Neuburg Siliceous Earth

in bisphenolic cured FKM

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VM-2/0416/04.2019

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1 Introduction

Fluoro polymers are generally known for high resistance against heat and chemicals. Therefore, they are preferred for joints and conveying systems for chemicals where the properties of other polymers are no longer sufficient.

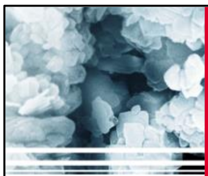
By using fillers it is possible to improve the property profile of fluoro carbon elastomers. Until now, either carbon black N990 or mineral fillers such as wollastonite or barium sulfate have been used.

In the following report different grades of Neuburg Siliceous Earth are compared with these traditionally used fillers in bisphenolic cured FKM, including examples for pertinent applications.

The study is based on two FKM grades, in order to show the influence of different polymers and their effects with respect to viscosity and curing agent concentration.

2 Experimental

2.1 Fillers, formulation and compound preparation



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Fillers, Characteristics
Manufacturer's Data

HOFFMANN MINERAL

	Particle Size d_{50} [µm]	Particle Size d_{97} [µm]	Oil Absorption [g/100g]	Specific Surface Area BET [m²/g]	Functiona-lization
N 990	-	-	-	-	-
Wollastonite AST	3.5	11	26	4	Amino silane
Wollastonite EST	3.5	11	26	4	Epoxy silane
Barium Sulfate	3	-	-	-	-
Aktisil Q	4.0	18	43	6	Methacrylic
Aktifit AM	2.0	10	55	7	Amino
Aktifit PF 115	-	-	-	-	Special Amino
Aktifit PF 111	2.0	10	49	7	Alkyl
Silfit Z 91	2.0	10	55	8	-

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Fig. 1

Typically, carbon black N990, amino silane or epoxy silane treated wollastonite or precipitated barium sulfate are used in FKM.

These fillers are compared in the present study with different grades of Neuburg Siliceous Earth with an average particle size d_{50} of 2 to 4 µm.

Apart from the untreated calcined Silfit Z 91 results are given for the amino functional Calcined Neuburg Siliceous Earth grade Aktifit AM. Furthermore, Aktifit PF 115, a product based on Calcined Neuburg Siliceous Earth after surface treatment with a special amino functional group was included in the tests. With Aktifit PF 111 another Calcined Neuburg Siliceous Earth was tested which carries an alkyl functional group on the surface. Aktisil Q is a non-calcined grade modified with a methacrylic funktiional group and whose particle size is twice as high as that of the other Siliceous Earth grades and, therefore, comes close to the competitive mineral fillers.

The base formulation given in Fig. 2 indicates the typical approach with MgO and $Ca(OH)_2$ as stabilizers and varying filler additions which were adjusted in different loadings between 30 and 74 phr according to the filler effects on the hardness of the cured compounds.

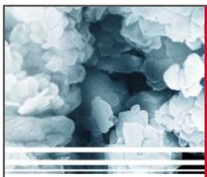
The study included two different FKM grades:

- Dyneon FC 2181Z: medium viscosity — low amount of bisphenolic curing agent
- Viton A-201C: low viscosity — high amount of bisphenolic curing agent

The compounds were prepared on a laboratory mill (Schwabenthan Polymix 150 L). The rubber was given onto the mill at 50 °C and milled to a uniform sheet. Then the filler was incorporated along with the MgO and $Ca(OH)_2$. In order to be able to remove the sheet off the mill, the mill temperature was reduced to 30 °C. The total mixing time was 15 minutes.

Total press cure was 7 minutes at 177 °C for Dyneon FC 2181Z, resp. 10 minutes at 177 °C for Viton A-201C.

The compounds based on Dyneon FC 2181Z were post-cured for 16 hours at 230 °C, those based on Viton A-201C for 24 hours at 232 °C.



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Formulation

HOFFMANN MINERAL

		in phr
FKM	66 % fluorine copolymer (HFP + VDF)	100
Elastomag 170	MgO	3
Vulcofac F45	$Ca(OH)_2$	6
Filler	-	as indicated

FKM grades used:	
Dyneon FC 2181Z FKM, low curative level	ML 1+10 (121 °C): 44 MU
Viton A-201C FKM, high curative level	ML 1+10 (121 °C): 20 MU

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Fig. 2

2.2 Tests

The results reported here were obtained on post-cured samples.

Basically, hardness was tested along with tension tests. Apart from compression set also the abrasion resistance of the cured compounds was measured

The resistance against exposure to various media was evaluated as follows:

- hot air 70 hours / 232 °C
- engine oil OS206304 168 hours / 150 °C
- fuel FAM B (DIN 51604) 70 hours / 23 °C
- distilled water 168 hours / 60 °C

As an indicator for the resistance the change of tensile strength was followed. The results for weight and volume changes largely showed similar levels if not otherwise illustrated in the diagrams.

The results of all studied compounds and all evaluations are summarized in tables at the end of this report.

3 Results – Dyneon FC 2181Z

3.1 Neuburg Siliceous Earth vs. N990

Filler loading:

Carbon black N990	30 phr
Neuburg Siliceous Earth (NSE)	45 phr

Resulting hardness range	80 ± 5 Shore A

3.1.1 Mechanical properties

All included Neuburg Siliceous Earth grades gave higher tensile strength levels compared with N990 (Fig. 3), with Aktifit PF 111 surpassing the carbon black particularly high with almost 4 MPa.

The use of NSE grades instead of N990 always leads to an improvement of the ISO compression set (Fig. 4). The best results are offered by Aktisil Q and Aktifit PF 111. These two grades also reach the lowest levels according to the VW compression set test (Fig. 5).

When plotting the elongation at break against the ISO compression set (Fig. 6) which means combining two opposed properties, the advantage of Aktisil Q comes out even more clearly.

It does not only arrive at a compression set lower than N990 but also stays on a similar level with respect to elongation at break. Using Silfit Z 91, elongation at break remains at the same good level as Aktisil Q while the compression set comes out somewhat higher. Aktifit PF 111 with respect to elongation at break roughly equals N990 while the two amino functional NSE grades remain somewhat behind.

The two last-mentioned grades, however, are particularly suited for applications which require a high abrasion resistance (Fig. 7). In effect, Aktifit AM and Aktifit PF 115 distinguish themselves by a particularly low volume loss. But also Silfit Z 91, Aktifit PF 111 and Aktisil Q offer an improved abrasion resistance compared to the carbon black.

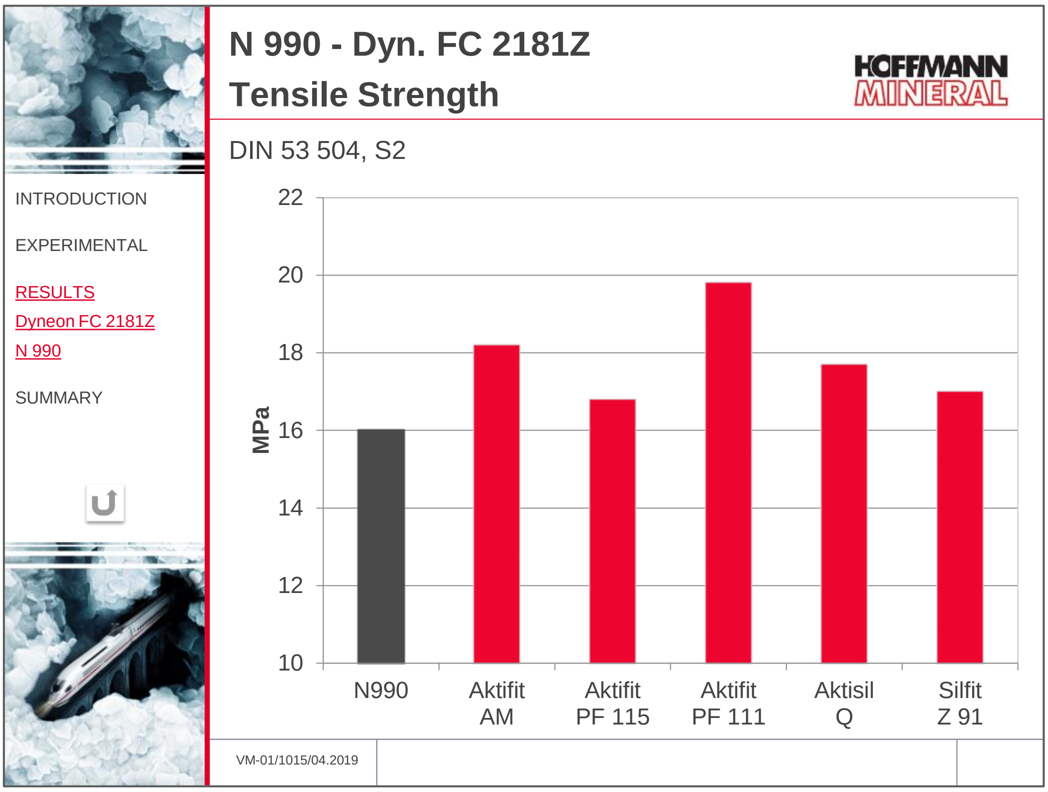
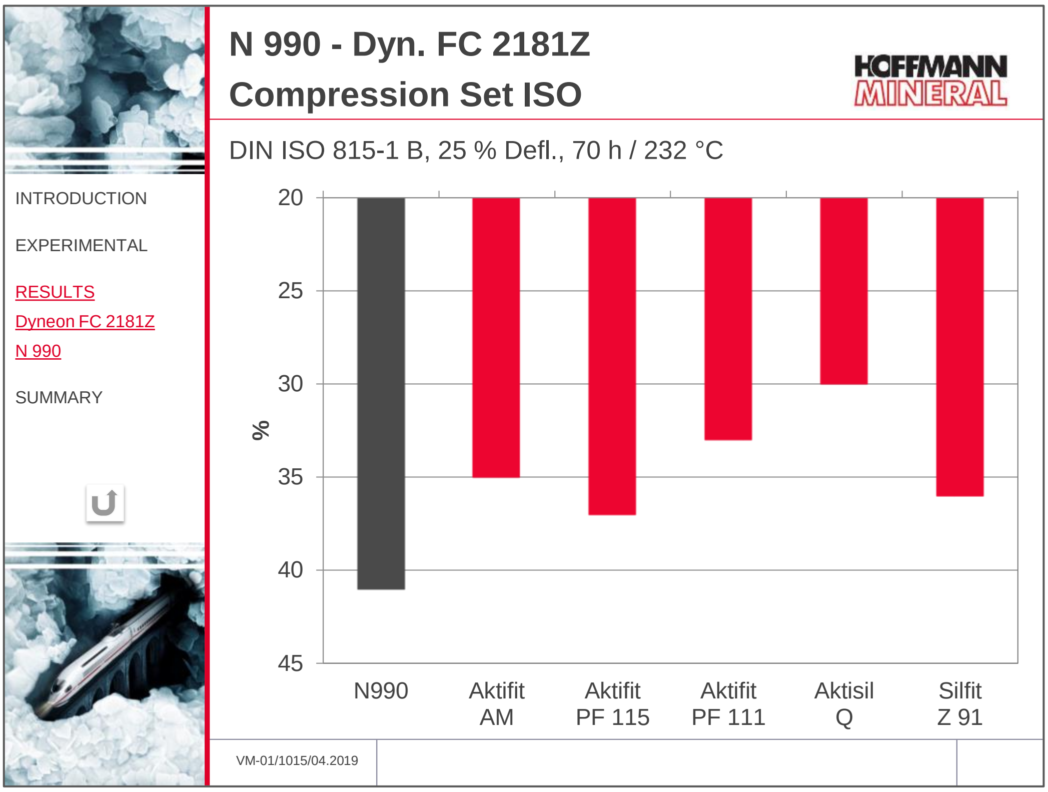


Fig. 3


N 990 - Dyn. FC 2181Z
Compression Set ISO
HOFFMANN MINERAL
DIN ISO 815-1 B, 25 % Defl., 70 h / 232 °C
INTRODUCTION
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Dyneon FC 2181Z
N 990
SUMMARY
%
20
25
30
35
40
45
N990
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
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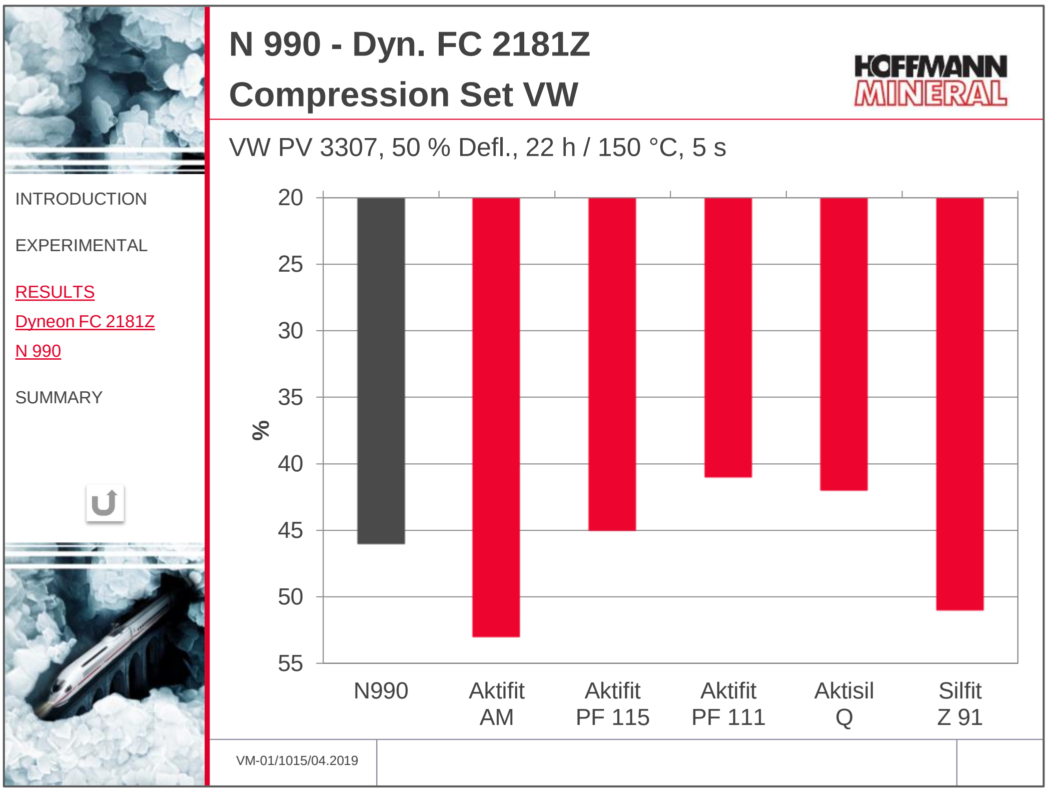
Fig. 4


N 990 - Dyn. FC 2181Z
Compression Set VW
HOFFMANN MINERAL
VW PV 3307, 50 % Defl., 22 h / 150 °C, 5 s
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Dyneon FC 2181Z
N 990
SUMMARY
%
20
25
30
35
40
45
50
55
N990
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
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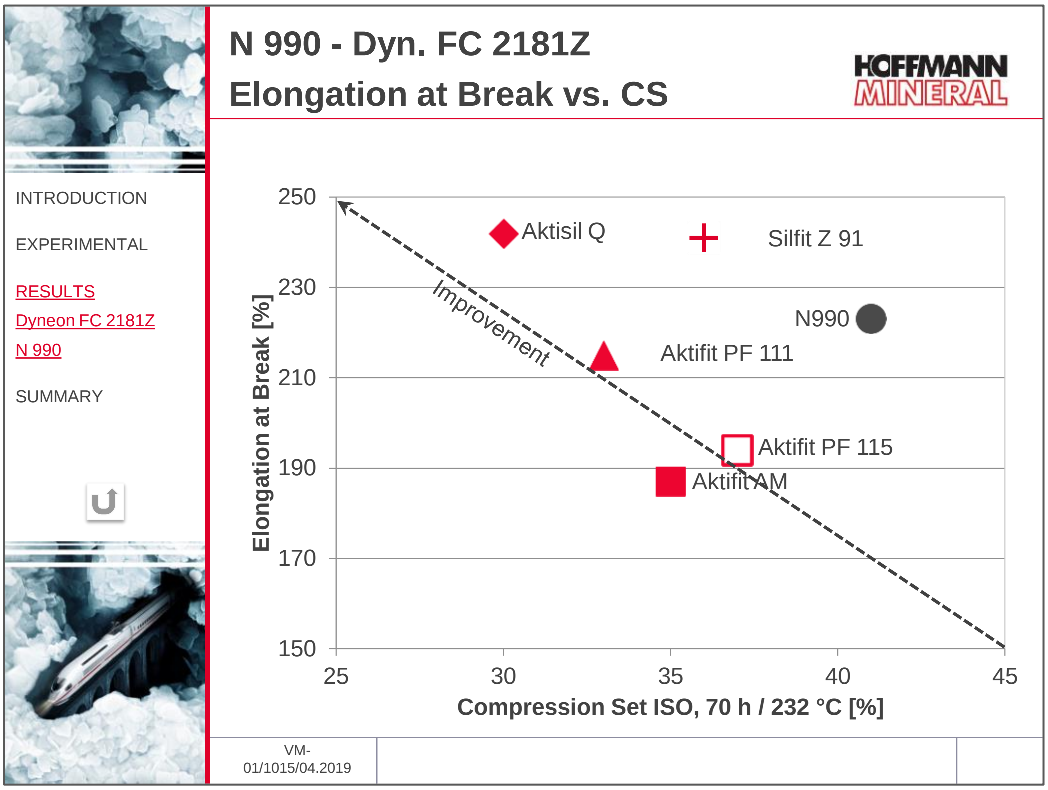
Fig. 5



N 990 - Dyn. FC 2181Z
Elongation at Break vs. CS
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Dyneon FC 2181Z
N 990
SUMMARY
Elongation at Break [%]
Compression Set ISO, 70 h / 232 °C [%]
Aktisil Q
Silfit Z 91
N990
Aktifit PF 111
Aktifit PF 115
Aktifit AM
Improvement
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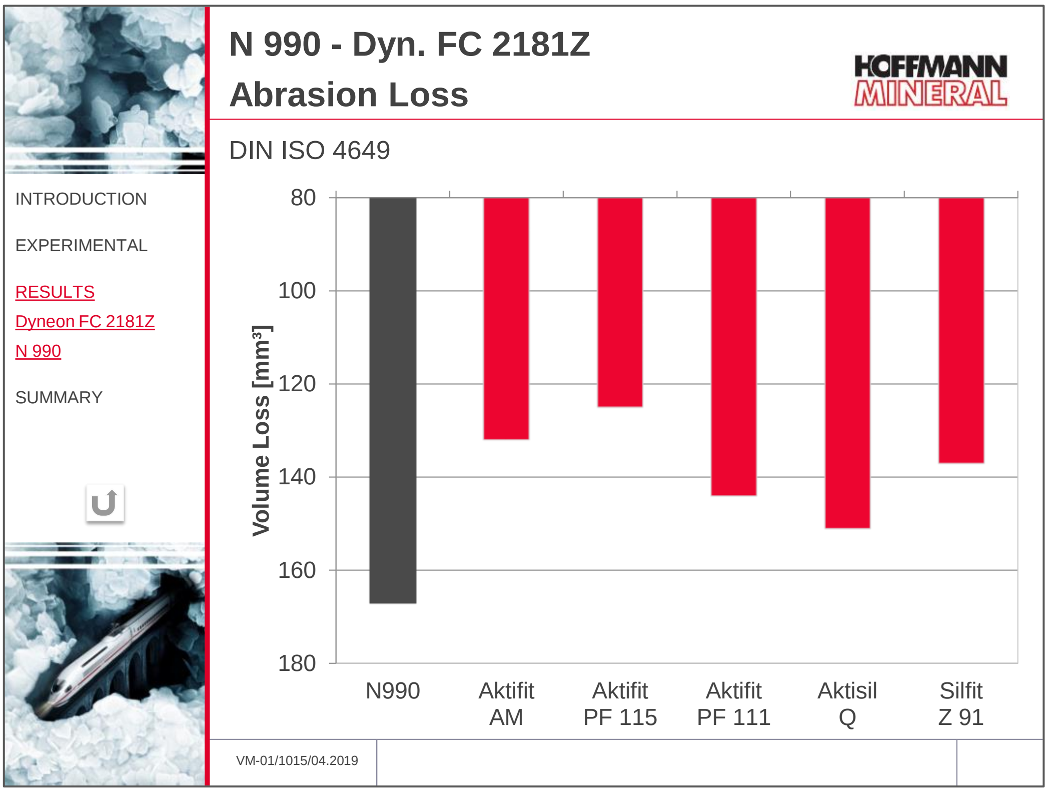
Fig. 6



N 990 - Dyn. FC 2181Z
Abrasion Loss
HOFFMANN MINERAL
DIN ISO 4649
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Dyneon FC 2181Z
N 990
SUMMARY
Volume Loss [mm³]
N990
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
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Fig. 7

3.1.2 Media resistance

The selection of the filler has no significant effect on the resistance against hot air (Fig. 8).

Silfit Z 91 and Aktifit PF 111, compared to N990, increase the oil resistance but give problems with respect to resistance against polar substances, here alcohol (methanol) containing fuel and water.

By contrast, Aktifit AM comes out with a resistance against water and fuel comparable to N990 but offers only a slightly lower resistance to oil.

With Aktisil Q the resistance to water is brought up to the level of the carbon black (Fig. 9). At the same time, the filler leads to an improved oil resistance.

In comparison with N990, Aktifit PF 115 is able to increase the resistance against polar as was well as to non-polar media, and therefore impresses with the very best results.

This will come out particularly impressive when these properties are put in relation to each other. In Fig. 10 the oil resistance of the cured compounds with different fillers is plotted against their resistance to water.

