standards DIN 7863 and RAL-GZ 716/1. The DIN 7863 serve differentiate with the tensile strength between window and application of fronts. Even with higher mineral filler loading all requirements as specified in the standards are still met, while they are clearly exceeded in window application *(Fig. 14).*

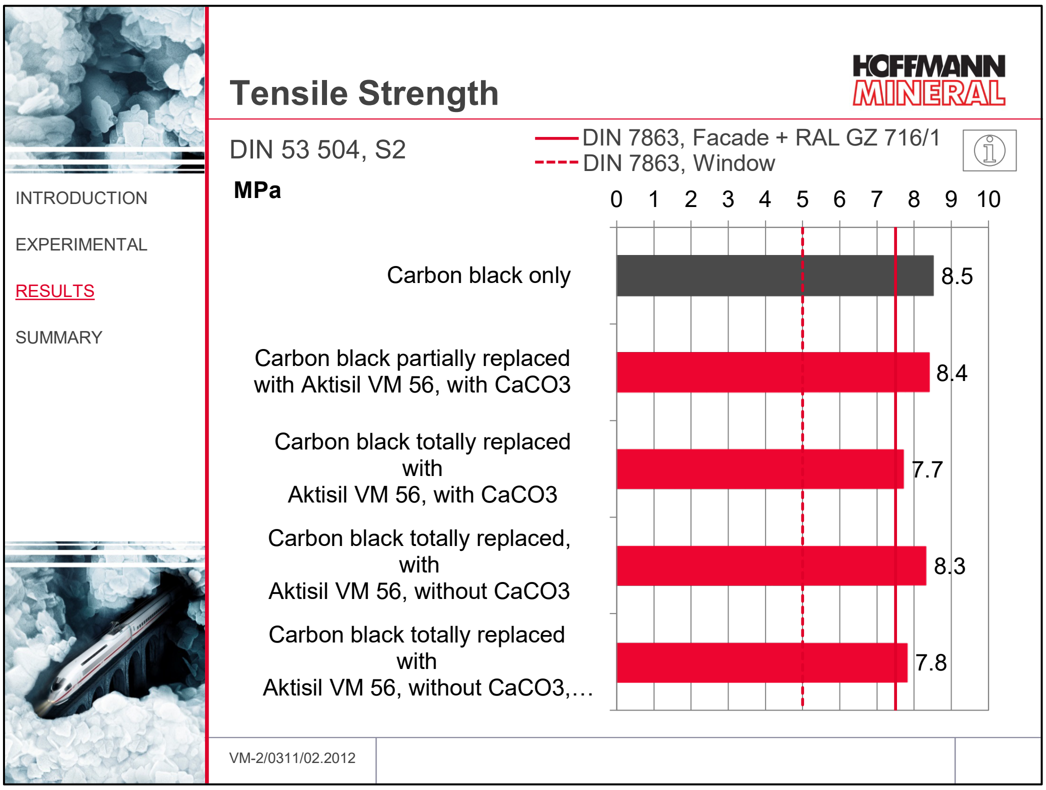

Fig. 14

The elongation at break shows a decrease with increasing amounts of mineral filler, but still remains above the limits of the DIN and RAL standard *(Fig. 15).*