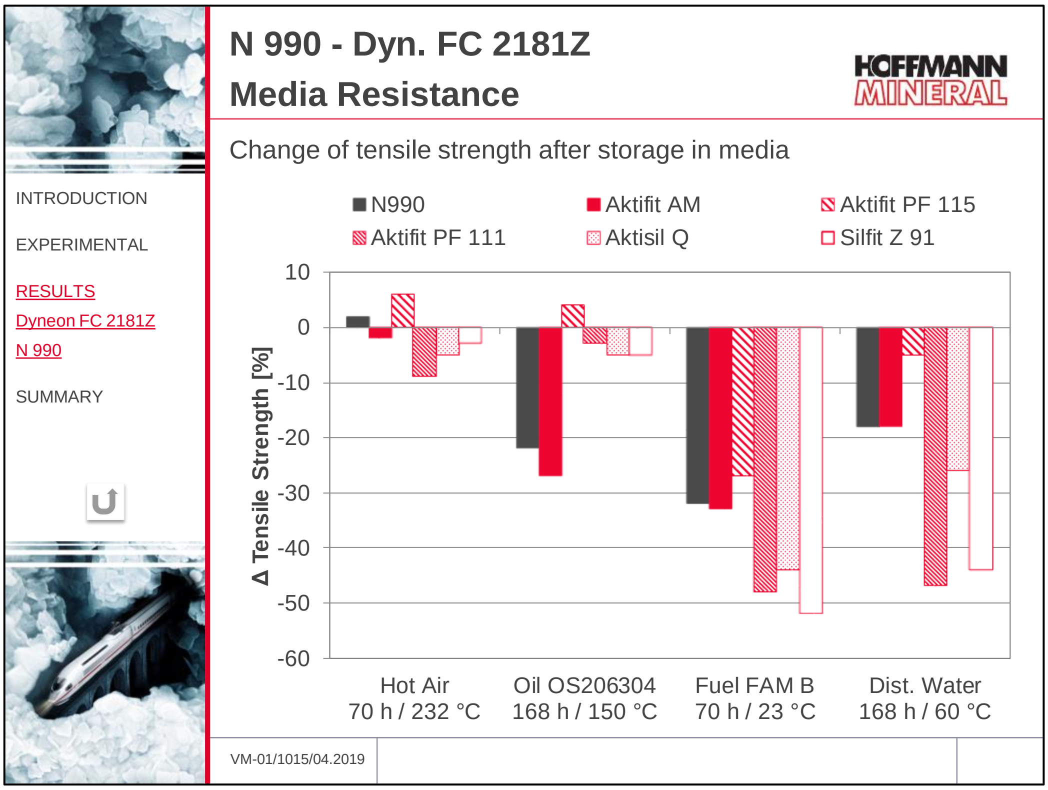

Fig. 8

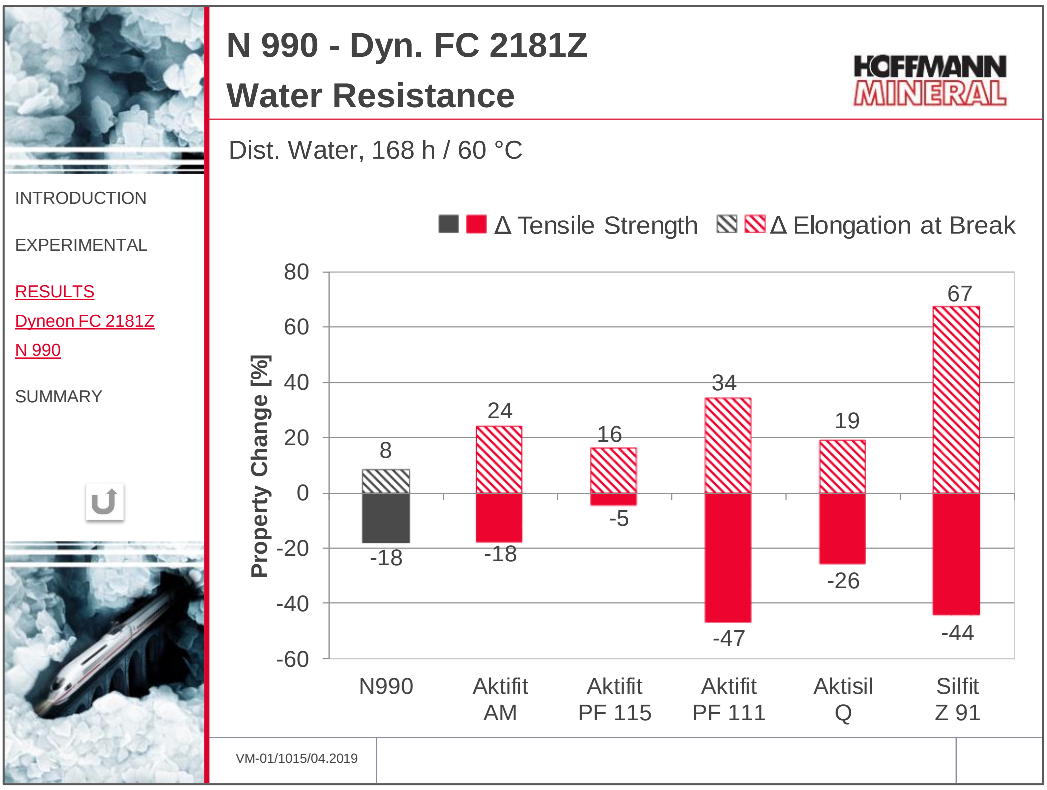
N 990 - Dyn. FC 2181Z
Water Resistance
HOFFMANN MINERAL
Dist. Water, 168 h / 60 °C
Δ Tensile Strength
Δ Elongation at Break
Property Change [%]
80
60
40
20
0
-20
-40
-60
8
-18
24
-18
16
-5
34
-47
19
-26
67
-44
N990
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
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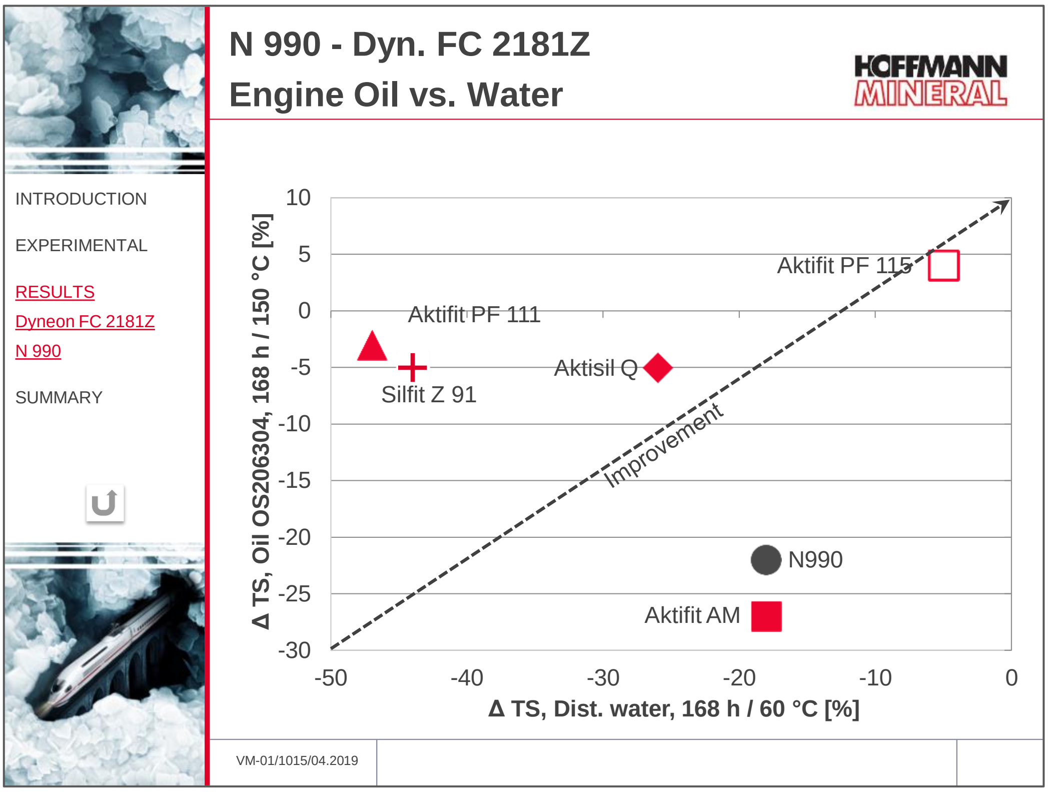
Fig. 9


N 990 - Dyn. FC 2181Z
Engine Oil vs. Water
HOFFMANN MINERAL
Δ TS, Oil OS206304, 168 h / 150 °C [%]
10
5
0
-5
-10
-15
-20
-25
-30
-50
-40
-30
-20
-10
0
Δ TS, Dist. water, 168 h / 60 °C [%]
Aktifit PF 115
Aktifit PF 111
Silfit Z 91
Aktisil Q
Improvement
N990
Aktifit AM
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N 990
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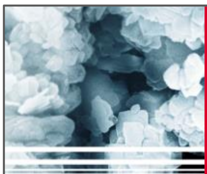
Fig. 10

3.1.3 Evaluation of the results

Varying properties and property combinations, often even contradictory, are positively influenced by NSE products. This is evident from the following assessment survey.



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Evaluation
Neuburg Siliceous Earth vs. N 990

HOFFMANN MINERAL

Dyneon FC 2181Z	Aktifit AM	Aktifit PF 115	Aktifit PF 111	Aktisil Q	Silfit Z 91
Tensile Strength	+	+	**+**	+	+
Elong. at Break			=	**+**	**+**
CS ISO	+	+	+	**+**	+
CS VW		=	**+**	**+**	
Abrasion Resist.	+	**+**	+	+	+
Hot Air Resistance	=	=	=	=	=
Water Resistance	=	**+**		=	
Fuel Resistance	=	**+**			
Oil Resistance		**+**	+	+	+
Cure Speed	=	**+**			
M_{min}				+	

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Fig. 11

Fig. 11 illustrates which grade of NSE is able to improve a particular property (+) compared with N990 or remains on an equal level (=). Red colored + signs indicate that this product achieves the optimum result for the particular property among the NSE grades.

The two amino funktional NSE grades Aktifit AM and Aktifit PF 115 additionally act as cure accelerators. The latter leads to an increased cure rate compared to N990.
Aktisil Q offers a lower viscosity which is favorable for processing by injection molding.

3.2 Neuburg Siliceous Earth vs. Wollastonite AST

Filler loading:

Wollastonite AST	45 phr
Neuburg Siliceous Earth	30 phr

Resulting hardness range 70 ± 5 Shore A

3.2.1 Mechanical properties

The replacement of the amino silane treated wollastonite with NSE practically does not change anything with respect to tensile strength (Fig. 12).

Compared with the wollastonite, the two amino funktional NSE grades Aktifit AM and Aktifit PF 115 but also Silfit Z 91 only give a slightly higher ISO compression set (Fig. 13), while Aktifit PF 111 and Aktisil Q come out at a comparable level.

Compression set tests according to the VW specification (Fig. 14) indicate that Aktisil Q here too is able to match the amino silane treated wollastonite.

As shown in Fig. 15, Aktifit PF 111 and Aktisil Q, at a comparable ISO compression set level, are additionally able to realize an improved elongation at break.
Also the other NSE grades give rise to a higher elongation at break with Silfit Z 91 at the top.

If the abrasion resistance should be increased in comparison with the amino silane treated wollastonite it is recommended to turn to Aktifit AM (Fig. 16).

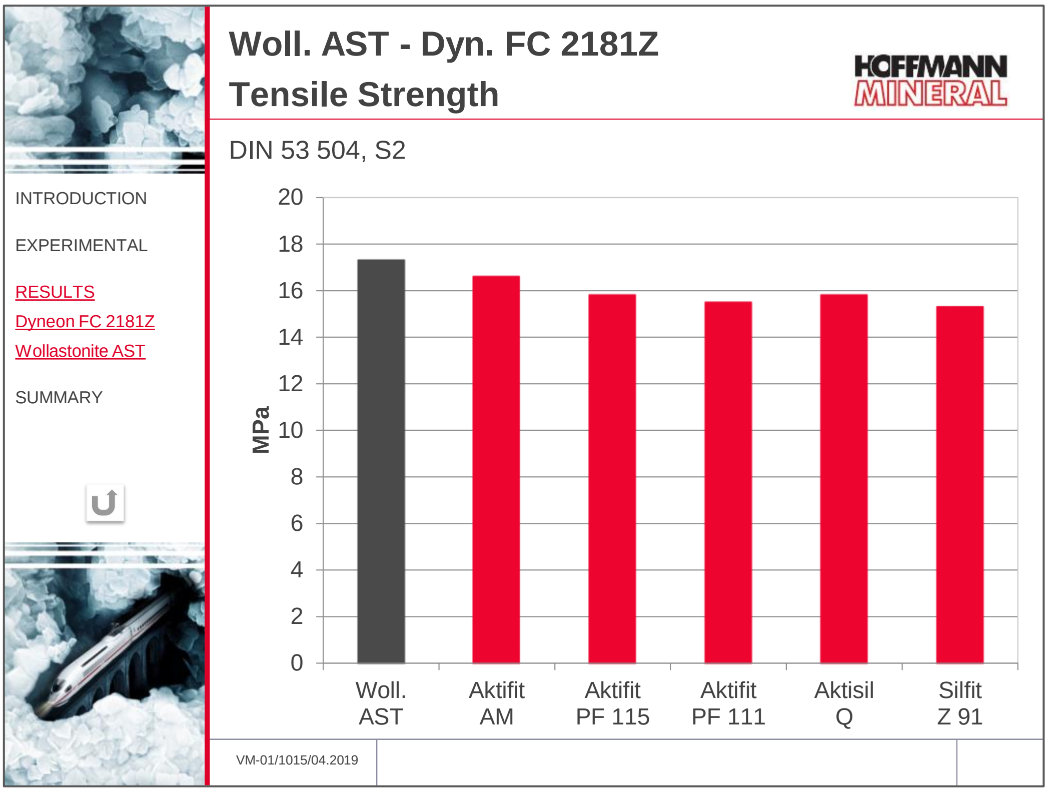
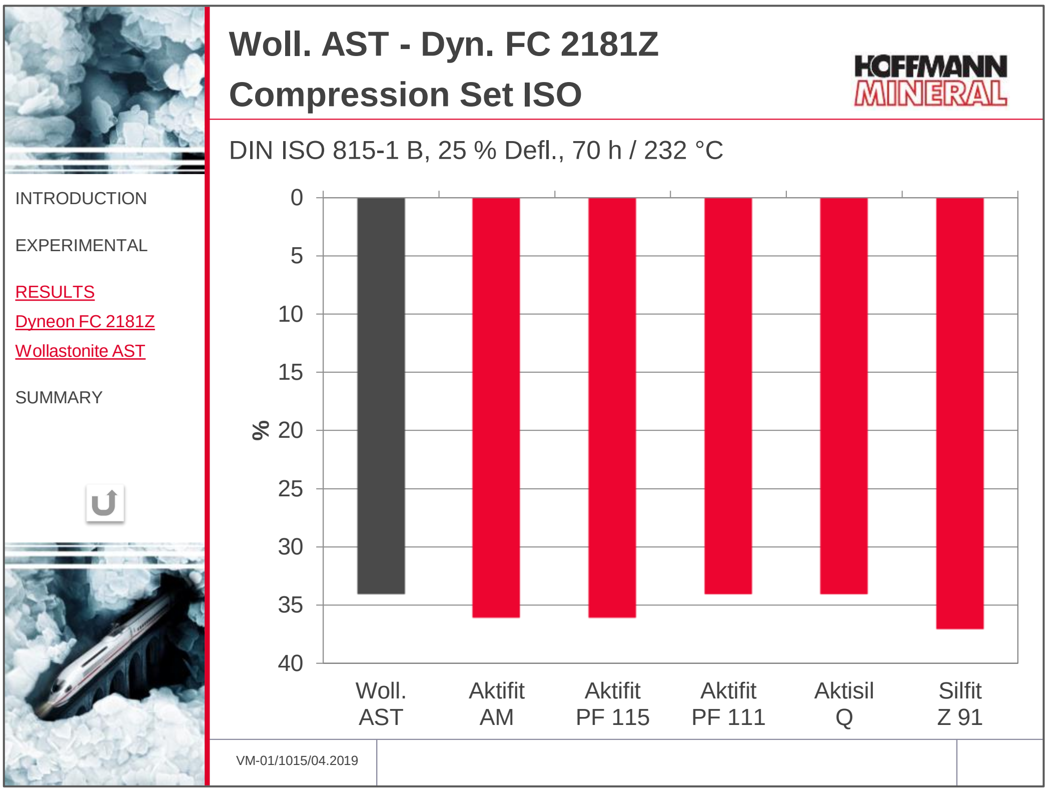


Fig. 12


Woll. AST - Dyn. FC 2181Z
Compression Set ISO
HOFFMANN MINERAL
DIN ISO 815-1 B, 25 % Defl., 70 h / 232 °C
INTRODUCTION
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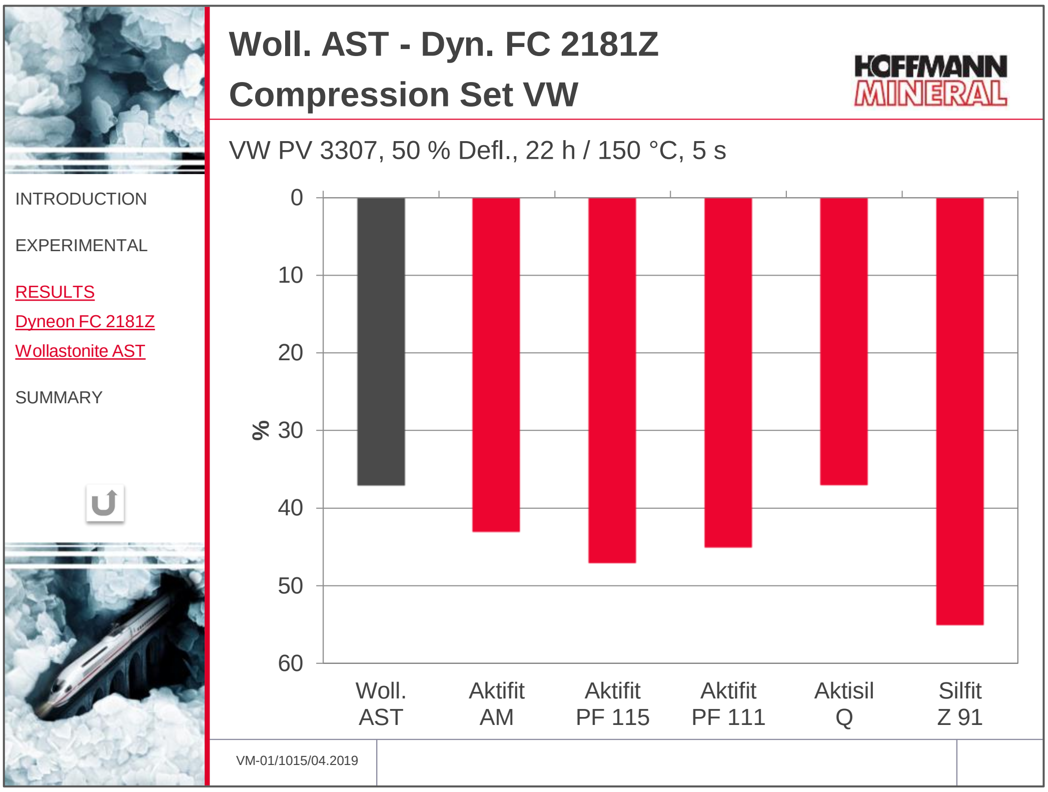
RESULTS
Dyneon FC 2181Z
Wollastonite AST
SUMMARY
%
0
5
10
15
20
25
30
35
40
Woll. AST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 13


Woll. AST - Dyn. FC 2181Z
Compression Set VW
HOFFMANN MINERAL
VW PV 3307, 50 % Defl., 22 h / 150 °C, 5 s
INTRODUCTION
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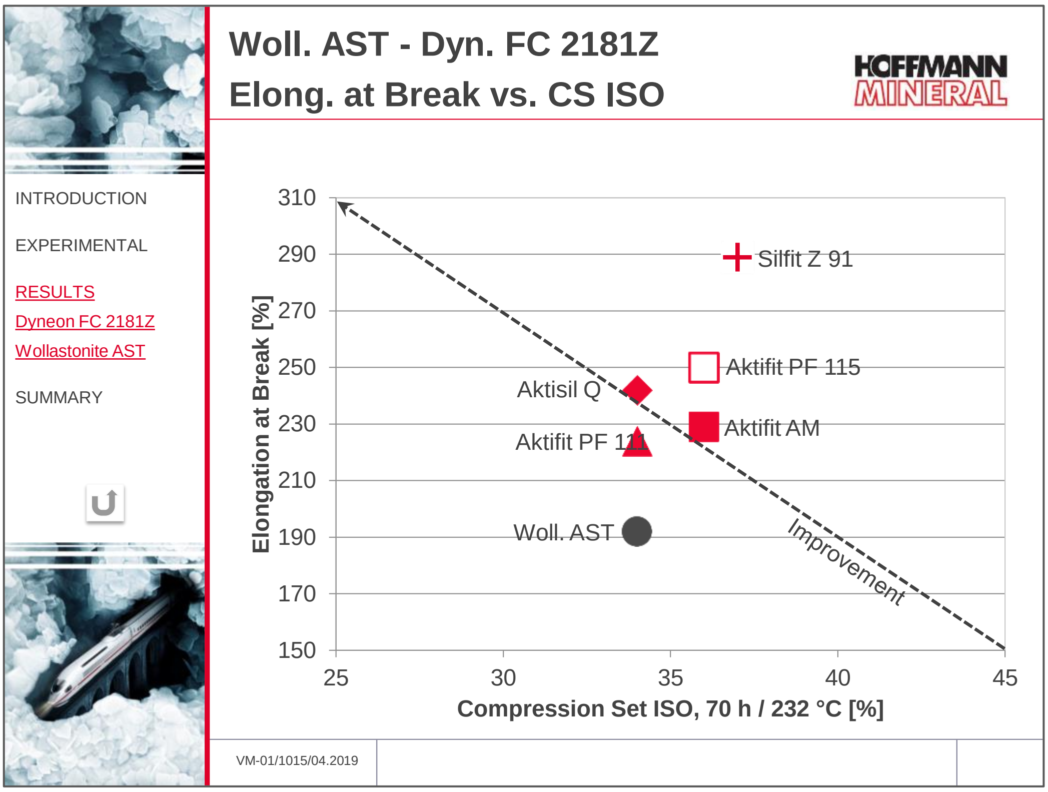
Dyneon FC 2181Z
Wollastonite AST
SUMMARY
%
0
10
20
30
40
50
60
Woll. AST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 14


Woll. AST - Dyn. FC 2181Z
Elong. at Break vs. CS ISO
HOFFMANN
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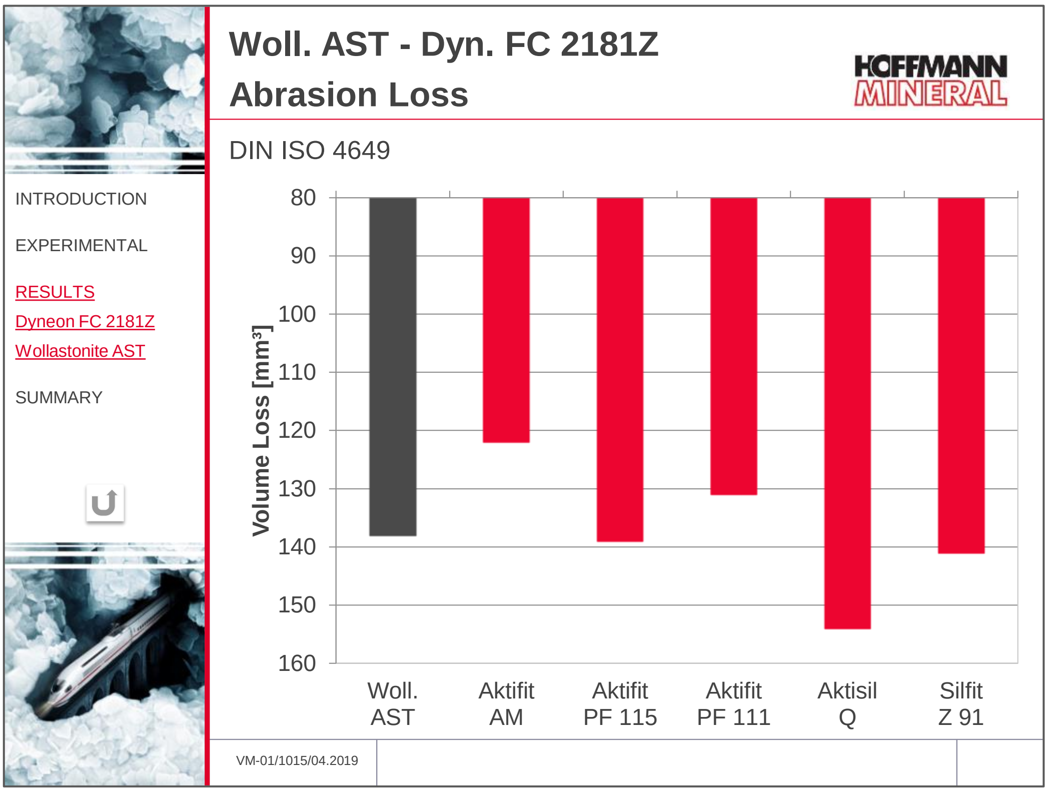
Dyneon FC 2181Z
Wollastonite AST
SUMMARY
Elongation at Break [%]
310
290
270
250
230
210
190
170
150
25
30
35
40
45
Compression Set ISO, 70 h / 232 °C [%]
Silfit Z 91
Aktifit PF 115
Aktisil Q
Aktifit AM
Aktifit PF 111
Woll. AST
Improvement
VM-01/1015/04.2019

Fig. 15


Woll. AST - Dyn. FC 2181Z
Abrasion Loss
HOFFMANN
MINERAL
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RESULTS
Dyneon FC 2181Z
Wollastonite AST
SUMMARY
DIN ISO 4649
Volume Loss [mm³]
80
90
100
110
120
130
140
150
160
Woll. AST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 16

3.2.2 Media resistance

With Aktifit AM, Aktifit PF 115 and Silfit Z 91 the resistance of the cured compounds against hot air is comparable with the amino silane treated wollastonite (Fig. 17).

The oil resistance conferred by the wollastonite lies on a high level which can even be somewhat outperformed by Silfit Z 91, Aktifit PF 111 and the two amino functional grades Aktifit AM and Aktifit PF 115.

The two last-mentioned NSE grades also allow to improve the resistance to fuel and water when compared with the wollastonite.

In particular, Aktifit PF 115 offers a very attractive combination of resistance against polar and non-polar media (Fig. 18) and therefore represents the very best product for an allround resistance.

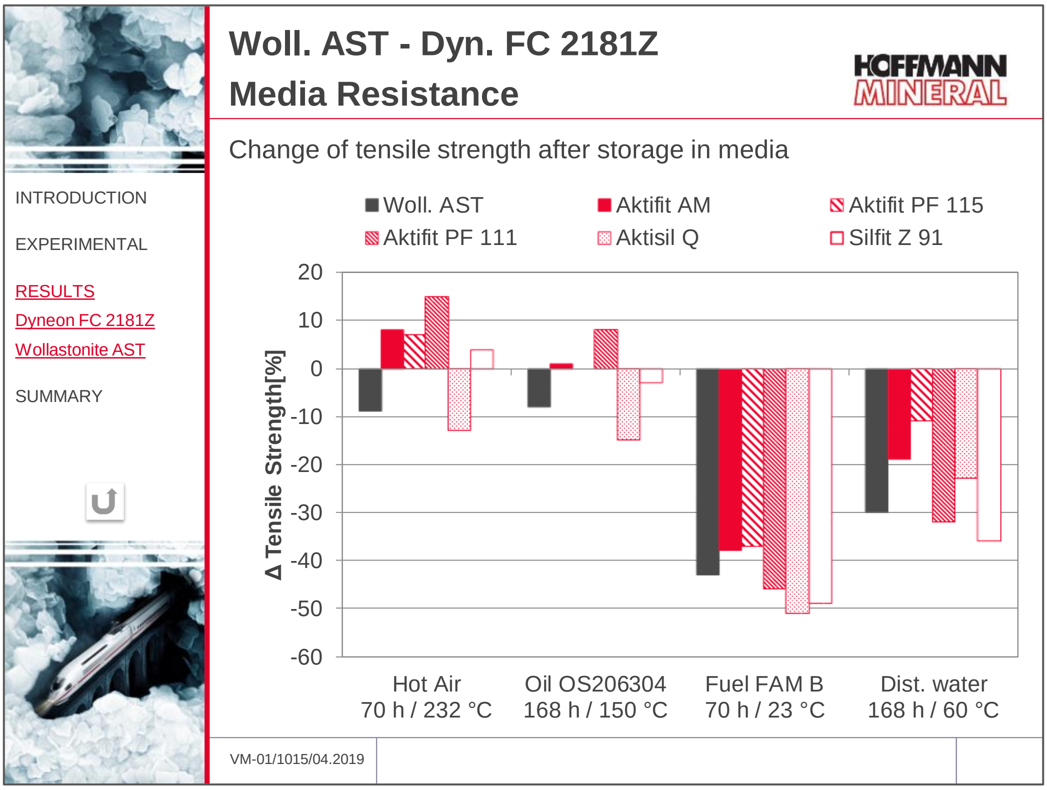
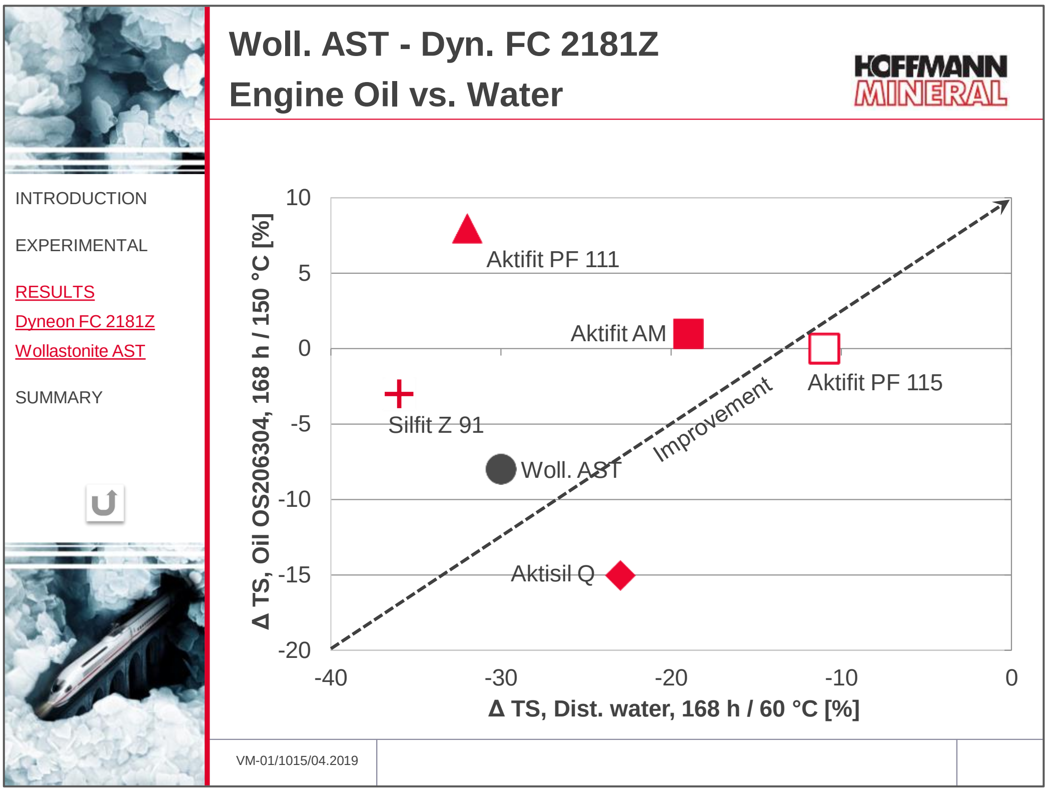


Fig. 17


Woll. AST - Dyn. FC 2181Z
Engine Oil vs. Water
HOFFMANN
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EXPERIMENTAL
RESULTS
Dyneon FC 2181Z
Wollastonite AST
SUMMARY
Δ TS, Oil OS206304, 168 h / 150 °C [%]
10
5
0
-5
-10
-15
-20
-40
-30
-20
-10
0
Δ TS, Dist. water, 168 h / 60 °C [%]
Aktifit PF 111
Aktifit AM
Aktifit PF 115
Silfit Z 91
Woll. AST
Improvement
Aktisil Q
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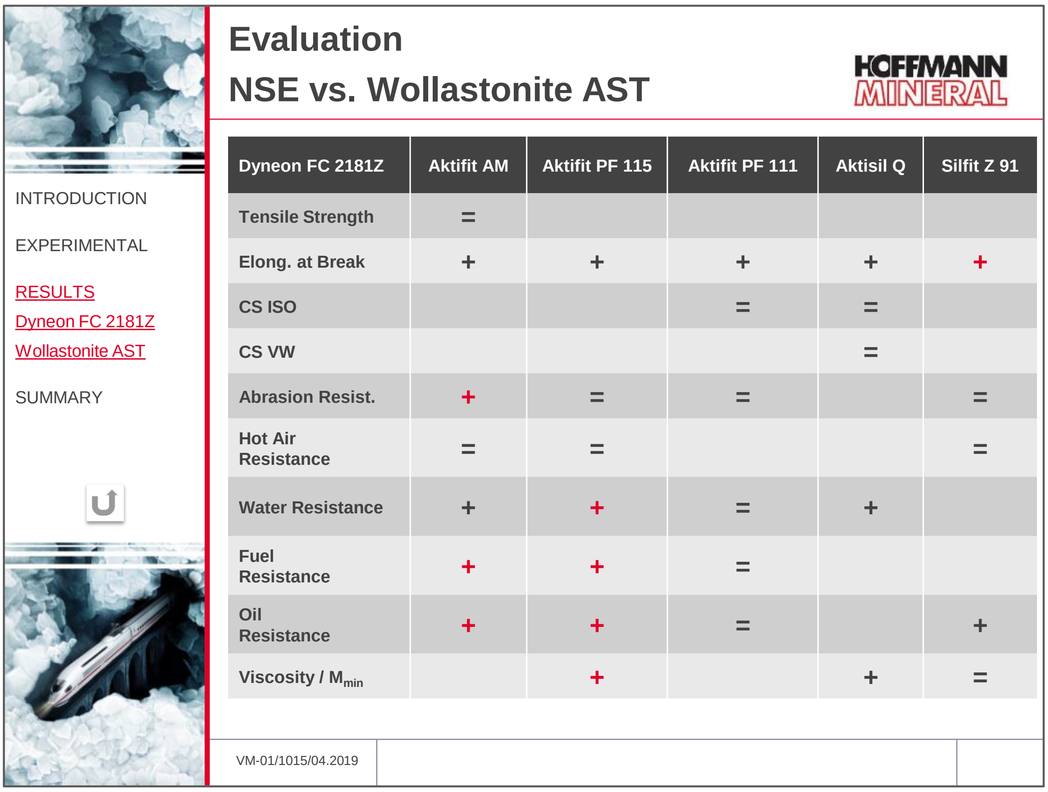
Fig. 18

3.2.3 Evaluation of the results

Different properties and property combinations, often even of contradictory nature, are positively influenced by the NSE grades. This is clearly seen in the following assessment survey.



Dyneon FC 2181Z	Aktifit AM	Aktifit PF 115	Aktifit PF 111	Aktisil Q	Silfit Z 91
Tensile Strength	=				
Elong. at Break	+	+	+	+	+
CS ISO			=	=	
CS VW				=	
Abrasion Resist.	+	=	=		=
Hot Air Resistance	=	=			=
Water Resistance	+	+	=	+	
Fuel Resistance	+	+	=		
Oil Resistance	+	+	=		+
Viscosity / M_{min}		+		+	=

Fig. 19

Fig. 19 shows which NSE grade is able to improve a pertinent property versus amino silane treated wollastonite (+) or arrives at a comparable level (=). Red colored + signs indicate that this product for the particular property arrives on top of the NSE grades.

Aktifit PF 115 and Aktisil Q offer a viscosity level which is favorable for injection molding processing.

3.3 Neuburg Siliceous Earth vs. Wollastonite EST

Filler loading:

Wollastonite EST	45 phr
Neuburg Siliceous Earth	30 phr

Resulting hardness range 70 ± 5 Shore A

3.3.1 Mechanical properties

Compared with the epoxy silane treated wollastonite Aktifit AM allows to somewhat increase the tensile strength; the other NSE grades are rather found on a comparable level (Fig. 20).

The ISO compression set practically does not change with the replacement of the wollastonite by the various NSE grades (Fig. 21).

Fig. 22 again proves the benefits of Aktisil Q with respect to the compression set according to the VW test which comes out at a comparable level with the wollastonite.

At comparable ISO compression set results the NSE grades are able to markedly increase the elongation at break beyond the level of the epoxy silane treated wollastonite (Fig. 23).

For a high abrasion resistance Aktifit AM should be used which outperforms the wollastonite (Fig. 24).

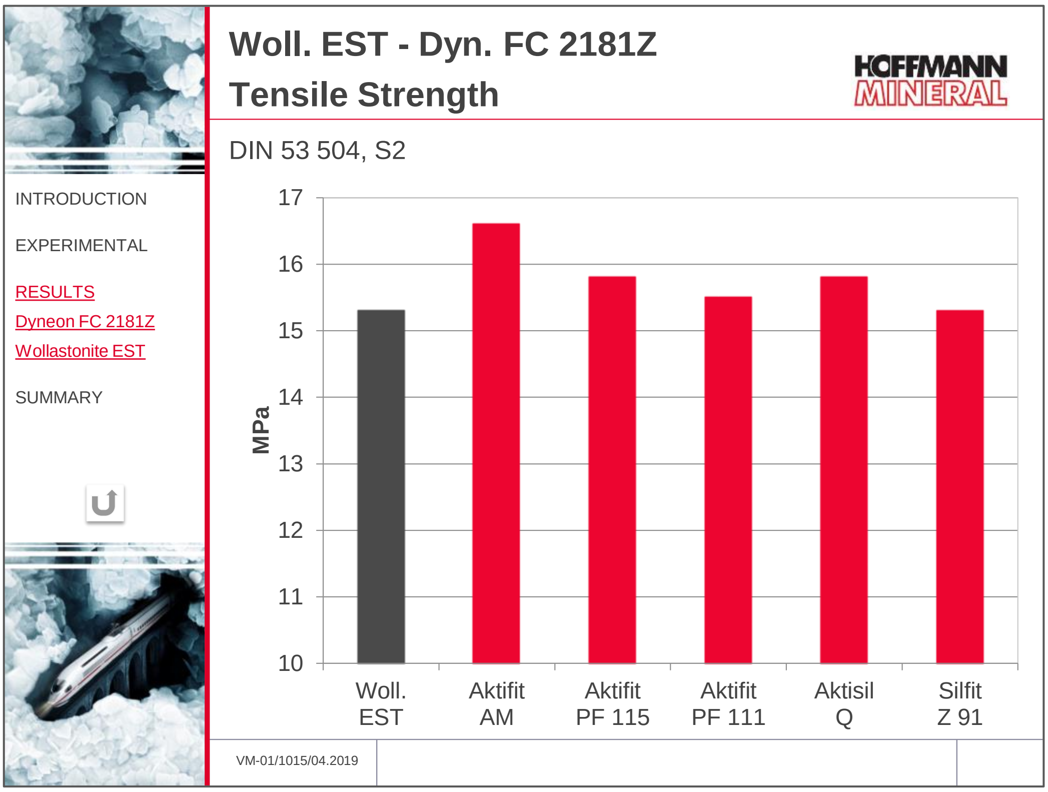
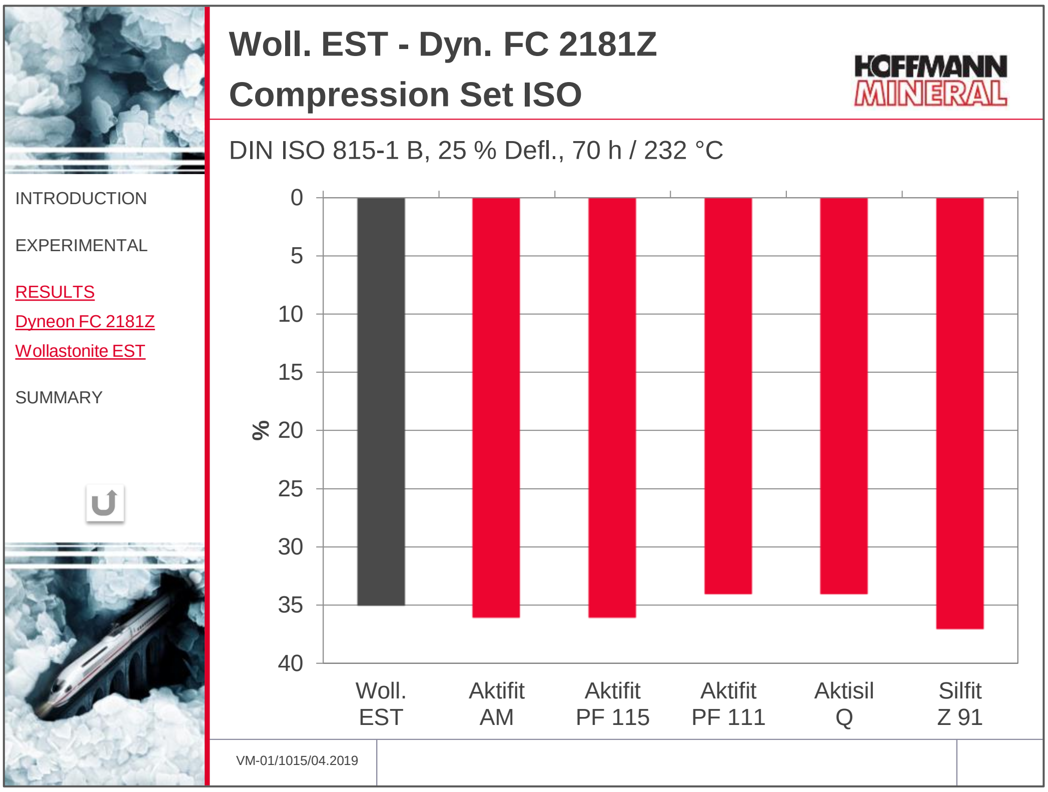


Fig. 20


Woll. EST - Dyn. FC 2181Z
Compression Set ISO
HOFFMANN MINERAL
DIN ISO 815-1 B, 25 % Defl., 70 h / 232 °C
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Dyneon FC 2181Z
Wollastonite EST
SUMMARY
%
0
5
10
15
20
25
30
35
40
Woll. EST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
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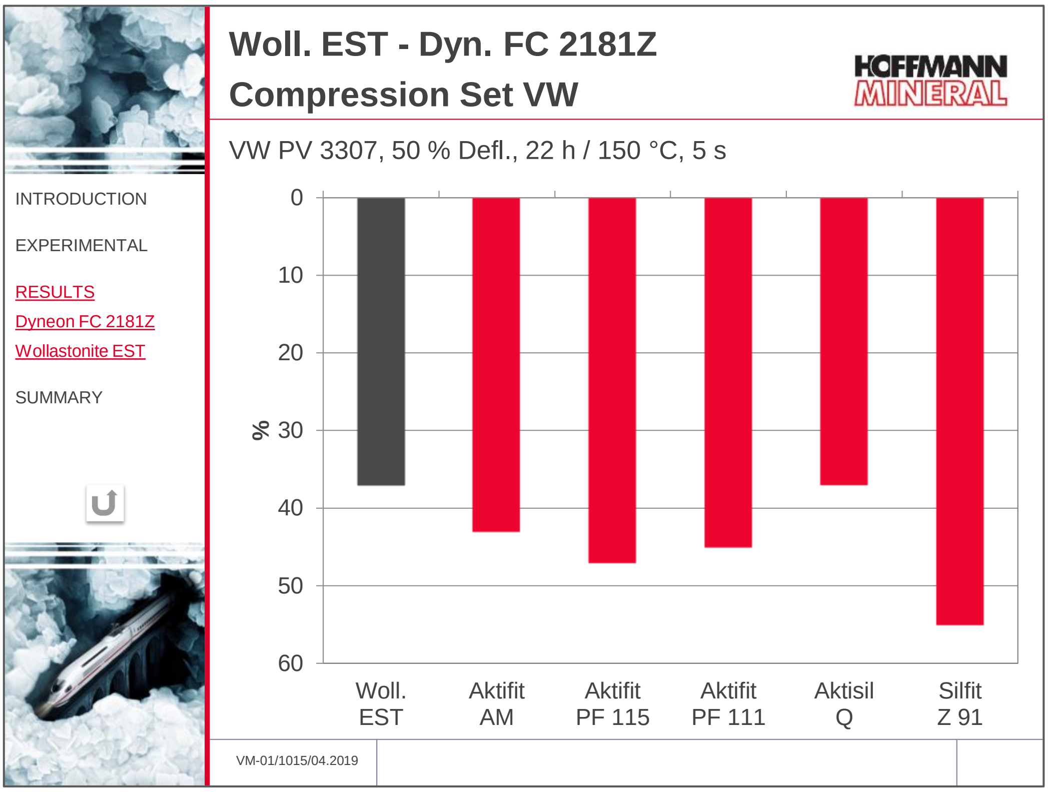
Fig. 21


Woll. EST - Dyn. FC 2181Z
Compression Set VW
HOFFMANN MINERAL
VW PV 3307, 50 % Defl., 22 h / 150 °C, 5 s
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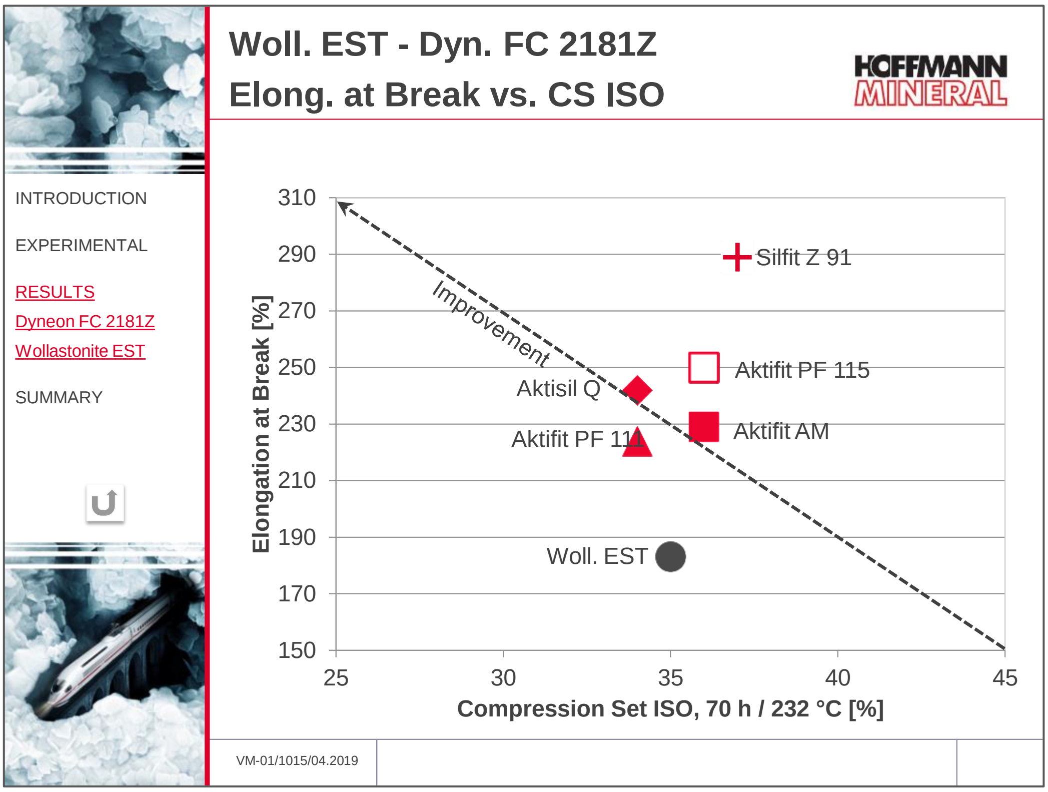
Dyneon FC 2181Z
Wollastonite EST
SUMMARY
%
0
10
20
30
40
50
60
Woll. EST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 22


Woll. EST - Dyn. FC 2181Z
Elong. at Break vs. CS ISO
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RESULTS
Dyneon FC 2181Z
Wollastonite EST
SUMMARY
Elongation at Break [%]
310
290
270
250
230
210
190
170
150
25
30
35
40
45
Compression Set ISO, 70 h / 232 °C [%]
Improvement
Silfit Z 91
Aktifit PF 115
Aktisil Q
Aktifit AM
Aktifit PF 111
Woll. EST
VM-01/1015/04.2019

Fig. 23

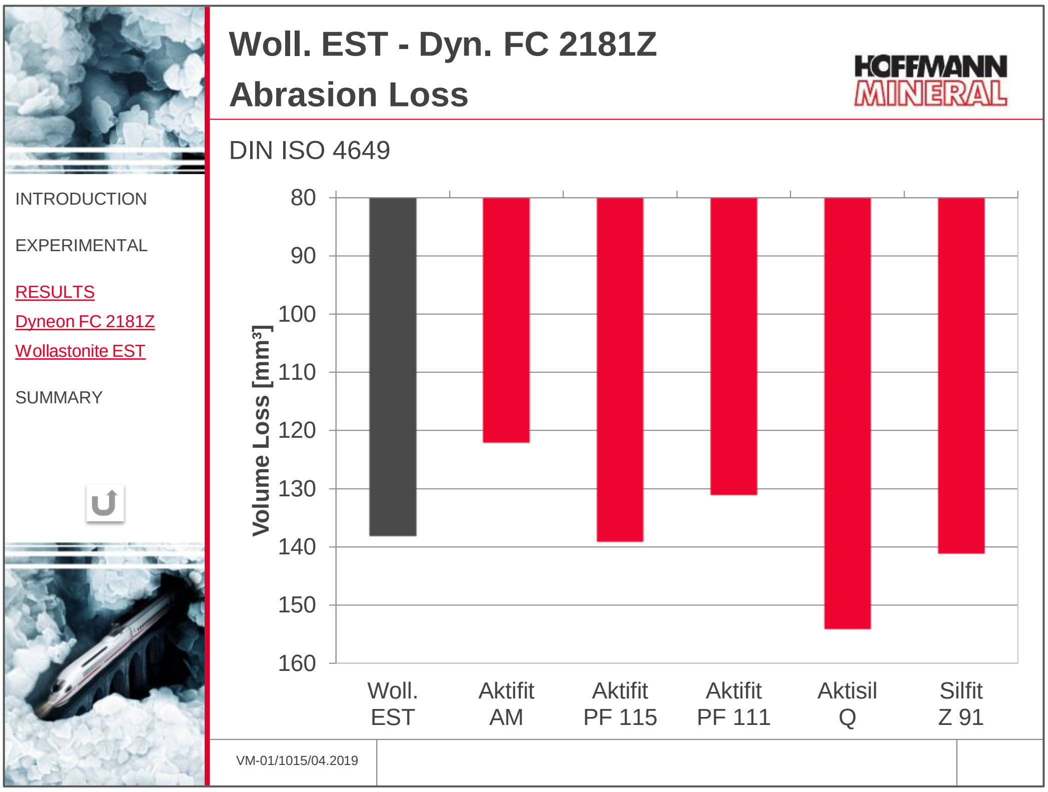

Woll. EST - Dyn. FC 2181Z
Abrasion Loss
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Dyneon FC 2181Z
Wollastonite EST
SUMMARY
DIN ISO 4649
Volume Loss [mm³]
80
90
100
110
120
130
140
150
160
Woll. EST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 24

3.3.2 Media resistance

With Aktifit AM, Aktifit PF 115 and Silfit Z 91 the hot air resistance of the cured compounds remains comparable with the epoxy silane treated wollastonite (Fig. 25).

The fuel resistance of the compound filled with the wollastonite will easily be matched by the two amino functional NSE grades Aktifit AM and Aktifit PF 115.

These two fillers, as well as Aktisil Q, are also able to markedly increase the water resistance over the level with the wollastonite while Aktifit PF 111 and Silfit Z 91 come out on an equal level.

In particular the Aktifit PF 115 offers an attractive combination of water and oil resistance (Fig. 26) and therefore underlines its importance as the best product for allround resistance properties.