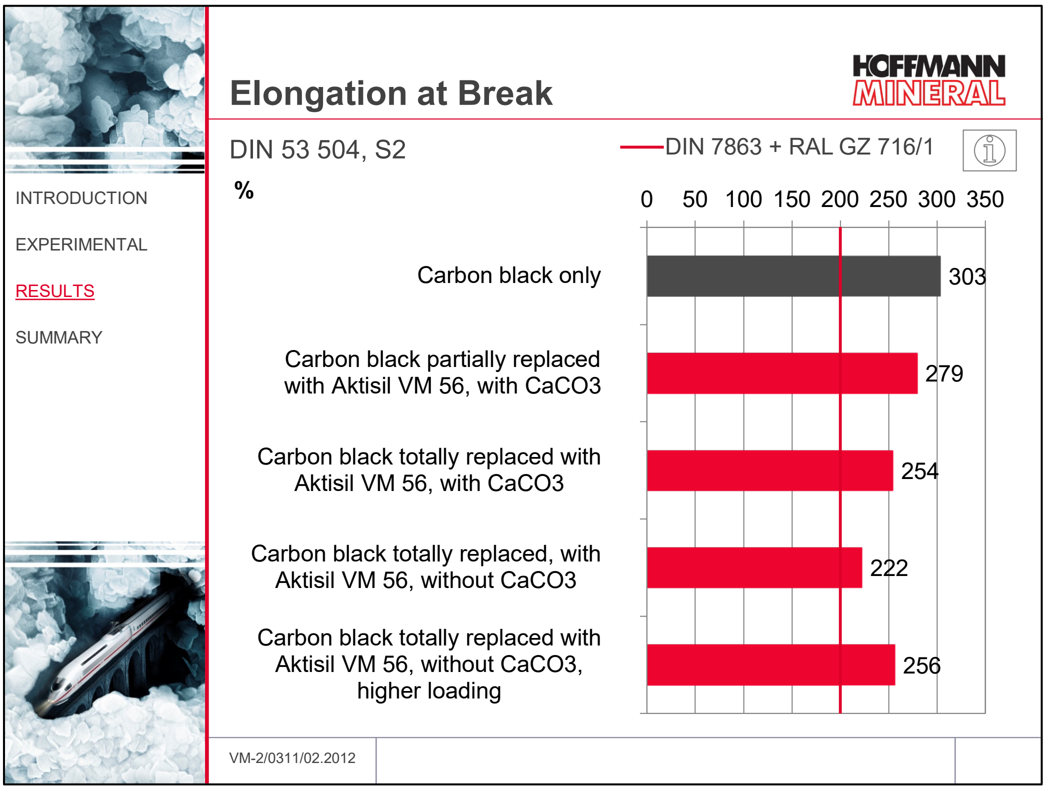

Fig. 15

The higher the portion of mineral filler the higher the tensile modulus at 100 % elongation is *(Fig. 16).*

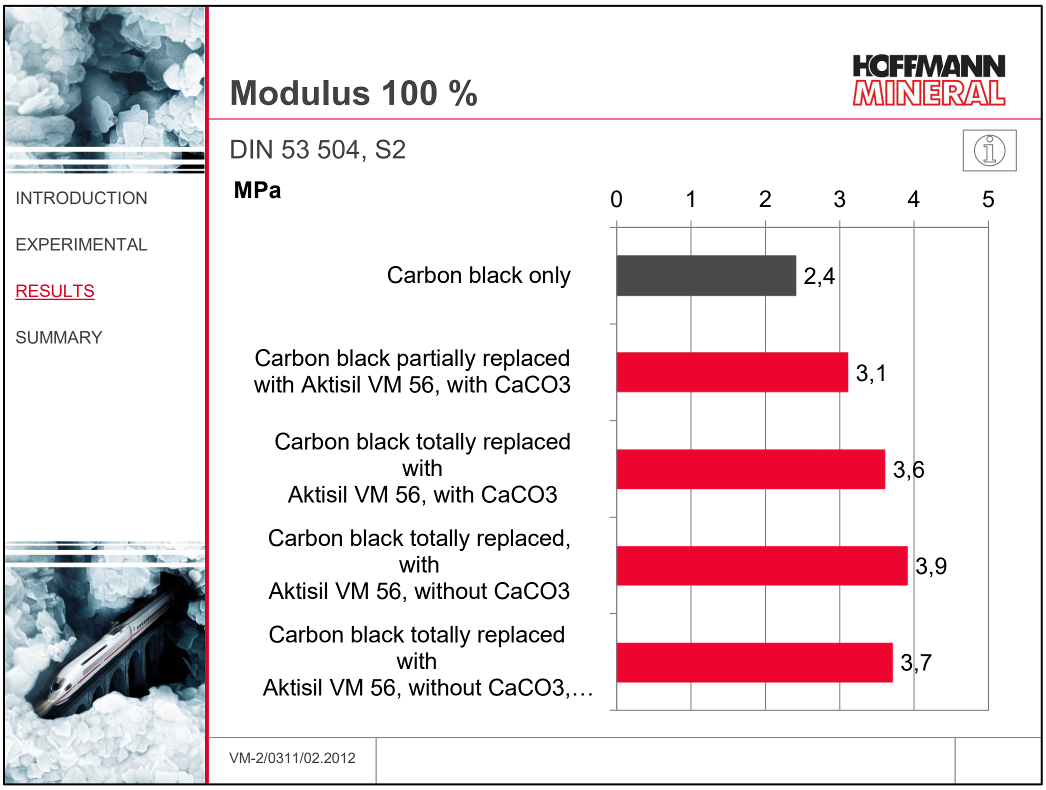

Fig. 16

With the mineral fillers, the compression set at high temperature remains unchanged or is slightly improved. Only in the last formulation variant with the increased loading, the compression set comes out somewhat increased. But all of them still remain within the specification of the DIN and RAL standard *(Fig. 17).*