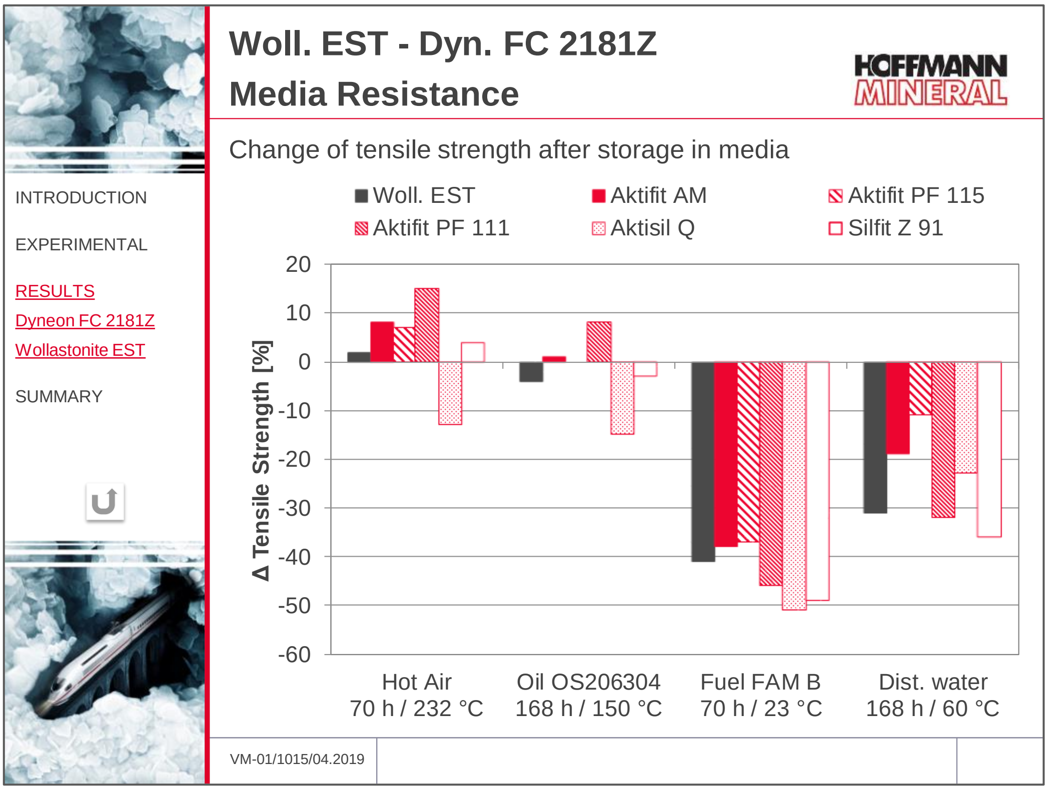
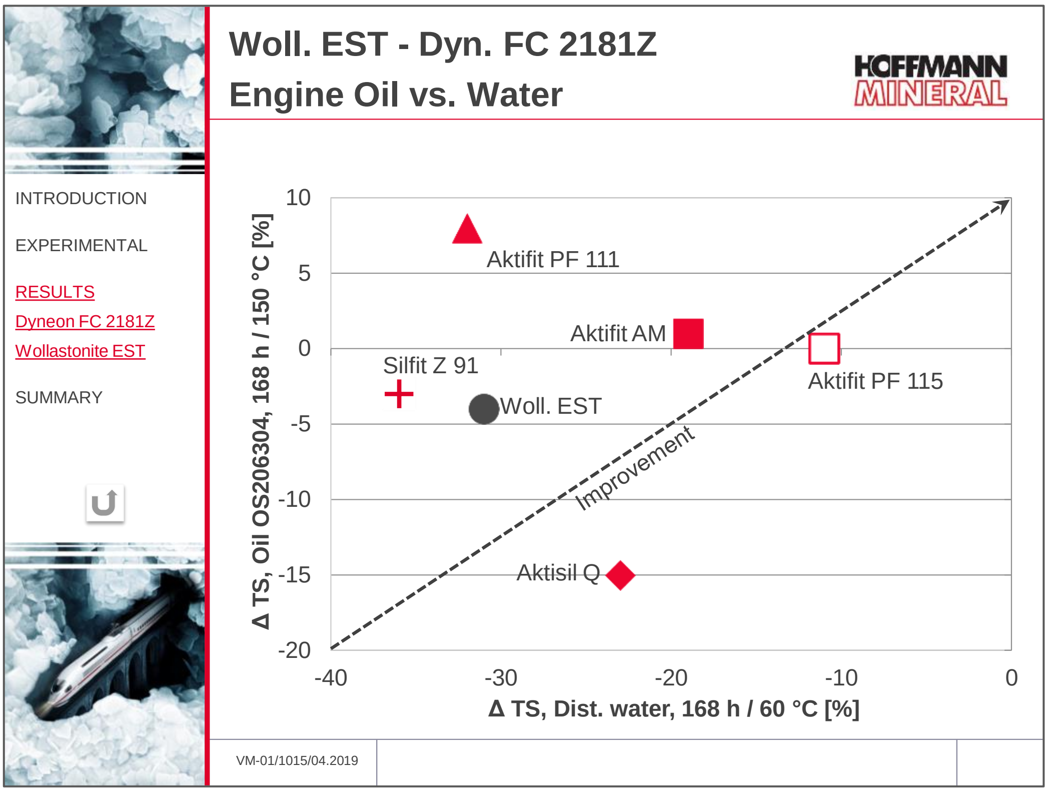


Fig. 25

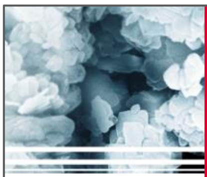


Woll. EST - Dyn. FC 2181Z
Engine Oil vs. Water
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Dyneon FC 2181Z
Wollastonite EST
SUMMARY
Δ TS, Oil OS206304, 168 h / 150 °C [%]
10
5
0
-5
-10
-15
-20
Aktifit PF 111
Aktifit AM
Silfit Z 91
Woll. EST
Aktifit PF 115
Improvement
Aktisil Q
-40
-30
-20
-10
0
Δ TS, Dist. water, 168 h / 60 °C [%]
VM-01/1015/04.2019

Fig. 26

3.3.3 Evaluation of the results

Several properties and combinations of properties, even sometimes contradictory, are positively influenced by the NSE grades. This is evident from the following assessment survey.



Evaluation
NSE vs. Wollastonite EST

HOFFMANN MINERAL

Dyneon FC 2181Z	Aktifit AM	Aktifit PF 115	Aktifit PF 111	Aktisil Q	Silfit Z 91
Tensile Strength	+	=	=	=	=
Elong. at Break	+	+	+	+	+
CS ISO	=	=	=	=	
CS VW				=	
Abrasion Resist.	+	=	=		=
Hot Air Resistance	=	=			=
Water Resistance	+	+	=	+	=
Fuel Resistance	=	=	=		
Oil Resistance	=	=	=		=
Cure Speed	=	=			
Viscosity / M_{min}		+	+	+	=

VM-01/1015/04.2019

Fig. 27

Fig. 27 shows which NSE grade, compared with the epoxy silane treated wollastonite, improves the particular property (+) or comes out at an equal level (=). Red colored + signs indicate that this product among the NSE grades offers the best results for the particular property.

The two amino functional NSE grades Aktifit AM and Aktifit PF 115 show a higher accelerating effect on the cure of the compounds than the other NSE grades in a way to here catch up with the wollastonite.

Viscosities favorable for processing by injection molding are brought about by Aktifit PF 115, Aktifit PF 111 and Aktisil Q.

3.4 Neuburg Siliceous Earth vs. Barium Sulfate

Filler loading:

Barium sulfate (precipitated)	74 phr
Neuburg Siliceous Earth	30 phr

Resulting hardness range 70 ± 5 Shore A

3.4.1 Mechanical properties

The tensile strength imparted by barium sulfate is clearly exceeded with all Neuburg Siliceous Earth grades (Fig. 28).

In Fig. 29, elongation at break is plotted against the abrasion loss. The untreated Calcined Neuburg Siliceous Earth grade Silfit Z 91 represents the counterpart of barium sulfate among the NSEs. With a slightly increased elongation at break the abrasion loss can be markedly improved.

This is also true for the surface treated NSE grades whose elongation at break in spite of the chemical modification still comes out on a very acceptable level.

Fig. 30 comes back to abrasion volume losses of the individual compounds in detail. With half the level of barium sulfate, Aktifit AM offers the optimum result.

The compression set according to ISO with the two amino funkctional NSE grades is on a comparable level with the barium sulfate (Fig. 31).

With Aktifit PF 111 and Aktisil Q the figures are somewhat lower which means a slight improvement over the barium sulfate.

Also when testing compression set according to the VW standard, Aktisil Q comes out with a somewhat more attractive result (Fig. 32).

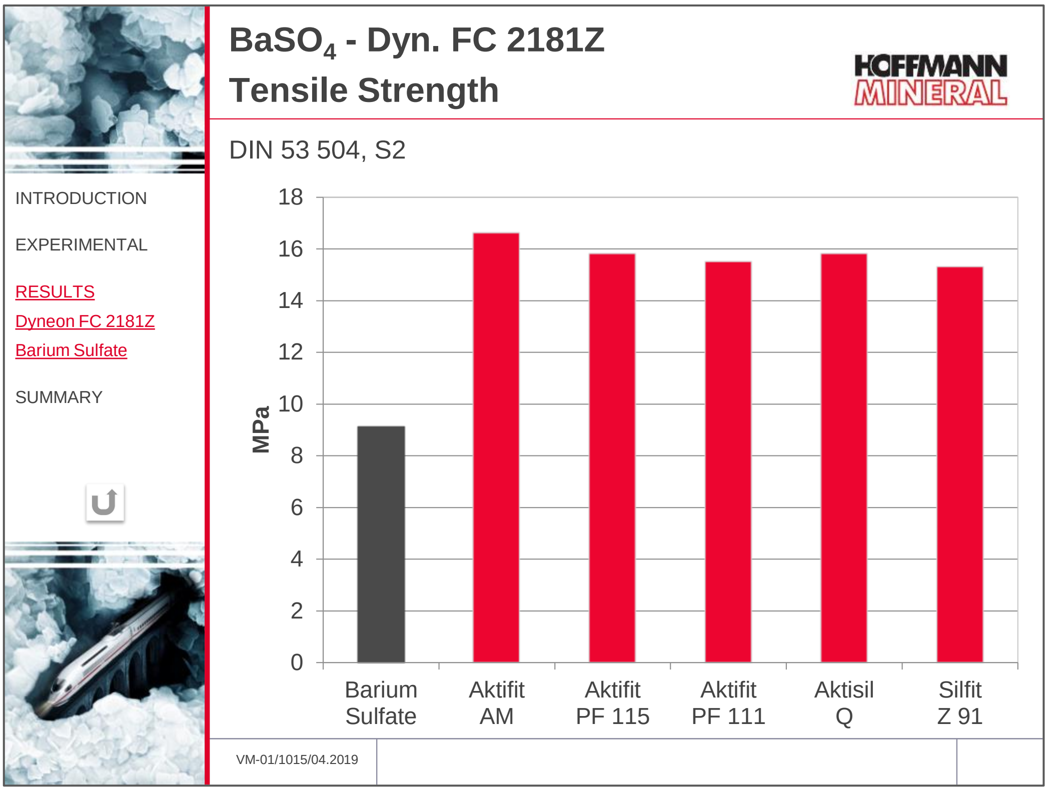


Fig. 28

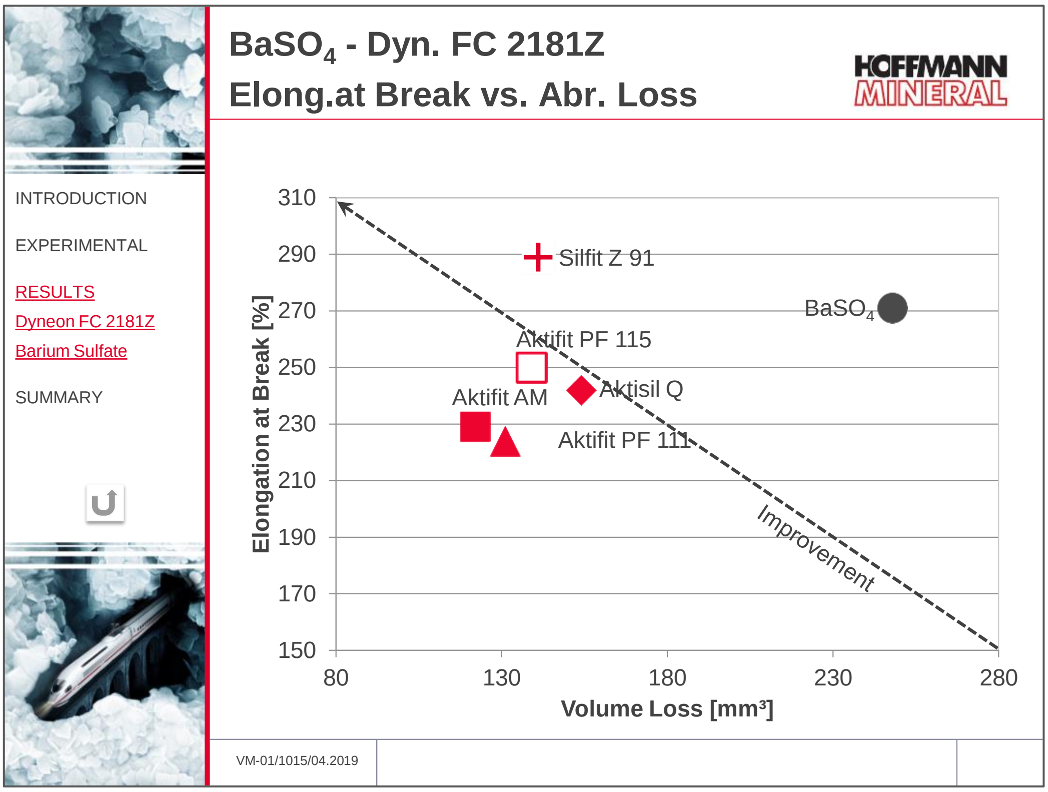

BaSO4 - Dyn. FC 2181Z
Elong.at Break vs. Abr. Loss
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Dyneon FC 2181Z
Barium Sulfate
SUMMARY
Elongation at Break [%]
Volume Loss [mm³]
Silfit Z 91
BaSO4
Aktifit PF 115
Aktifit AM
Aktisil Q
Aktifit PF 111
Improvement
VM-01/1015/04.2019

Fig. 29

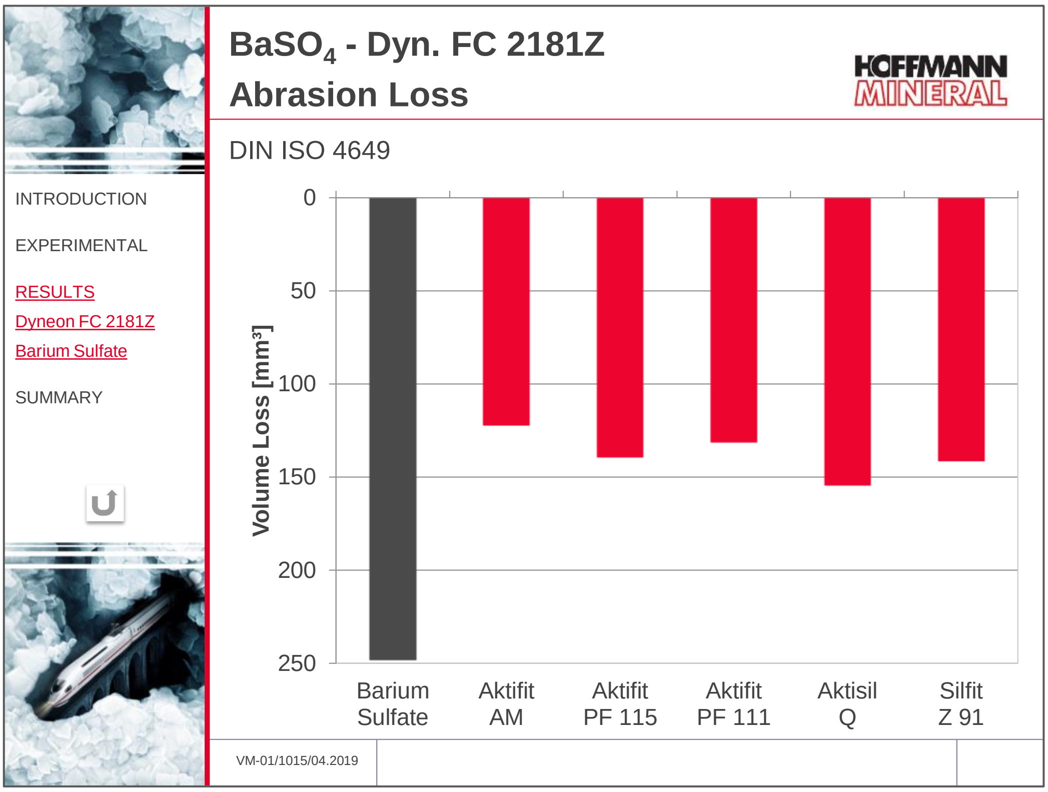

BaSO4 - Dyn. FC 2181Z
Abrasion Loss
HOFFMANN MINERAL
DIN ISO 4649
INTRODUCTION
EXPERIMENTAL
RESULTS
Dyneon FC 2181Z
Barium Sulfate
SUMMARY
Volume Loss [mm³]
Barium Sulfate
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 30

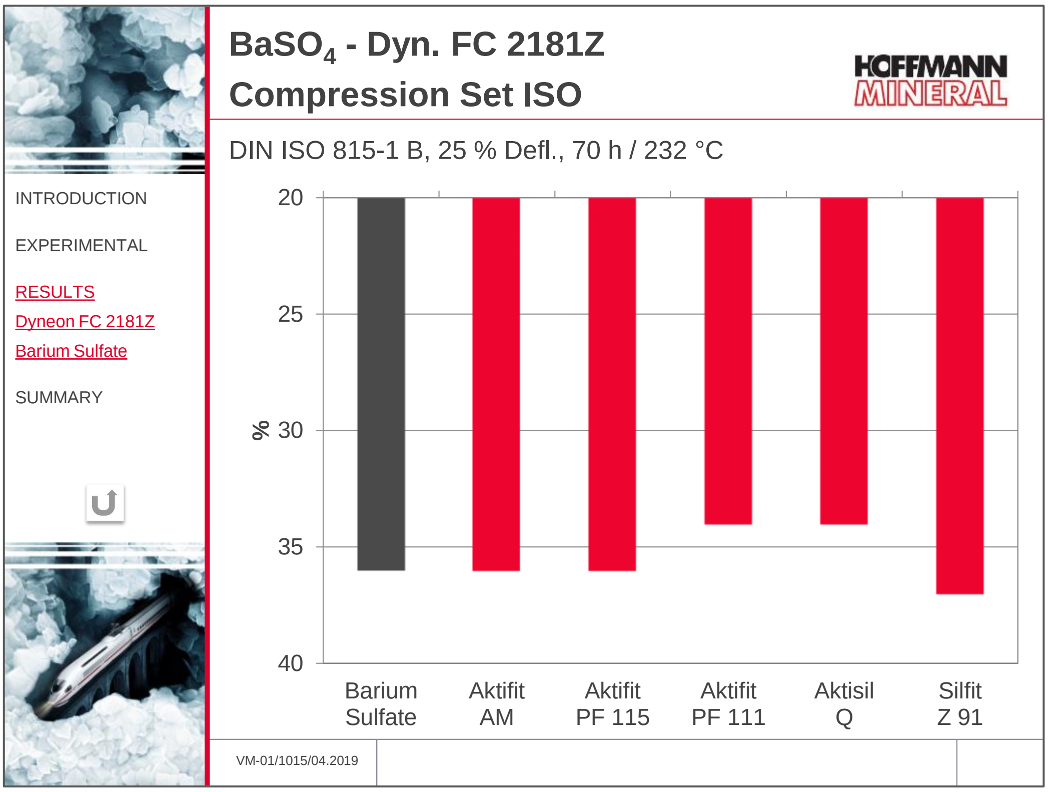

BaSO4 - Dyn. FC 2181Z
Compression Set ISO
HOFFMANN MINERAL
DIN ISO 815-1 B, 25 % Defl., 70 h / 232 °C
INTRODUCTION
EXPERIMENTAL
RESULTS
Dyneon FC 2181Z
Barium Sulfate
SUMMARY
%
20
25
30
35
40
Barium Sulfate
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 31

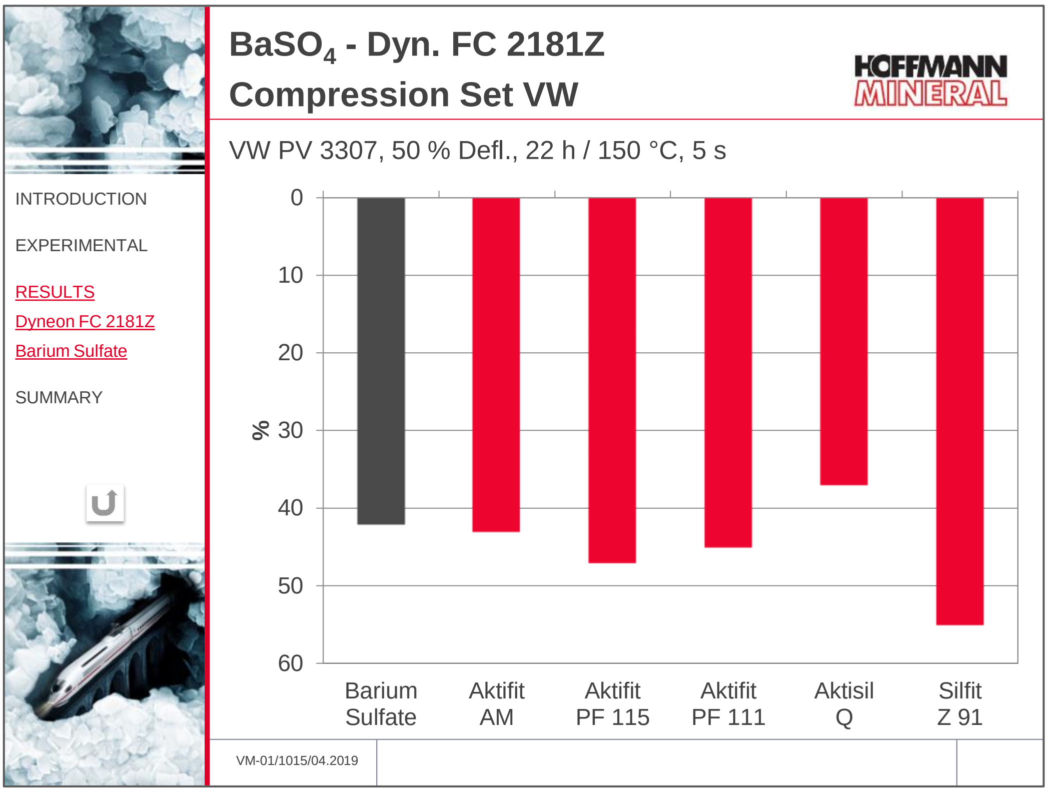

BaSO4 - Dyn. FC 2181Z
Compression Set VW
HOFFMANN MINERAL
VW PV 3307, 50 % Defl., 22 h / 150 °C, 5 s
INTRODUCTION
EXPERIMENTAL
RESULTS
Dyneon FC 2181Z
Barium Sulfate
SUMMARY
%
0
10
20
30
40
50
60
Barium Sulfate
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 32

3.4.2 Media resistance

The nature of the filler does not exert a significant influence on the hot air resistance (Fig. 33).

The two amino functional Calcined Neuburg Siliceous Earth grades Aktifit AM and Aktifit PF 115 offer an increase of the fuel resistance not only in comparison with the other NSE grades but also versus the barium sulfate.

Aktifit AM, Aktifit PF 115 and Silfit Z 91 enhance the oil resistance compared to barium sulfate which will come out particularly evident when the change of the elongation at break is also taken into consideration (Fig. 34).

While Aktifit AM draws level with the barium sulfate with respect to the water resistance the Aktifit PF 115 is able to impart an improvement as clearly shown in Fig. 35.

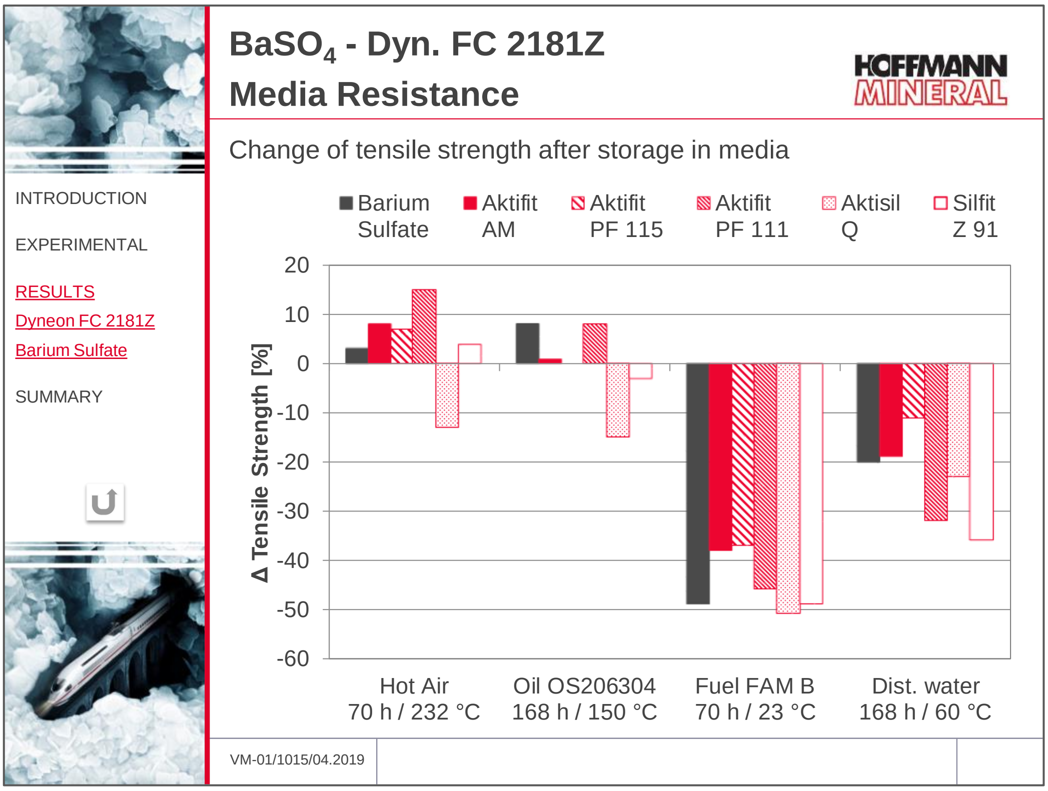


Fig. 33

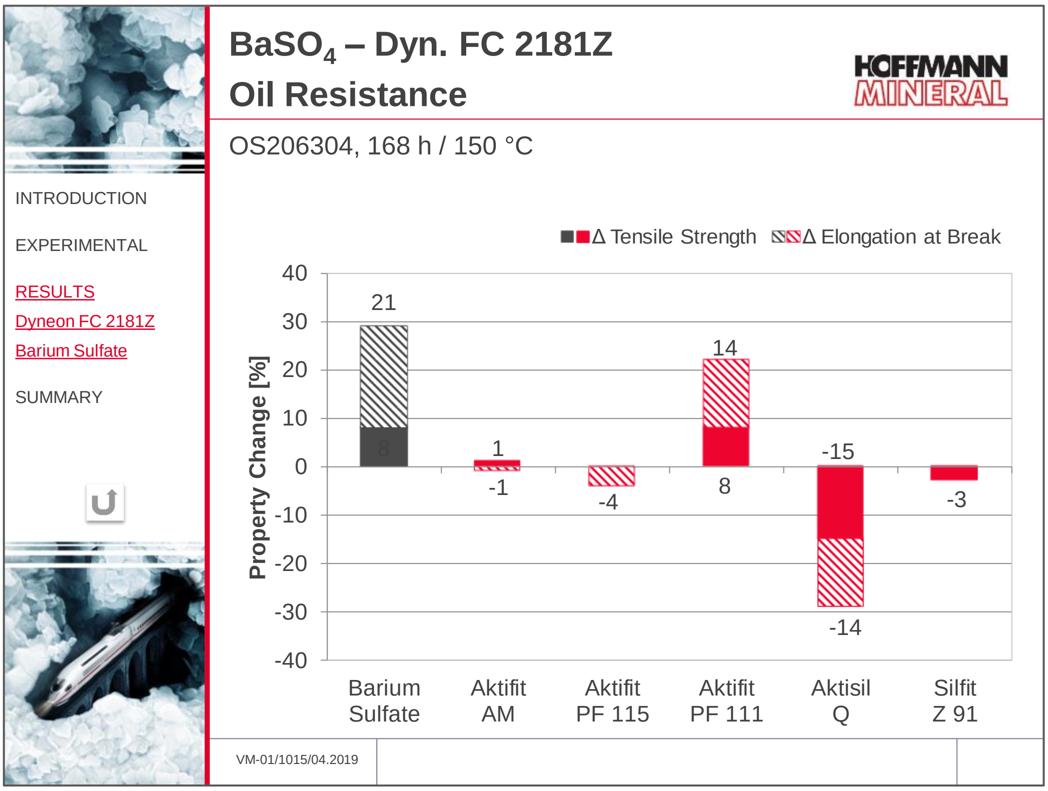

BaSO4 – Dyn. FC 2181Z
Oil Resistance
HOFFMANN MINERAL
OS206304, 168 h / 150 °C
INTRODUCTION
EXPERIMENTAL
RESULTS
Dyneon FC 2181Z
Barium Sulfate
SUMMARY
Δ Tensile Strength
Δ Elongation at Break
Property Change [%]
40
30
20
10
0
-10
-20
-30
-40
21
8
1
-1
-4
14
8
-15
-14
-3
Barium Sulfate
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 34

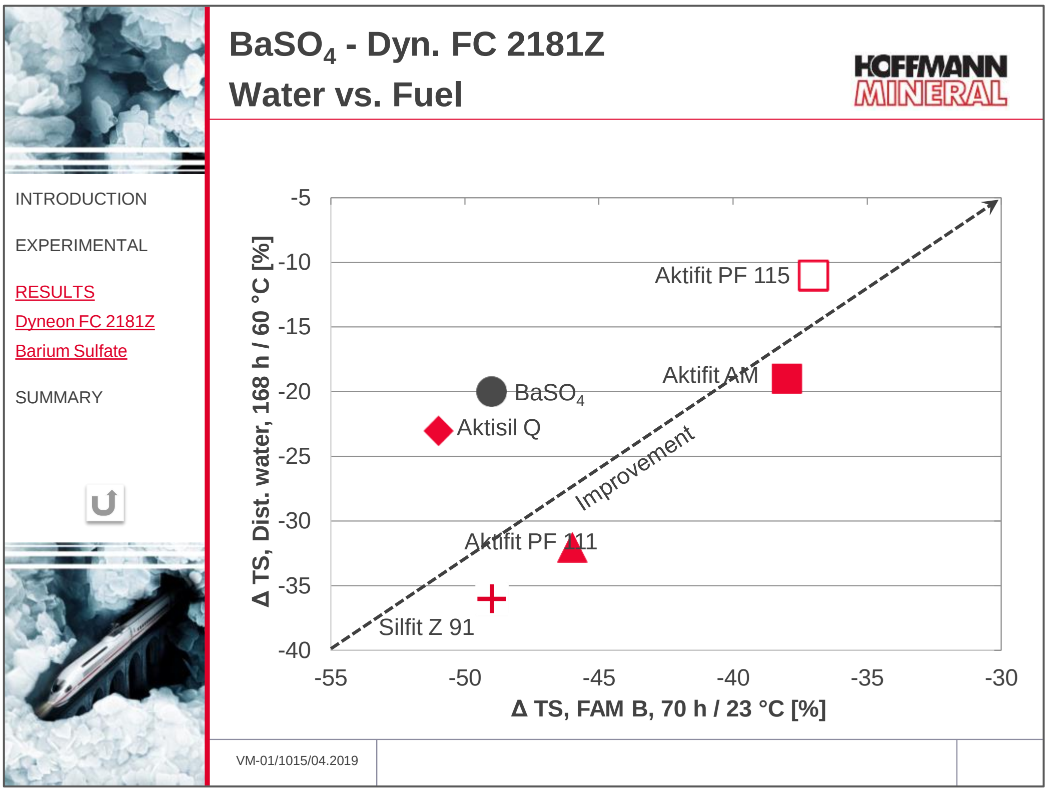
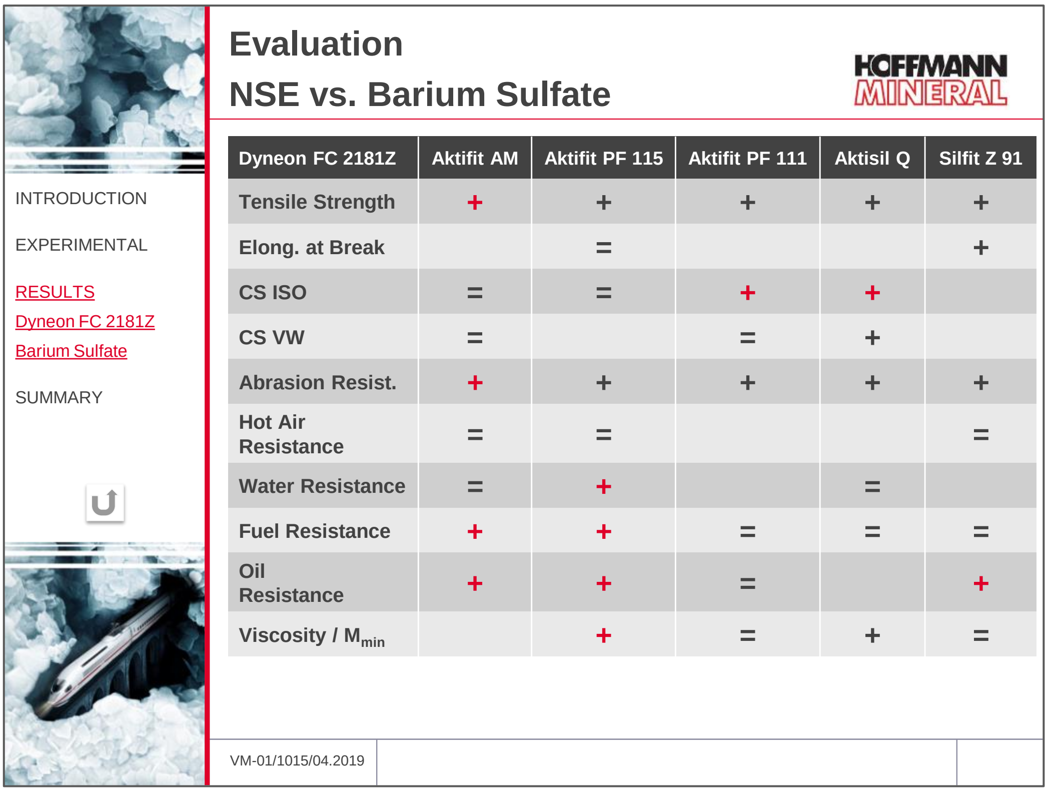

BaSO4 - Dyn. FC 2181Z
Water vs. Fuel
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Dyneon FC 2181Z
Barium Sulfate
SUMMARY
Δ TS, Dist. water, 168 h / 60 °C [%]
-5
-10
-15
-20
-25
-30
-35
-40
Aktifit PF 115
Aktifit AM
BaSO4
Aktisil Q
Improvement
Aktifit PF 111
Silfit Z 91
-55
-50
-45
-40
-35
-30
Δ TS, FAM B, 70 h / 23 °C [%]
VM-01/1015/04.2019

Fig. 35

3.4.3 Evaluation of the results

Various properties and property combinations, often even contradictory, are positively influenced by the NSE grades. This is clearly evident from the assessment survey.



Dyneon FC 2181Z	Aktifit AM	Aktifit PF 115	Aktifit PF 111	Aktisil Q	Silfit Z 91
Tensile Strength	+	+	+	+	+
Elong. at Break		=			+
CS ISO	=	=	+	+	
CS VW	=		=	+	
Abrasion Resist.	+	+	+	+	+
Hot Air Resistance	=	=			=
Water Resistance	=	+		=	
Fuel Resistance	+	+	=	=	=
Oil Resistance	+	+	=		+
Viscosity / M_{min}		+	=	+	=

Fig. 36

Fig. 36 indicates which NSE grade improves (+) a particular property in comparison with barium sulfate or comes out at an equal level (=). Red colored + signs call the attention to the product which gives rise to be the optimum improvement of the corresponding property among the NSE grades.

A viscosity level favorable for processing via injection molding is obtained with Aktifit PF 115 and Aktisil Q.

4 Results – Viton A-201C

4.1 Neuburg Siliceous Earth vs. N990

Filler loading:

Carbon black N990	30 phr
Neuburg Siliceous Earth	45 phr
Resulting hardness range	80 ± 5 Shore A

4.1.1 Mechanical properties

The tensile strength obtained with the carbon back can be outperformed with all tested surface treated Neuburg Siliceous Earth grades (Fig. 37). The highest tensile strength is offered by the special amino functional Aktifit PF 115. Silfit Z 91 comes out at a level comparable with N990.

Fig. 38 shows the compression set according to the ISO specification which when using Aktisil Q is comparable with N990. If the black is replaced by Silfit Z 91, the compression set is somewhat reduced which indicates a slight improvement.

Fig. 39 shows the compression set according to the VW specification; the results, compared with the carbon black, are already slightly reduced with the two amino functional NSE grades Aktifit AM and Aktifit PF 115. Aktifit PF 111, Aktisil Q and Silfit Z 91 impart a clear further improvement.

The last mentioned grade also gives rise to a higher elongation at break (Fig. 40) which is particularly interesting in view of the lower compression set.

Again, the very best products among the studied NSE grades for an increased abrasion resistance are the two amino functional grades Aktifit AM and Aktifit PF 115 (Fig. 41).

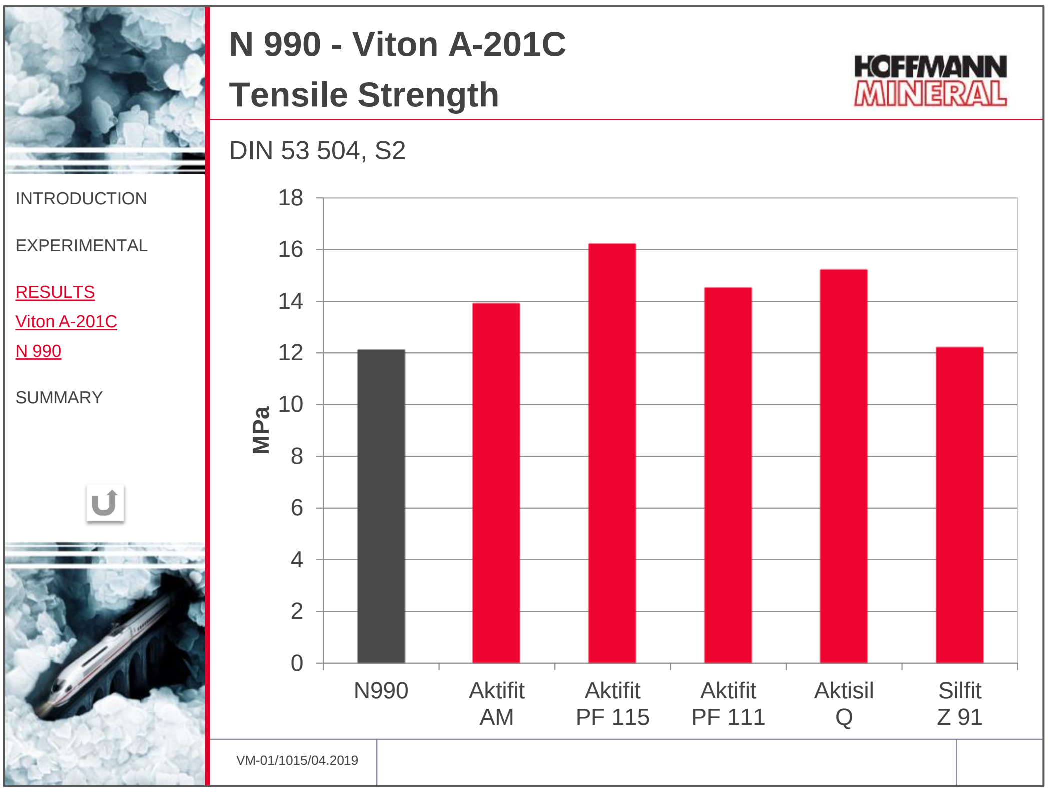


Fig. 37

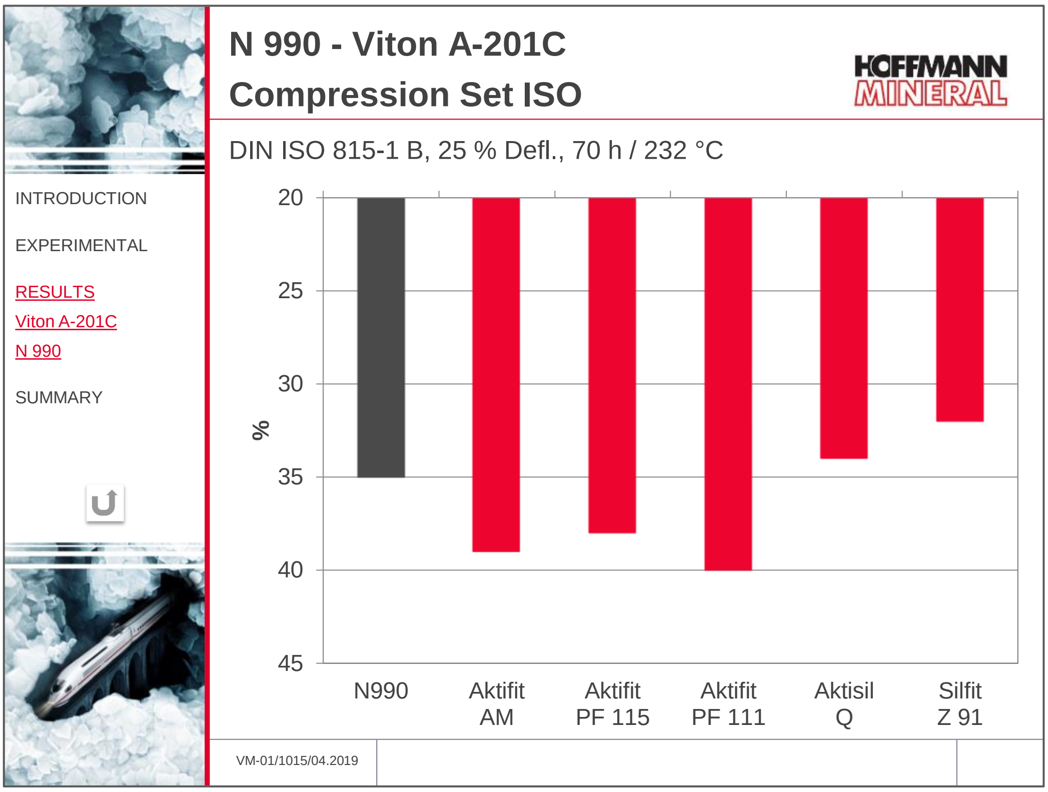

N 990 - Viton A-201C
Compression Set ISO
HOFFMANN MINERAL
DIN ISO 815-1 B, 25 % Defl., 70 h / 232 °C
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
N 990
SUMMARY
%
20
25
30
35
40
45
N990
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 38

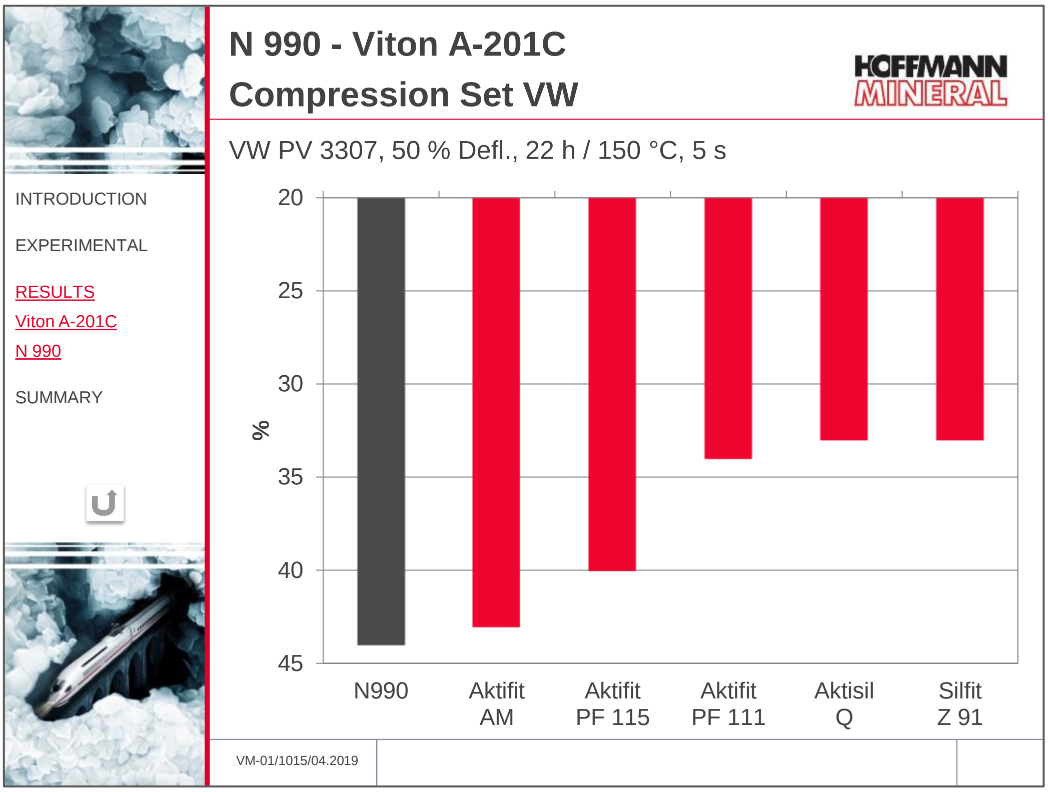

N 990 - Viton A-201C
Compression Set VW
HOFFMANN MINERAL
VW PV 3307, 50 % Defl., 22 h / 150 °C, 5 s
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
N 990
SUMMARY
%
20
25
30
35
40
45
N990
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 39

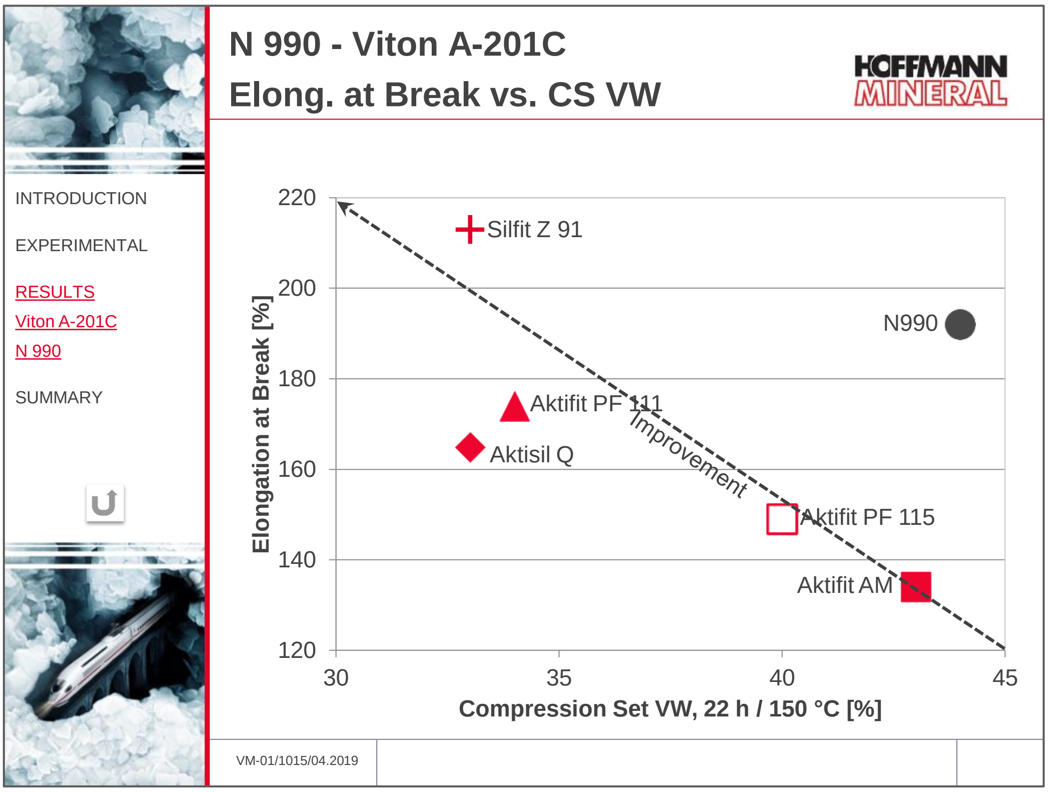

N 990 - Viton A-201C
Elong. at Break vs. CS VW
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
N 990
SUMMARY
Elongation at Break [%]
220
200
180
160
140
120
Silfit Z 91
N990
Aktifit PF 111
Aktisil Q
Improvement
Aktifit PF 115
Aktifit AM
30
35
40
45
Compression Set VW, 22 h / 150 °C [%]
VM-01/1015/04.2019

Fig. 40

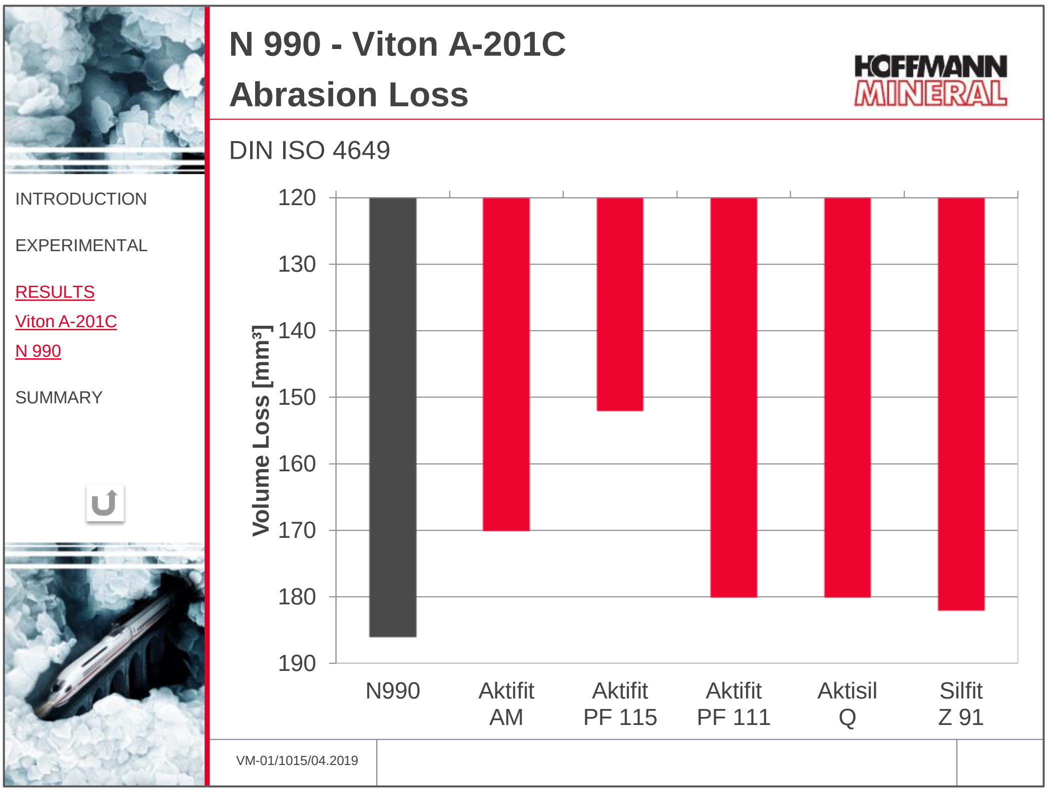

N 990 - Viton A-201C
Abrasion Loss
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
N 990
SUMMARY
DIN ISO 4649
Volume Loss [mm³]
120
130
140
150
160
170
180
190
N990
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 41

4.1.2 Media resistance

Compared to the carbon black, hot air and oil resistance can be improved with the NSE grades (Fig. 42).

By working with the amino functional variants Aktifit AM or Aktifit PF 115 the resistance of the cured compounds against water can be adjusted to a level comparable with N990.