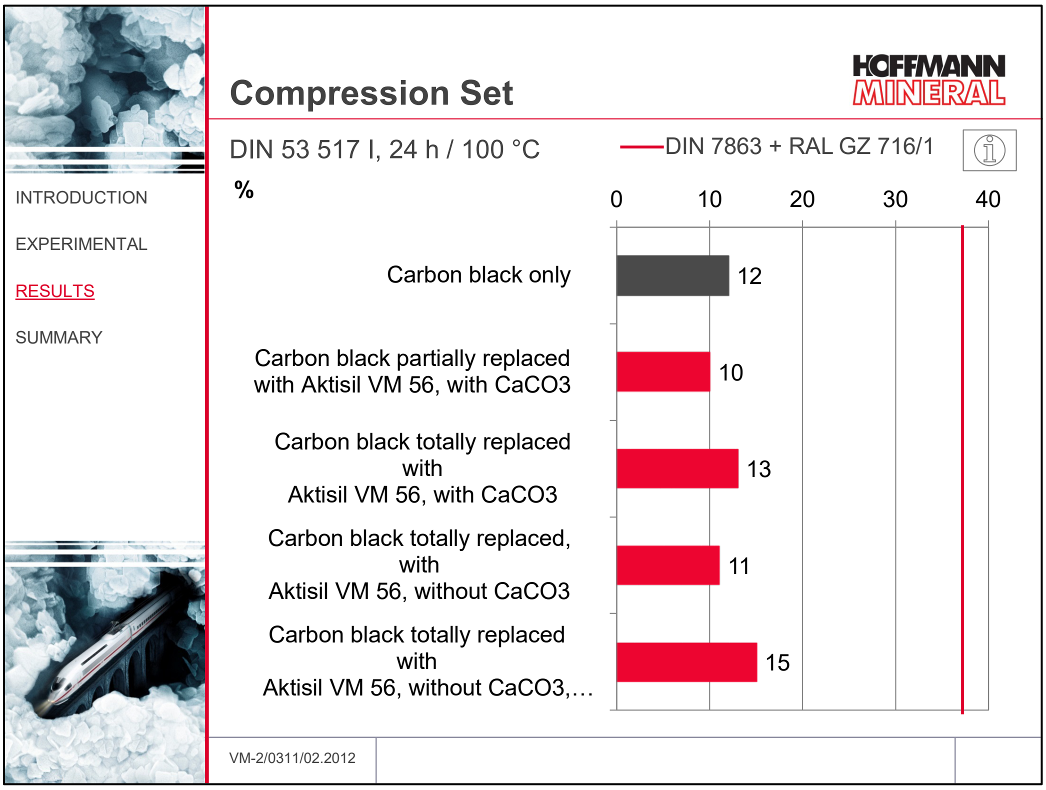

Fig. 17

The results at 23 °C are partially already close to the limit of the RAL standard, even if all formulations meet the requirement of RAL-GZ 716/1 regarding to the compression set at ambient temperature.
The partly or total replacement of Carbon black with mineral fillers leads to a markedly lower compression set. Despite the higher filler loading of the last compound variant it achieves the compression set level of the straight carbon black formulation *(Fig. 18).*