Aktifit AM and Aktifit PF 115 in this polymer represent excellent alternatives for carbon black in all tested liquids, which is particularly evident for the improved oil resistance, as underlined in Fig. 43.

If with respect to fuel resistance with the change of tensile strength one regards the weight and volume changes (Fig. 44), the benefits of Aktifit AM and Aktifit PF 115 come out even more clearly. Aktifit PF 111 is another candidate which should be considered for improving fuel resistance over the level obtained with N990.

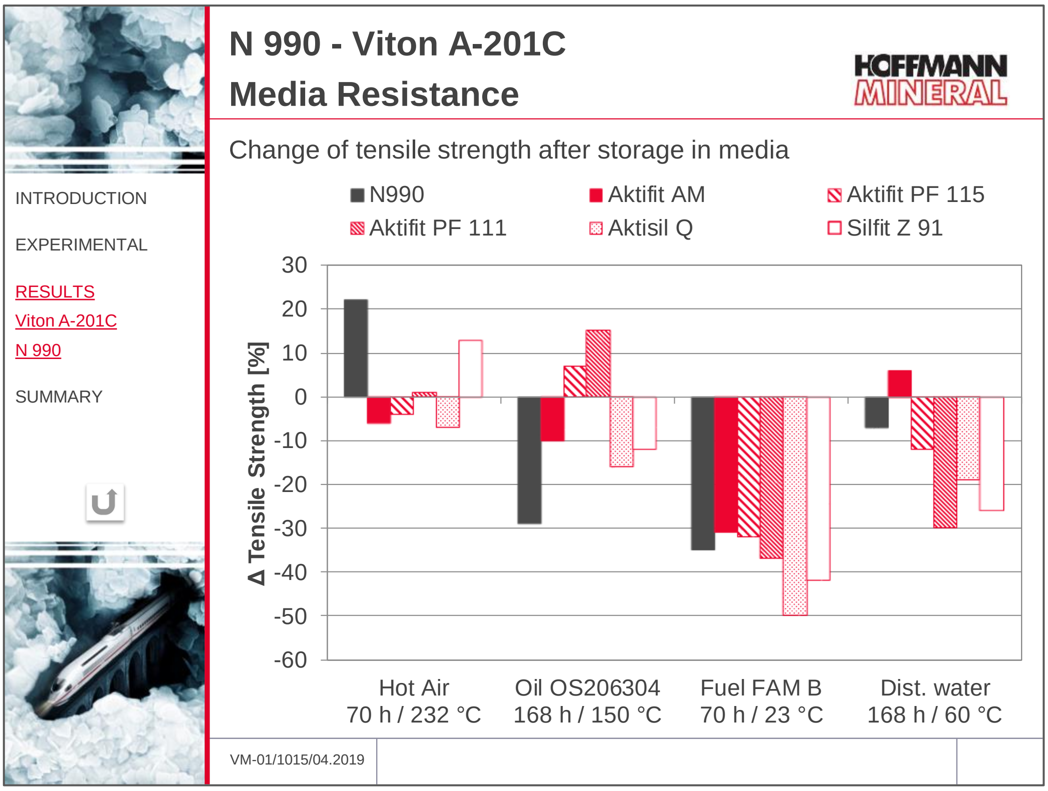


Fig. 42

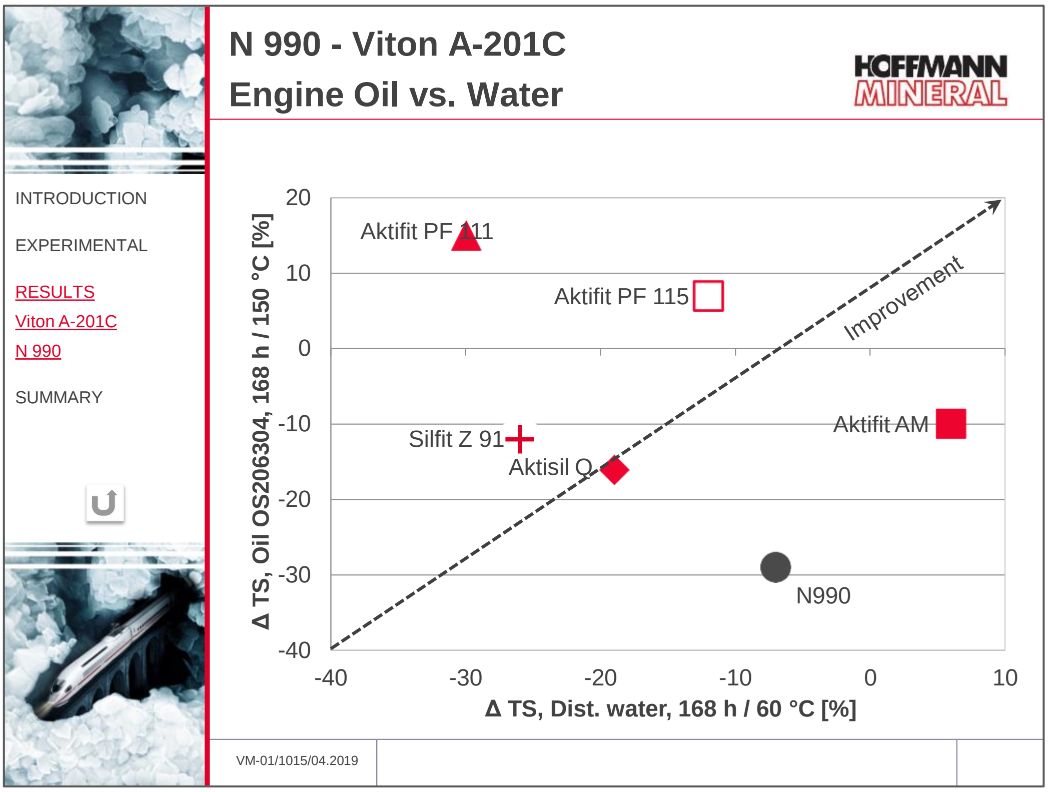

N 990 - Viton A-201C
Engine Oil vs. Water
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
N 990
SUMMARY
Aktifit PF 111
Aktifit PF 115
Improvement
Silfit Z 91
Aktisil Q
Aktifit AM
N990
Δ TS, Oil OS206304, 168 h / 150 °C [%]
Δ TS, Dist. water, 168 h / 60 °C [%]
20
10
0
-10
-20
-30
-40
-40
-30
-20
-10
0
10
VM-01/1015/04.2019

Fig. 43

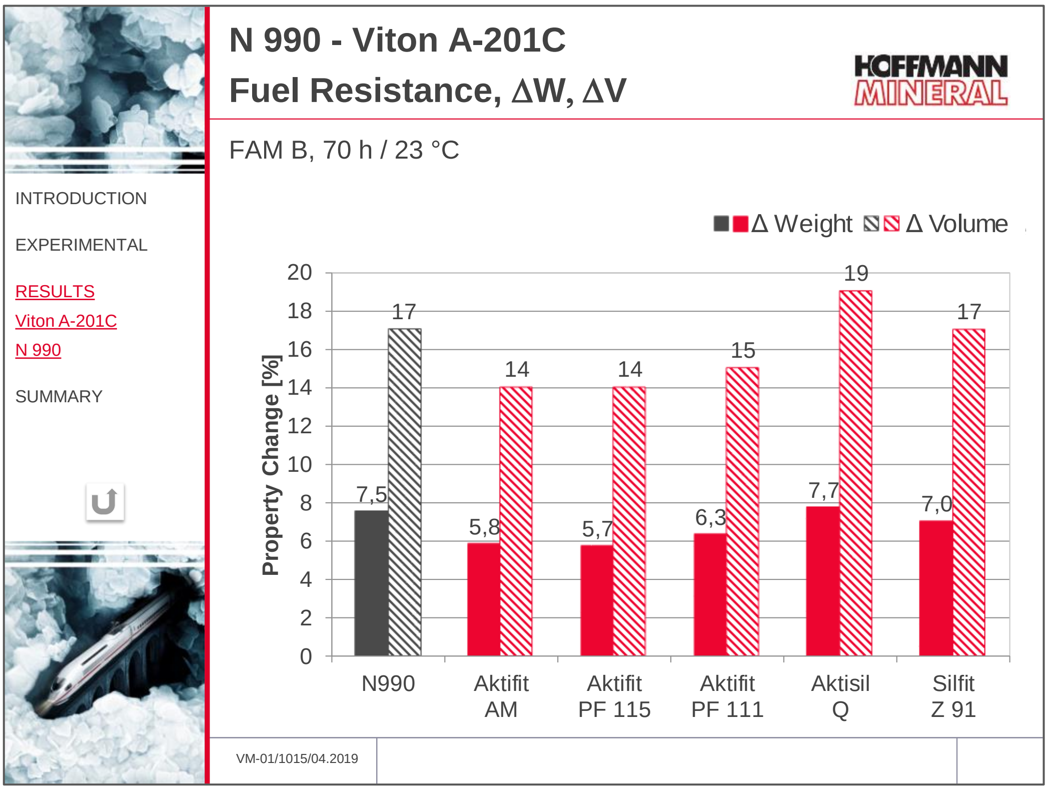
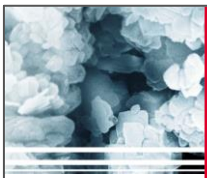

N 990 - Viton A-201C
Fuel Resistance, ΔW, ΔV
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
N 990
SUMMARY
FAM B, 70 h / 23 °C
Δ Weight
Δ Volume
Property Change [%]
20
18
16
14
12
10
8
6
4
2
0
7,5
17
5,8
14
5,7
14
6,3
15
7,7
19
7,0
17
N990
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 44

4.1.3 Evaluation of the results

Various properties and property combinations, sometimes even contradictory, are positively influenced by the NSE grades. This becomes very evident in the following assessment survey.



INTRODUCTION

EXPERIMENTAL

RESULTS
Viton A-201C
N 990

SUMMARY

Evaluation
NSE vs. N 990

HOFFMANN MINERAL

Viton A-201C	Aktifit AM	Aktifit PF 115	Aktifit PF 111	Aktisil Q	Silfit Z 91
Tensile Strength	+	**+**	+	+	=
Elong. at Break					**+**
CS ISO				=	**+**
CS VW	=	+	+	**+**	**+**
Abrasion Resist.	+	**+**	=	=	=
Hot Air Resistance	+	+	+	+	+
Water Resistance	=	=			
Fuel Resistance	**+**	**+**	+		
Oil Resistance	+	**+**	**+**	+	+
Cure Speed	**+**	+			

VM-01/1015/04.2019

Fig. 45

Fig. 45 shows which NSE grade improves (+) a property obtained with N990 or comes out at an equal level (=). Red colored + signs point to product which among the NSE grades lead to the best level of the corresponding property.

The two amino functional NSE grades Aktifit AM and Aktifit PF 115 are distinguished by an accelerating effect on the cure of the compounds compared with the carbon black.

4.2 Neuburg Siliceous Earth vs. Wollastonite AST

Filler loading:

Wollastonite AST	45 phr
Neuburg Siliceous Earth	30 phr

Resulting hardness range 70 ± 5 Shore A

4.2.1 Mechanical properties

Silfit Z 91, Aktifit PF 111 and Aktisil Q do not allow to maintain the tensile strength obtained with the amino silane treated wollastonite (Fig. 46). The two amino functional NSE grades Aktifit AM and Aktifit PF 115, by contrast, almost reach the level of the wollastonite.

All NSE grades improve the elongation at break compared with the amino silane treated wollastonite (Fig. 47). The best result is obtained with Silfit Z 91 which also offers the best compression set in the ISO test (Fig. 48).

If the focus is directed towards the VW PV 3307, the use of Aktisil Q is recommended which here draws level with the amino silane treated wollastonite (Fig. 49) but also impresses with a higher elongation at break.

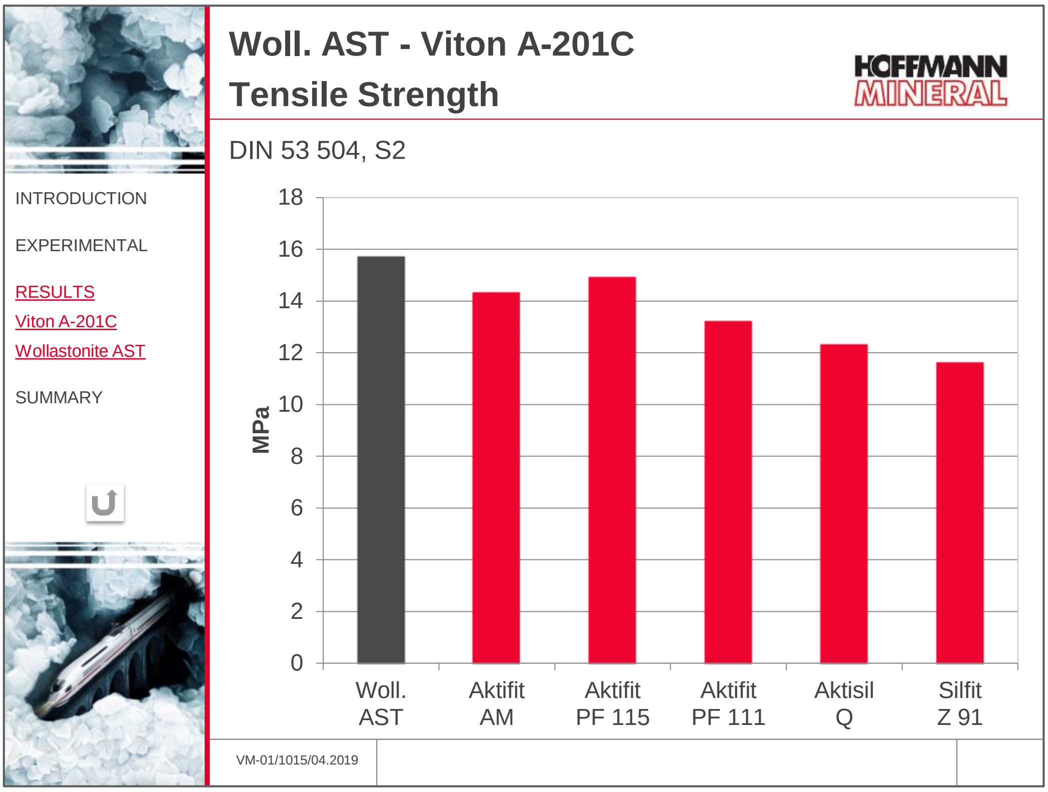


Fig. 46

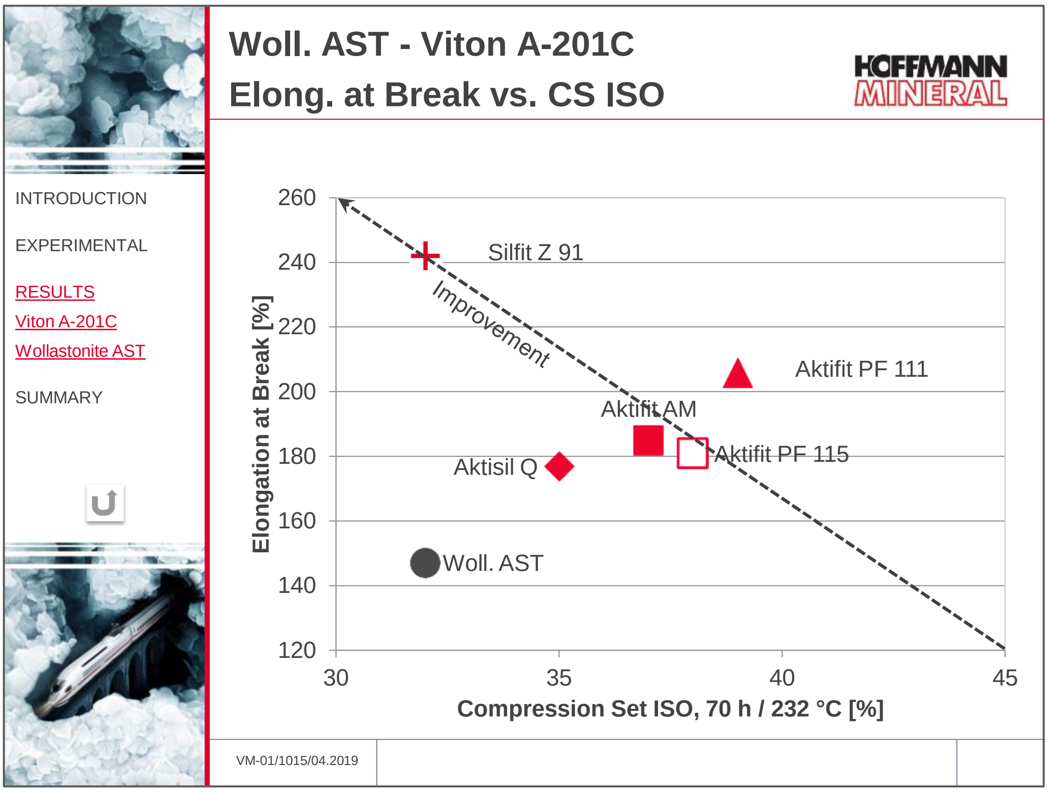

Woll. AST - Viton A-201C
Elong. at Break vs. CS ISO
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Wollastonite AST
SUMMARY
Elongation at Break [%]
260
240
220
200
180
160
140
120
30
35
40
45
Compression Set ISO, 70 h / 232 °C [%]
Silfit Z 91
Improvement
Aktifit PF 111
Aktifit AM
Aktifit PF 115
Aktisil Q
Woll. AST
VM-01/1015/04.2019

Fig. 47

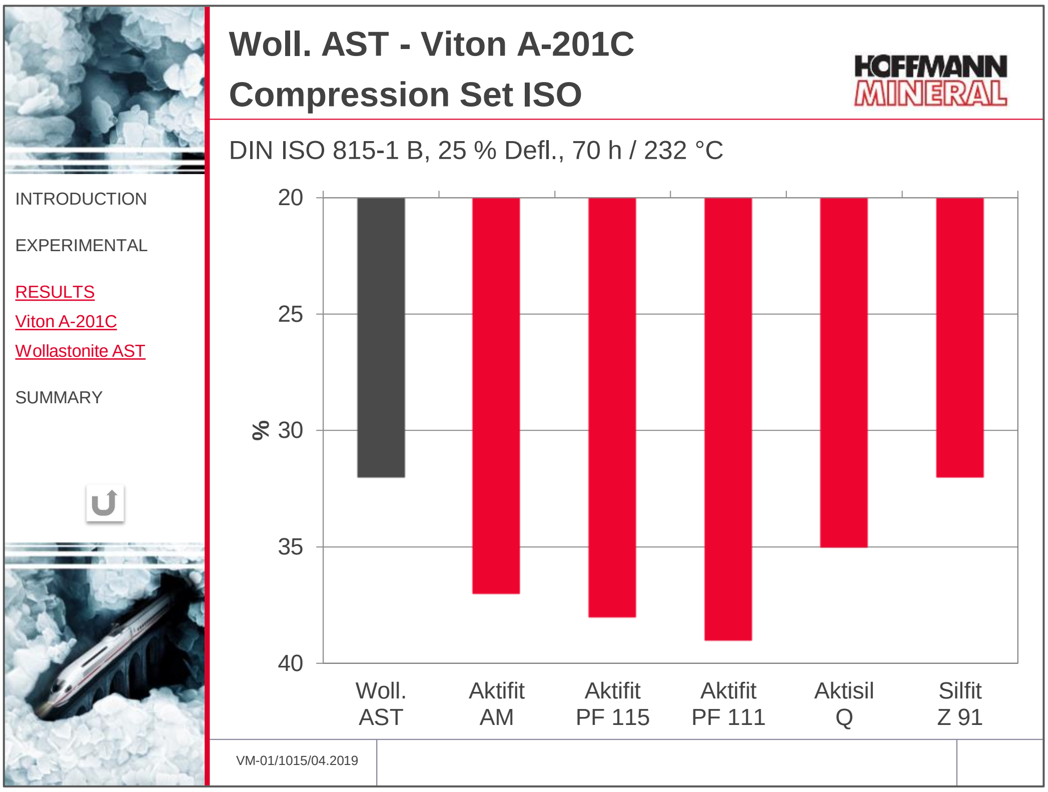

Woll. AST - Viton A-201C
Compression Set ISO
HOFFMANN MINERAL
DIN ISO 815-1 B, 25 % Defl., 70 h / 232 °C
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Wollastonite AST
SUMMARY
%
20
25
30
35
40
Woll. AST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 48

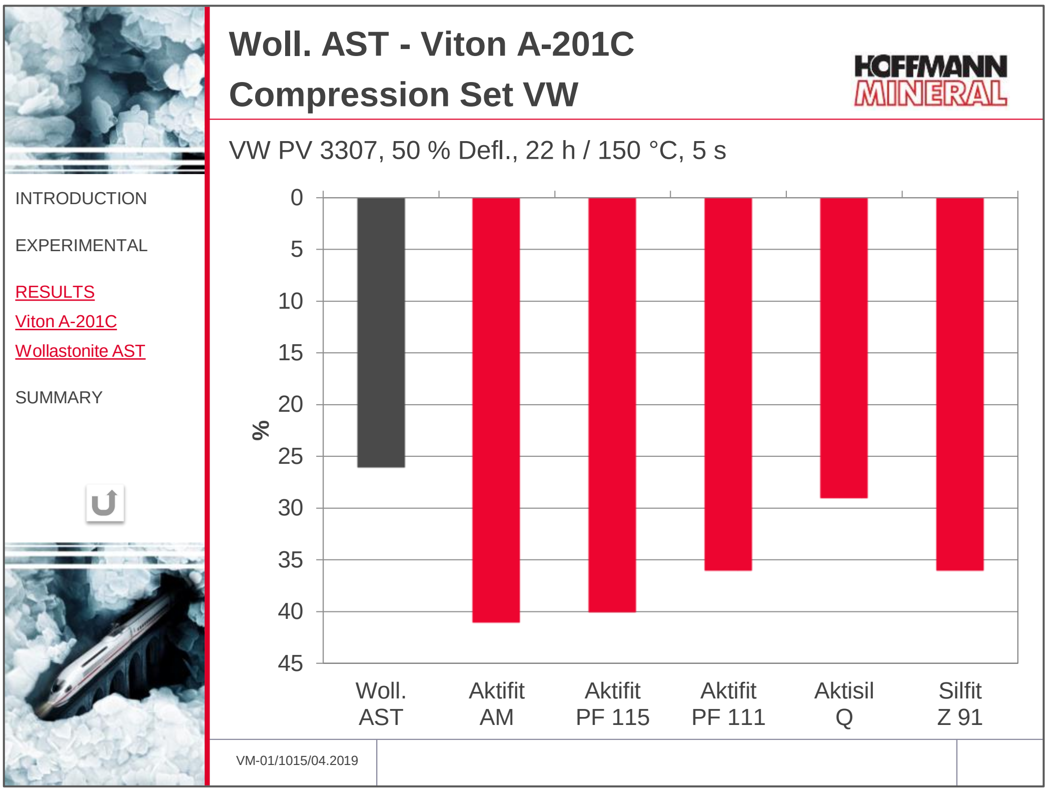

Woll. AST - Viton A-201C
Compression Set VW
HOFFMANN MINERAL
VW PV 3307, 50 % Defl., 22 h / 150 °C, 5 s
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Wollastonite AST
SUMMARY
%
0
5
10
15
20
25
30
35
40
45
Woll. AST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 49

4.2.2 Media resistance

The choice of the filler does not exert a significant influence on the resistance against hot air (Fig. 50).

Aktifit AM offers a combination of improved resistance against fuel and water compared with the amino silane treated wollastonite but does not quite come up to its level of oil resistance.

Aktifit PF 115 which has been treated with a special amino functional group is able to combine a fuel resistance comparable with the wollastonite along with increased water and oil resistance, and therefore offers a very well balanced property profile (Fig. 51).

As a positive effect of Aktisil Q, the oil resistance comparable with the wollastonite goes along with an improved water resistance.

Silfit Z 91 as well as Aktifit PF 111 lead to compounds which have a fuel and water resistance comparable with the amino silane treated wollastonite.

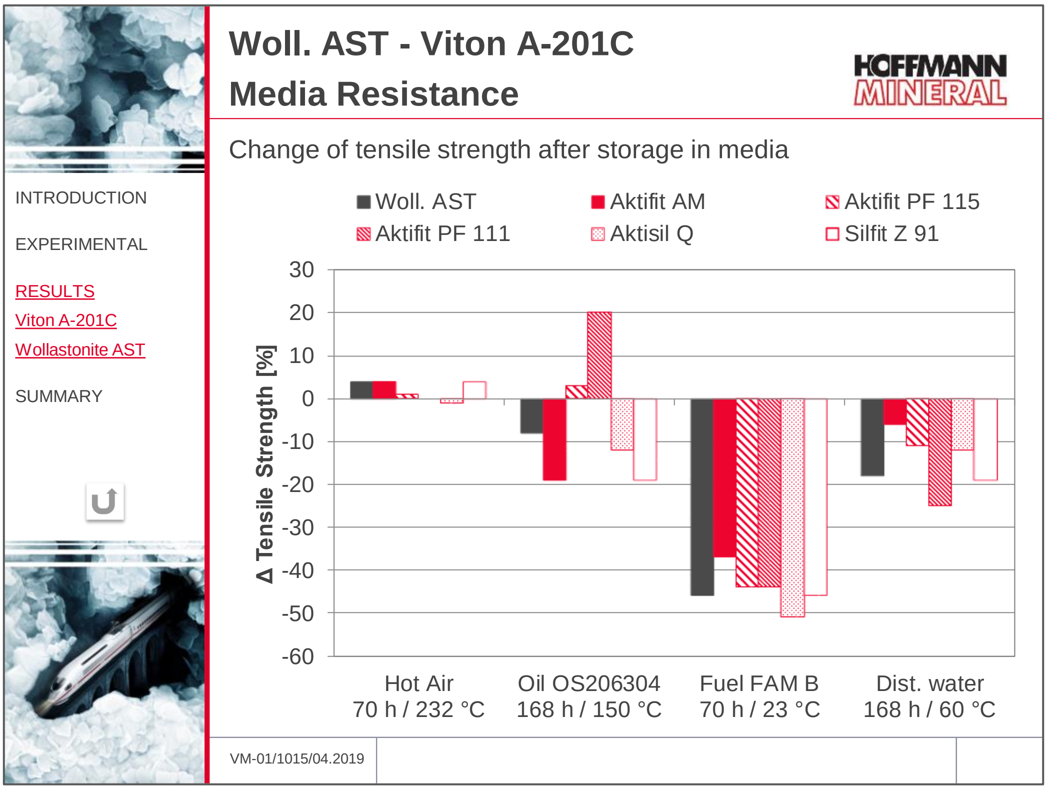


Fig. 50

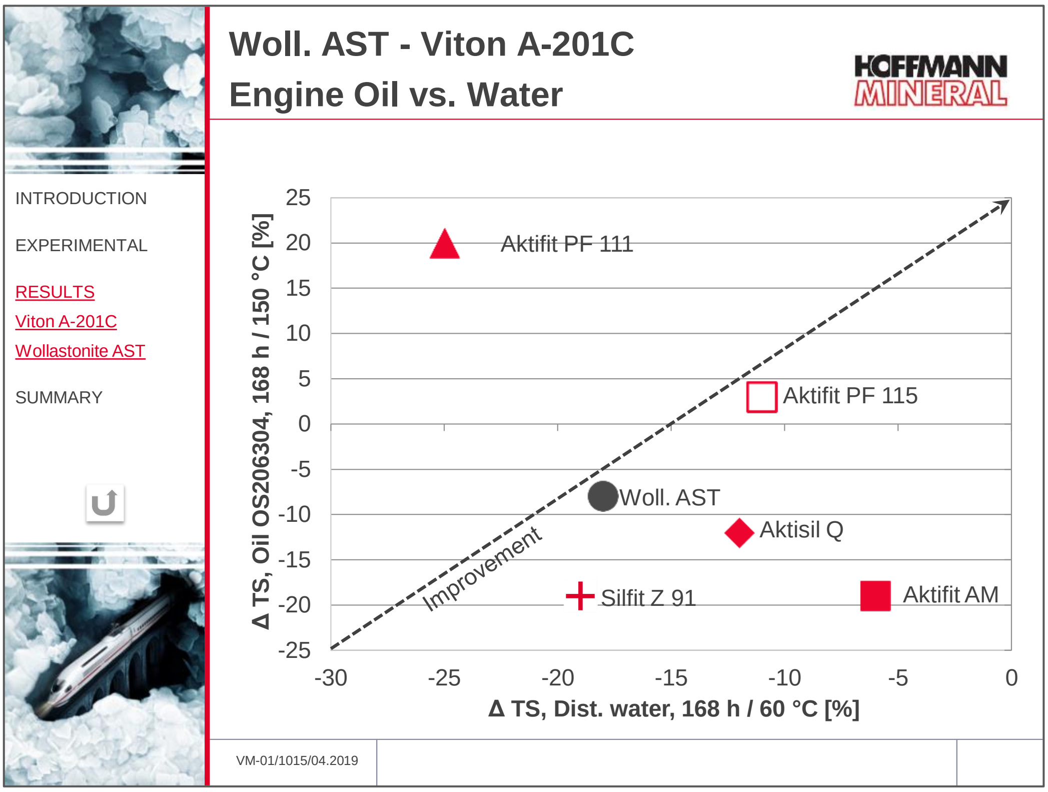
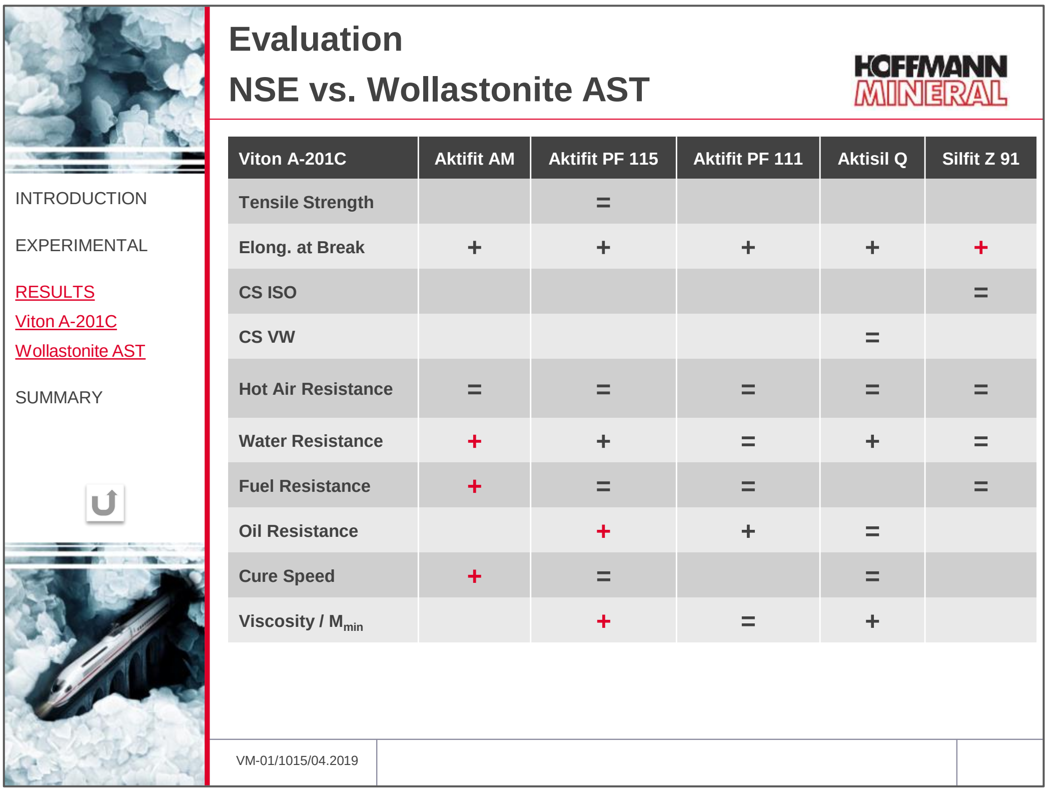

Woll. AST - Viton A-201C
Engine Oil vs. Water
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Wollastonite AST
SUMMARY
Aktifit PF 111
Aktifit PF 115
Woll. AST
Aktisil Q
Silfit Z 91
Aktifit AM
Improvement
Δ TS, Oil OS206304, 168 h / 150 °C [%]
Δ TS, Dist. water, 168 h / 60 °C [%]
VM-01/1015/04.2019

Fig. 51

4.2.3 Evaluation of the results

Various properties and property combinations, often also of a contradictory nature, are positively influenced by the NSE grades. This is clearly shown in the following assessment survey.



Viton A-201C	Aktifit AM	Aktifit PF 115	Aktifit PF 111	Aktisil Q	Silfit Z 91
Tensile Strength		=			
Elong. at Break	+	+	+	+	+
CS ISO					=
CS VW				=	
Hot Air Resistance	=	=	=	=	=
Water Resistance	+	+	=	+	=
Fuel Resistance	+	=	=		=
Oil Resistance		+	+	=	
Cure Speed	+	=		=	
Viscosity / M_{min}		+	=	+	

Fig. 52

Fig. 52 shows which NSE grade in comparison with the amino silane treated wollastonite improves a particular property (+) or comes out on an equal level (=). The red colored + signs point out that this product gives rise to the best results for the corresponding property amongt the NSE grades.

Aktifit AM is able to accelerate the cure of the compound compared with the wollastonite. Aktifit PF 115 and Aktisil Q give rise to a comparable cure rate and at the same time to a viscosity favorable for injection molding processing.

4.3 Neuburg Siliceous Earth vs. Wollastonite EST

Filler loading:

Wollastonite EST	45 phr
Neuburg Siliceous Earth	30 phr

Resulting hardness range 70 ± 5 Shore A

4.3.1 Mechanical properties

The amino functional modified Calcined Neuburg Siliceous Earth Aktifit PF 115 is able to reach the same tensile strength as obtained with the epoxy silane treated wollastonite (Fig. 53).

All NSE grades outperform the elongation at break obtained with the epoxy silane treated wollastonite (Fig. 54). As shown in Fig. 55, this marked increase goes along with just a small reduction of the tensile strength.

Two NSE grades, namely Aktisil Q and Silfit Z 91, are able to reduce the ISO compression set as obtained with the epoxy silane treated wollastonite (Fig. 56). Especially Silfit Z 91 at the same time gives rise to an increased elongation at break.

If the compression set level obtained with the wollastonite is sufficient and the elongation at break should be increased, Aktifit PF 111 here comes out very favorably with an increase of more than 50 % (absolutely).

Abrasion resistance (Fig. 57) vs. the epoxy silane treated wollastonite is hardly changed when working with Aktifit AM or Aktifit PF 115, while the other NSE grades do not quite arrive at the same level.

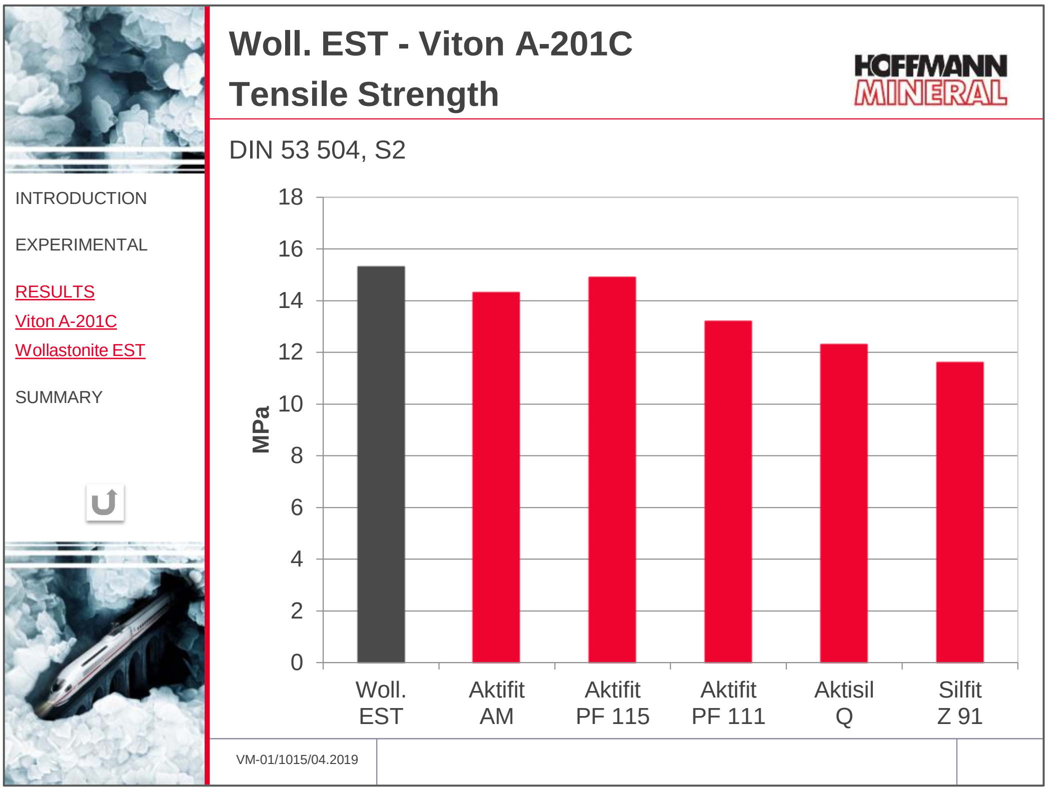


Fig. 53

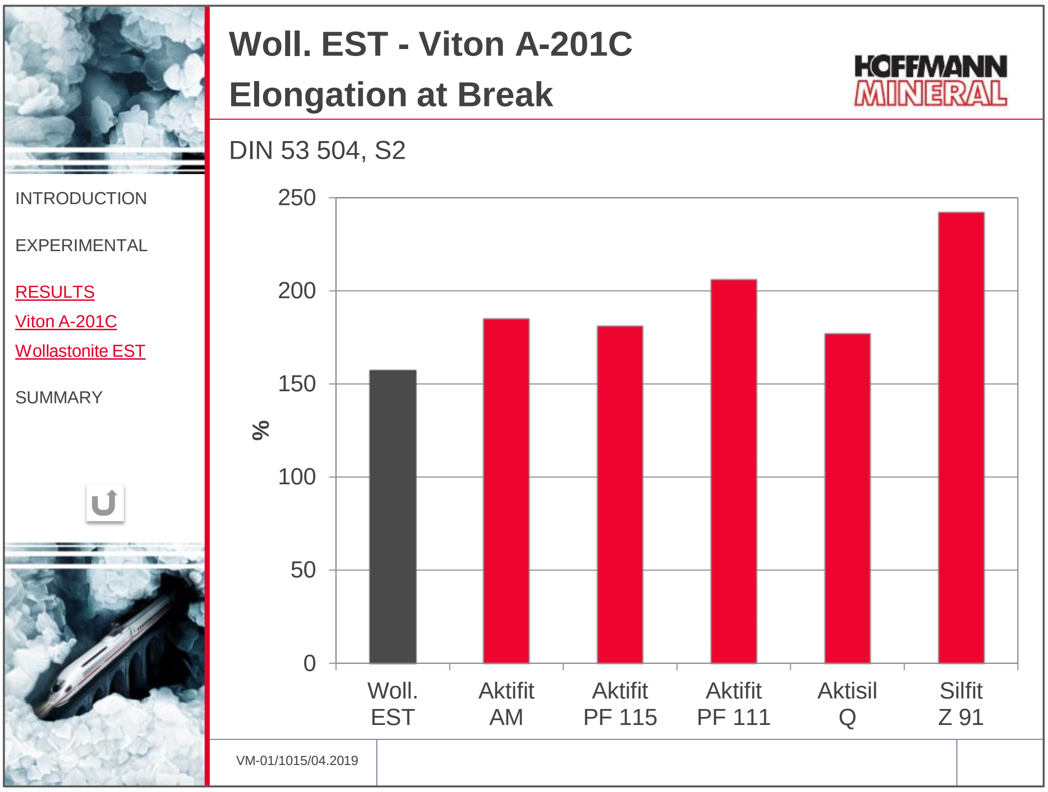

Woll. EST - Viton A-201C
Elongation at Break
HOFFMANN MINERAL
DIN 53 504, S2
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Wollastonite EST
SUMMARY
%
250
200
150
100
50
0
Woll. EST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 54

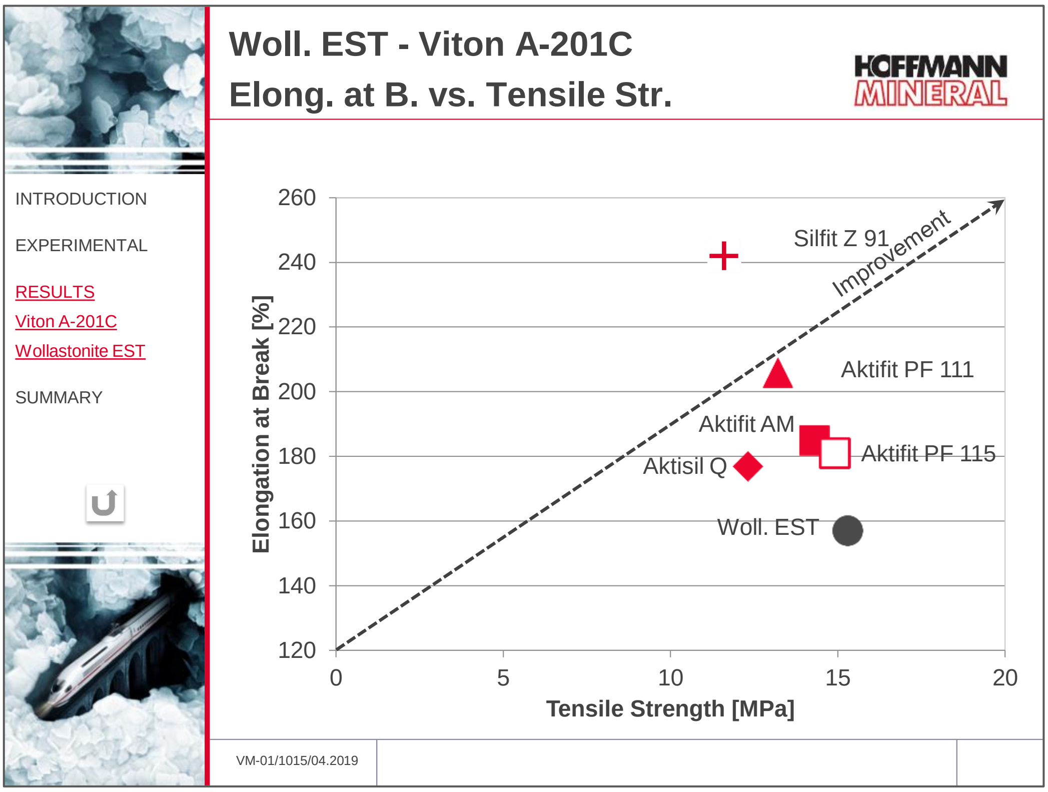
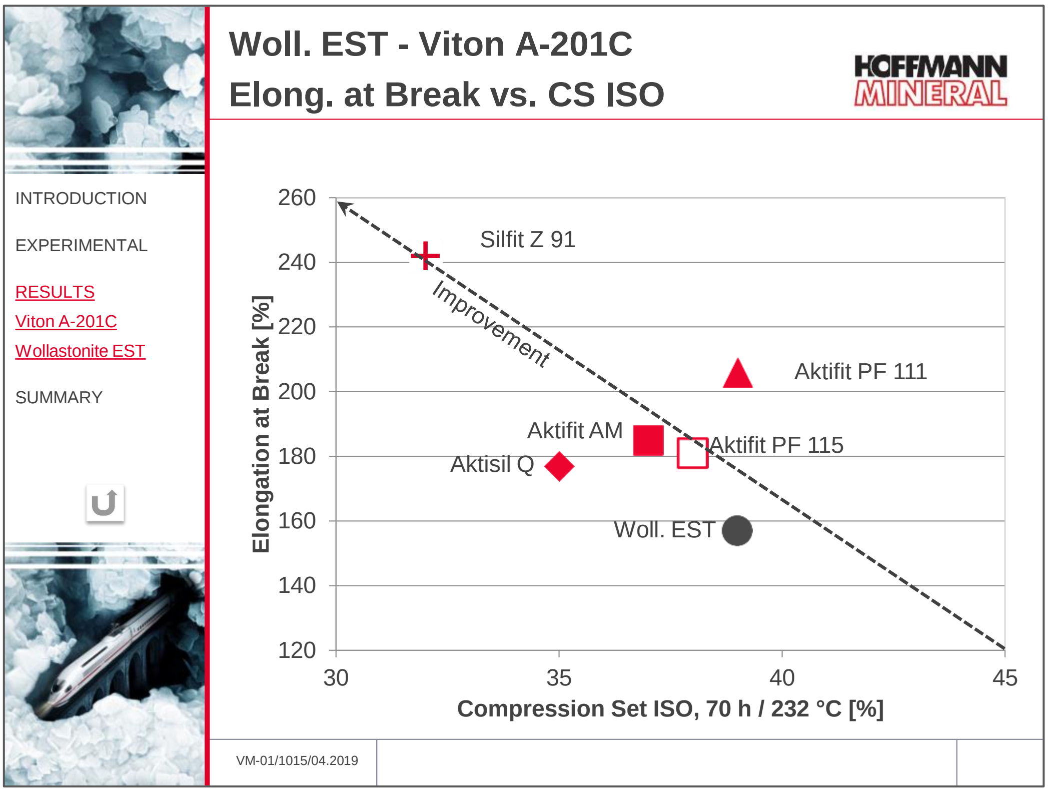
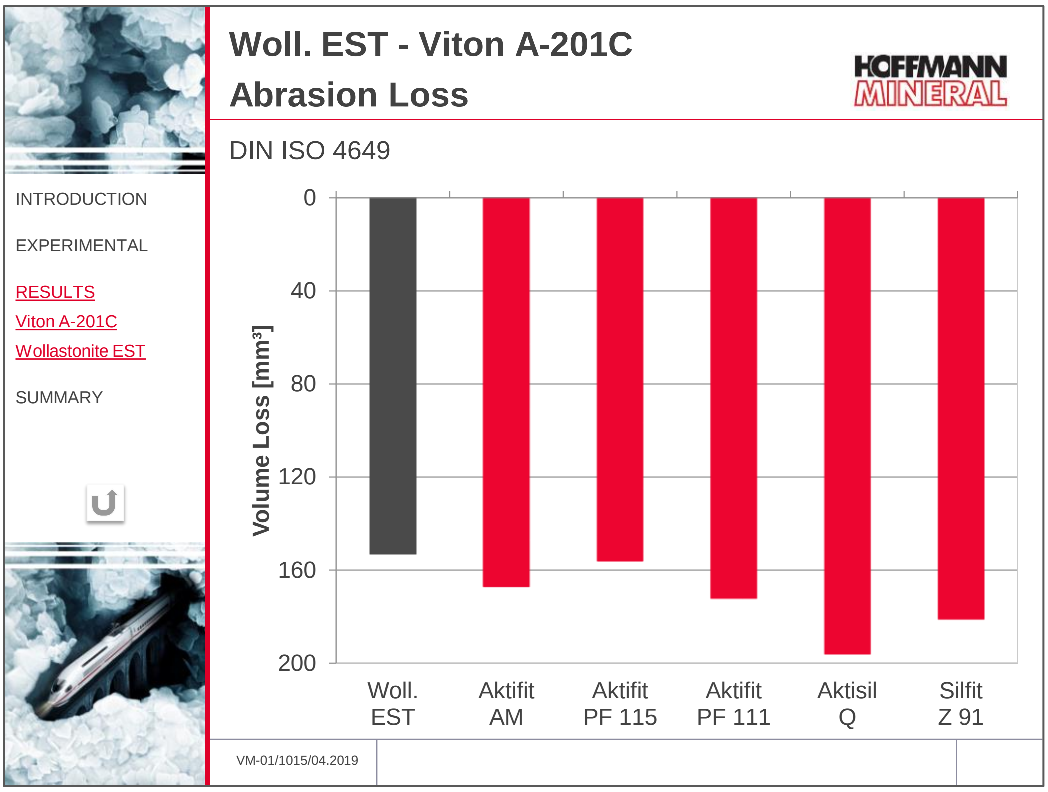

Woll. EST - Viton A-201C
Elong. at B. vs. Tensile Str.
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Wollastonite EST
SUMMARY
Elongation at Break [%]
260
240
220
200
180
160
140
120
Silfit Z 91
Improvement
Aktifit PF 111
Aktifit AM
Aktifit PF 115
Aktisil Q
Woll. EST
0
5
10
15
20
Tensile Strength [MPa]
VM-01/1015/04.2019

Fig. 55



Woll. EST - Viton A-201C
Elong. at Break vs. CS ISO
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Wollastonite EST
SUMMARY
Elongation at Break [%]
260
240
220
200
180
160
140
120
30
35
40
45
Compression Set ISO, 70 h / 232 °C [%]
Silfit Z 91
Improvement
Aktifit PF 111
Aktifit AM
Aktifit PF 115
Aktisil Q
Woll. EST
VM-01/1015/04.2019

Fig. 56



Woll. EST - Viton A-201C
Abrasion Loss
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Wollastonite EST
SUMMARY
DIN ISO 4649
Volume Loss [mm³]
0
40
80
120
160
200
Woll. EST
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 57

4.3.2 Media resistance

With respect to the hot air resistance, the NSE grades offer a slight advantage compared to the epoxy silane treated wollastonite (Fig. 58).

Worth noting is the fact that Aktifit PF 115 treated with a special amino functional group, in all tested media gives rise to improved properties, mostly shown in the resistance against fuels and water (Fig. 60) without any detriments in the oil resistance (Fig. 59).

All NSE grades are able to improve the fuel and water resistance in comparison with the wollastonite, in particular Aktifit AM (Fig. 60).