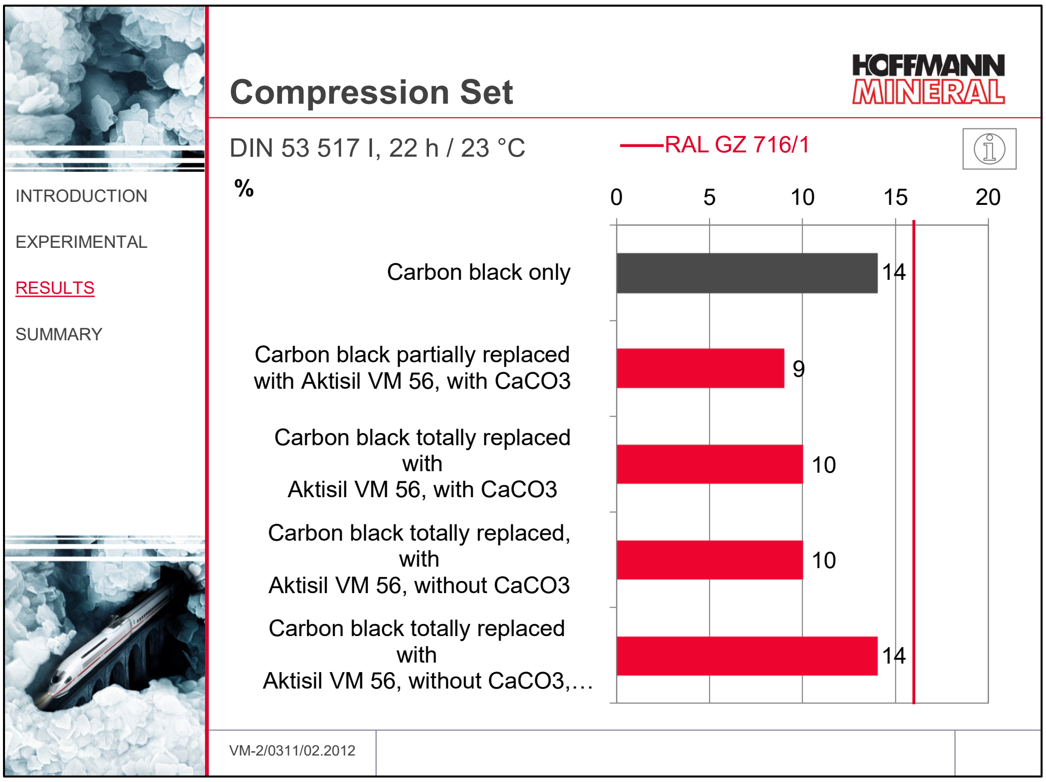

Fig. 18

3.4 Response to low Temperature

Straight carbon black meets the requirement of the standards just borderline. Here a higher portion of mineral filler has a very positive effect on the hardness change at low temperature, thus complying the standards more safely *(Fig. 19).*

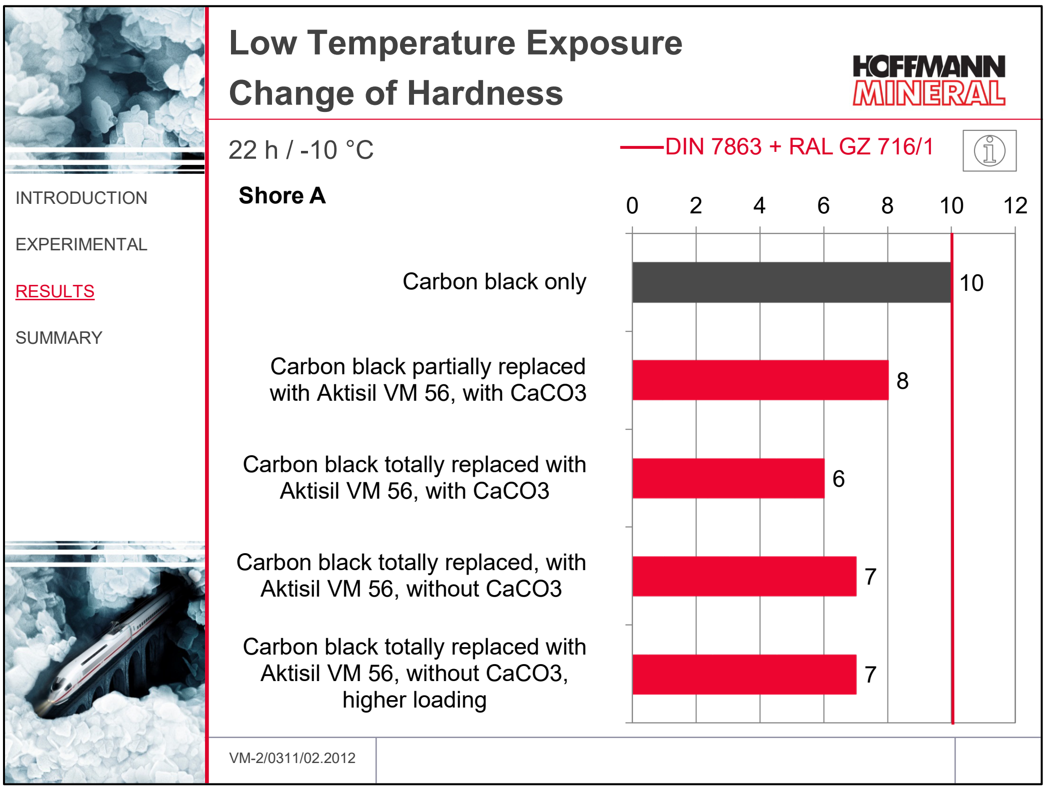

Fig. 19

4 Summary

- Aktisil VM 56 allows to meet the essential requirements of the DIN 7863 and RAL-GZ 716/1.
- According to the circumstances, a refining optimization approach such as a reduction of the peroxide concentration, can be useful.
- This way, it is possible to considerably decrease the portion of petroleum based raw materials in the compound, which leads to more safety in planning of the raw material costs.
- On the technical side, according to the formulation used the following results can be attained:
    - lower viscosity
    - increased scorch safety
    - increased tensile moduli
    - improved compression set
    - lower change of hardness at -10 °C