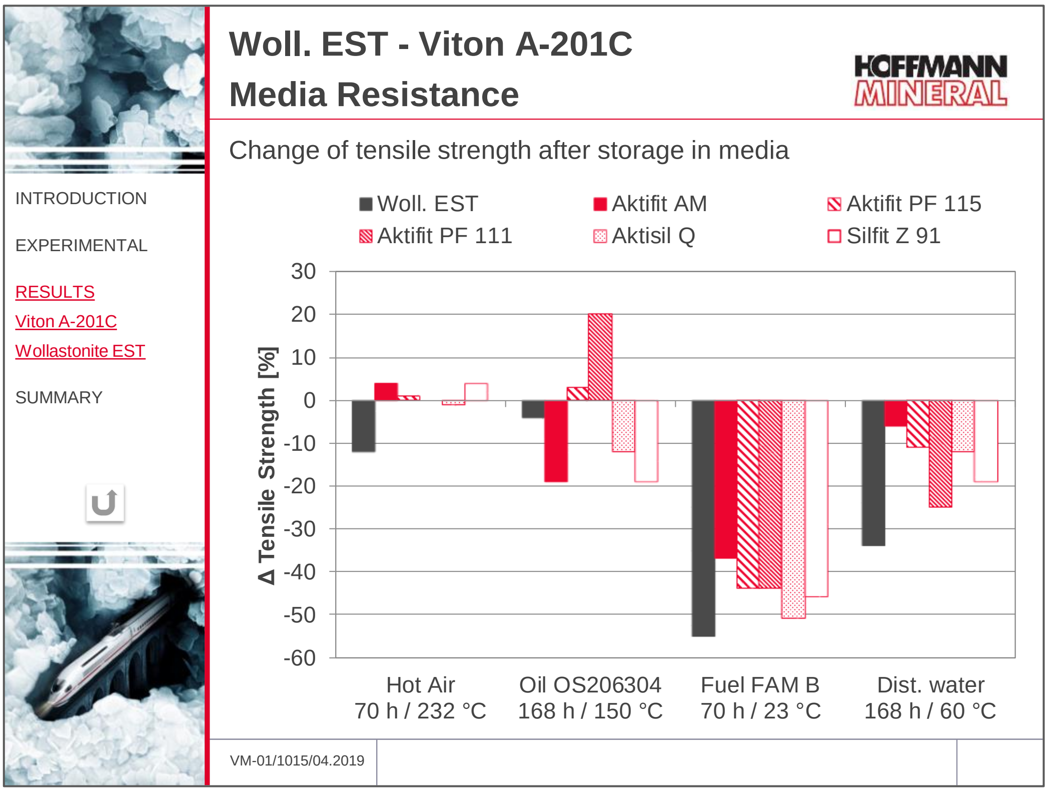


Fig. 58

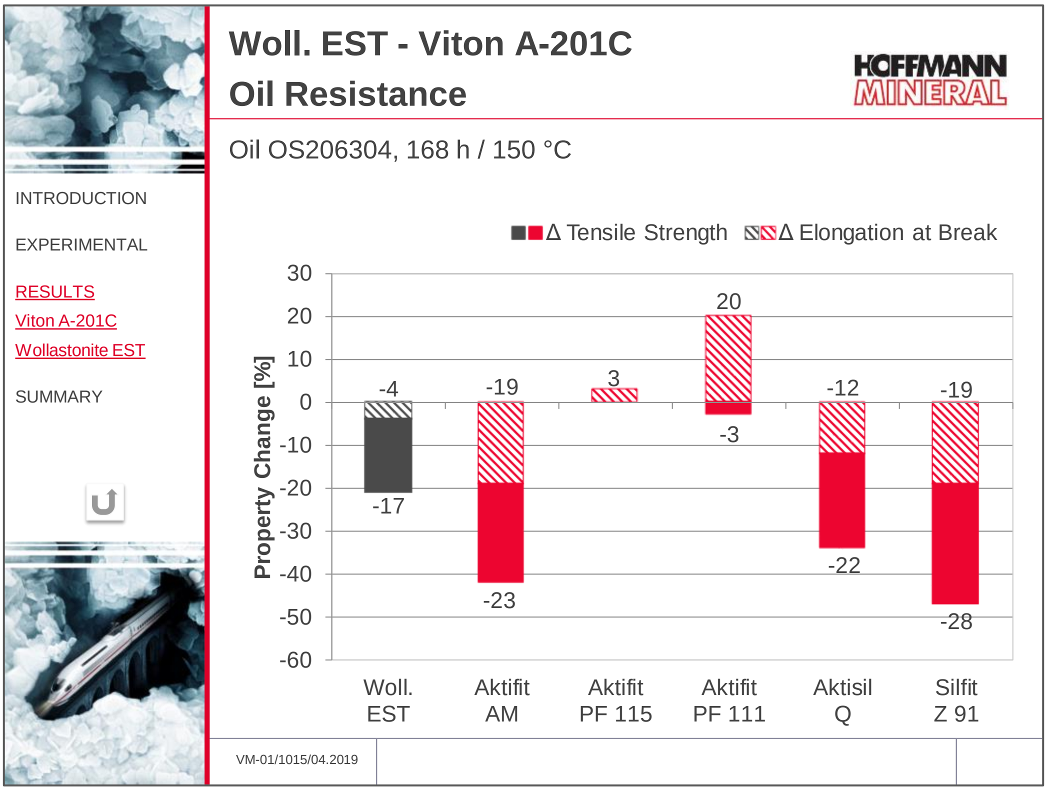


Fig. 59

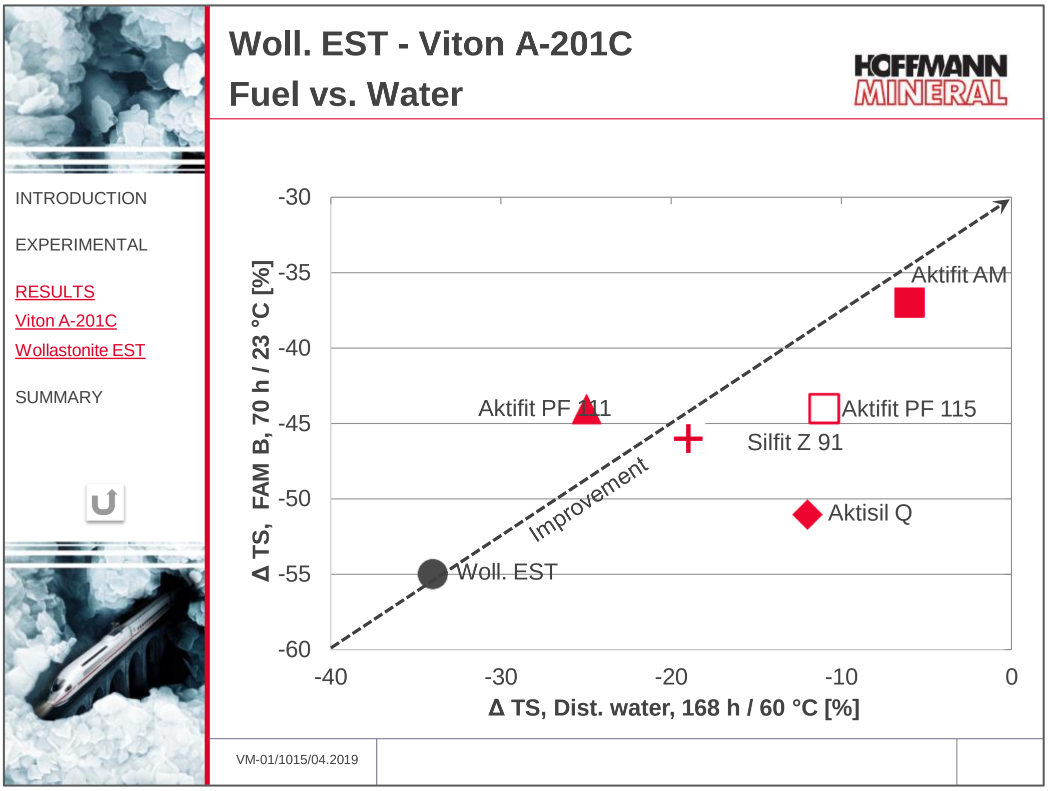
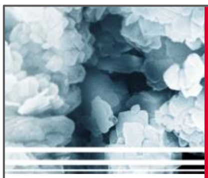

Woll. EST - Viton A-201C
Fuel vs. Water
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Wollastonite EST
SUMMARY
Δ TS, FAM B, 70 h / 23 °C [%]
-30
-35
-40
-45
-50
-55
-60
-40
-30
-20
-10
0
Δ TS, Dist. water, 168 h / 60 °C [%]
Aktifit AM
Aktifit PF 111
Aktifit PF 115
Silfit Z 91
Aktisil Q
Woll. EST
Improvement
VM-01/1015/04.2019

Fig. 60

4.3.3 Evaluation of the results

Various properties and property combinations, often even of contradictory nature, are positively influenced by the NSE grades. This is very evident from the following assessment survey.



INTRODUCTION

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RESULTS
Viton A-201C
Wollastonite EST

SUMMARY

Evaluation
NSE vs. Wollastonite EST

HOFFMANN MINERAL

Viton A-201C	Aktifit AM	Aktifit PF 115	Aktifit PF 111	Aktisil Q	Silfit Z 91
Tensile Strength		=			
Elong. at Break	+	+	+	+	+
CS ISO	=	=	=	+	+
Abrasion Resist.		=			
Hot Air Resistance	+	+	+	+	+
Water Resistance	+	+	+	+	+
Fuel Resistance	+	+	+	=	+
Oil Resistance		+	=		
Cure Speed	+				
Viscosity / M_{min}	=	+	=	+	=

VM-01/1015/04.2019

Fig. 61

Fig. 61 indicates which NSE grade, compared with the epoxy silane treated wollastonite, improves a particular property (+) or imparts a comparable level (=). Red colored + signs point out that this product among the NSE grades gives the very best result for the corresponding property.

At comparable viscosity, Aktifit AM accelerates the cure of the compounds. With Aktifit PF 115 and Aktisil Q viscosity comes out more favorable for injection molding processing than with the wollastonite.

4.4 Neuburg Silicoeus Earth vs. Barium Sulfate

Filler loading:

Barium sulfate (precipitated)	74 phr
Neuburg Siliceous Earth	30 phr

Resulting hardness range 70 ± 5 Shore A

4.4.1 Mechanical properties

All tested NSE grades give rise to a markedly higher tensile strength than the barium sulfate (Fig. 62). The highest level will be obtained with the two amino functional grades.

The high level of elongation at break achieved with the barium sulfate cannot be attained with the surface modified NSE grades (Fig. 63). Silfit Z 91, however, comes very close to the level of the barium sulfate.

As shown in Fig. 63 and Fig. 64, barium sulfate causes a high abrasion loss which can be markedly reduced, i.e. improved with the NSE grades.

Silfit Z 91 allows to somewhat reduce the compression set at 232 °C (Fig. 65), and even more when testing at 200 °C (Fig. 66).

Aktisil Q comes out with a compression set comparable with barium sulfate and at 200 °C even gives rise to a slight reduction.

The other NSE grades at 232 °C finish with slightly higher compression set results but come out slightly lower when testing at 200 °C. Overall, however, the differences here are not very pronounced.

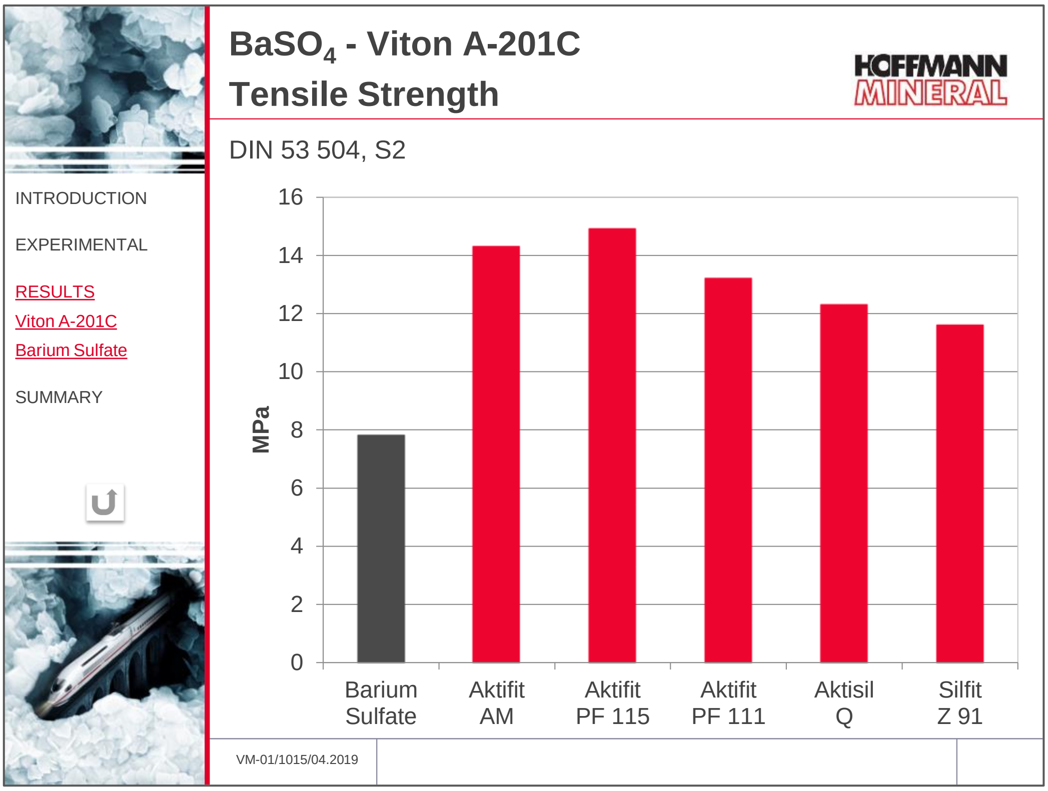


Fig. 62

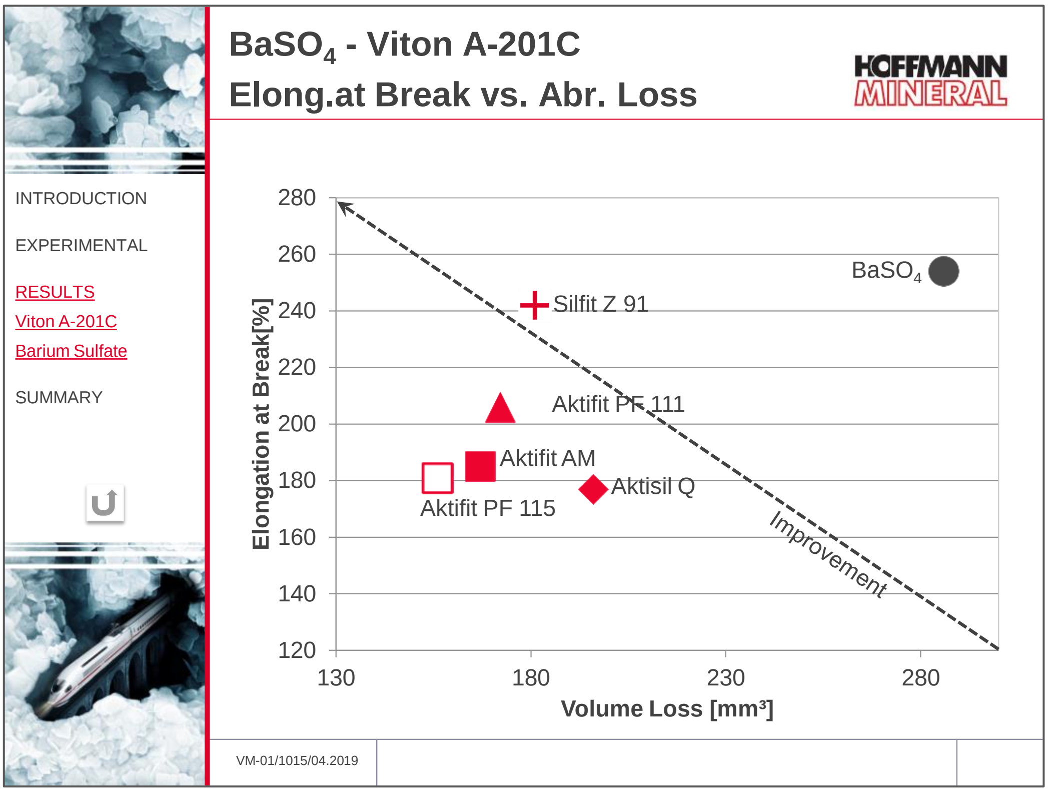

BaSO4 - Viton A-201C
Elong.at Break vs. Abr. Loss
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Barium Sulfate
SUMMARY
Elongation at Break[%]
280
260
240
220
200
180
160
140
120
130
180
230
280
Volume Loss [mm³]
BaSO4
Silfit Z 91
Aktifit PF 111
Aktifit AM
Aktisil Q
Aktifit PF 115
Improvement
VM-01/1015/04.2019

Fig. 63

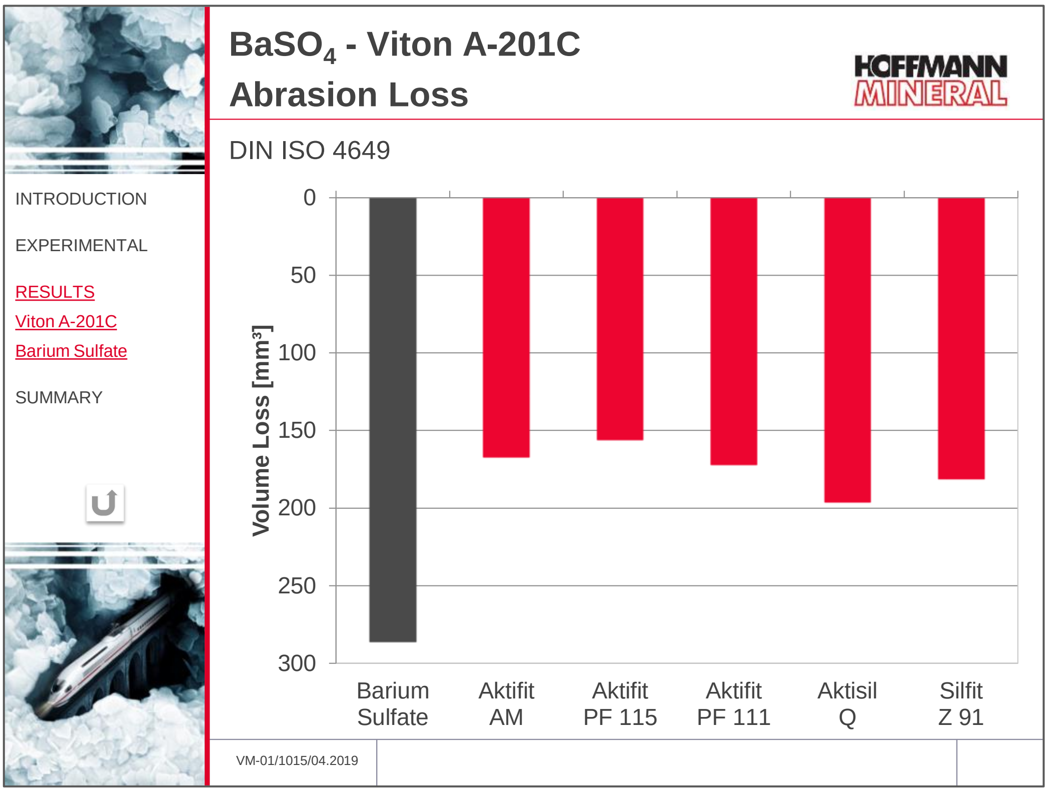

BaSO4 - Viton A-201C
Abrasion Loss
HOFFMANN MINERAL
DIN ISO 4649
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Barium Sulfate
SUMMARY
Volume Loss [mm³]
0
50
100
150
200
250
300
Barium Sulfate
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 64

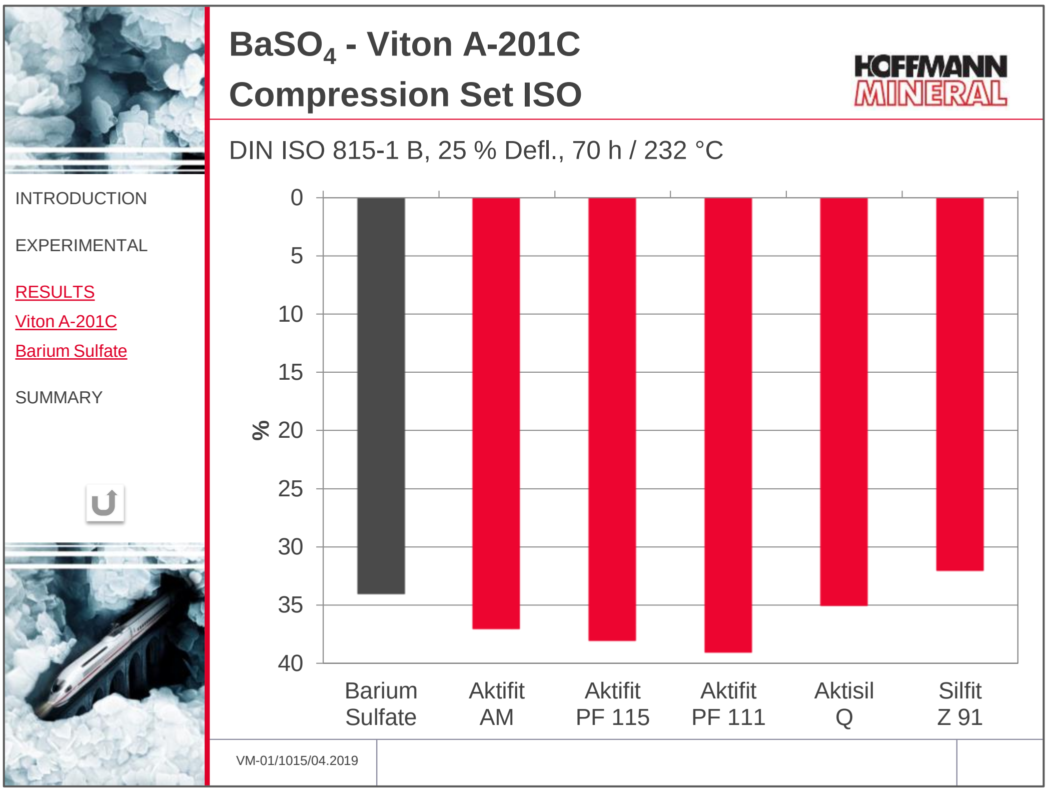

BaSO4 - Viton A-201C
Compression Set ISO
HOFFMANN MINERAL
DIN ISO 815-1 B, 25 % Defl., 70 h / 232 °C
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Barium Sulfate
SUMMARY
%
0
5
10
15
20
25
30
35
40
Barium Sulfate
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 65

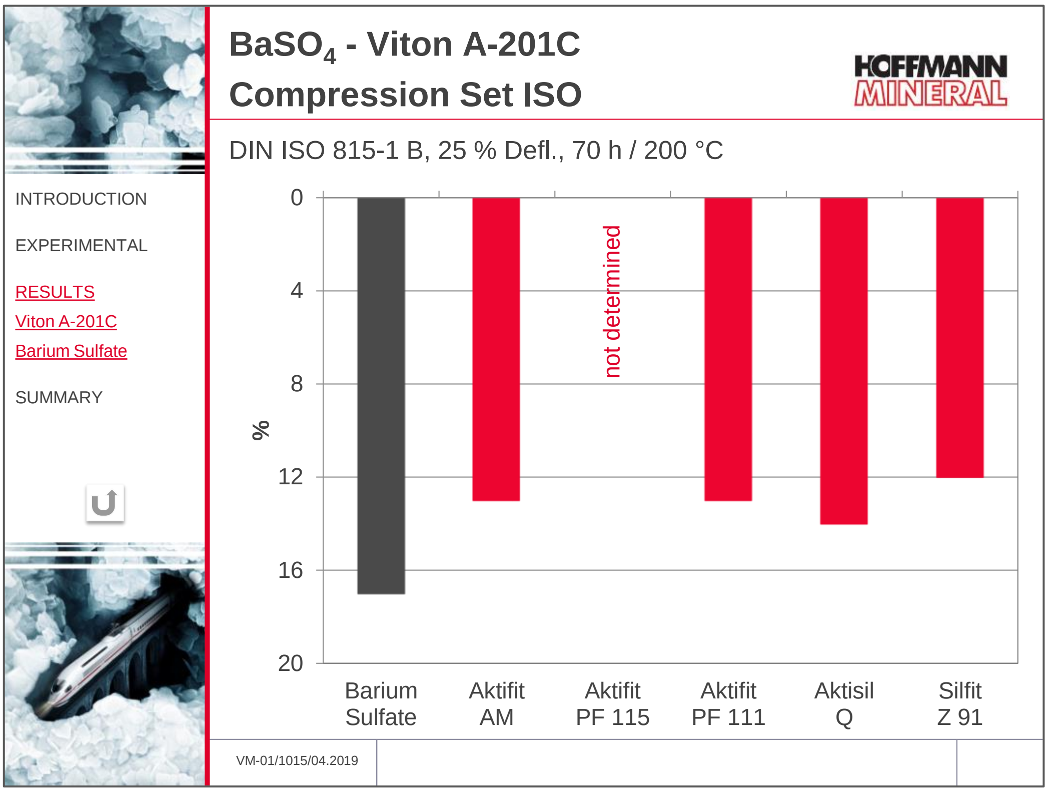

BaSO4 - Viton A-201C
Compression Set ISO
HOFFMANN MINERAL
DIN ISO 815-1 B, 25 % Defl., 70 h / 200 °C
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Barium Sulfate
SUMMARY
%
0
4
8
12
16
20
not determined
Barium Sulfate
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 66

4.4.2 Media resistance

The choice of the filler does not give rise to a significant influence on the hot air resistance (Fig. 67).

With Aktifit AM, the water resistance is comparable with barium sulfate, followed by Aktifit PF 115 and Aktisil Q. The other NSE grades are characterized by a slightly lower resistance against water.

Silfit Z 91 and Aktifit AM combine an oil resistance comparable with the barium sulfate, along with an improved fuel resistance, when along with the tensile changes also elongation at break and hardness are considered (Fig. 68, Fig. 69, Fig. 70).

Aktisil Q results in a comparable oil resistance accompanied by equal fuel resistance.

An improved fuel resistance in combination with an improved oil resistance can be obtained with Aktifit PF 111 or Aktifit PF 115 (Fig. 69, Fig. 70).

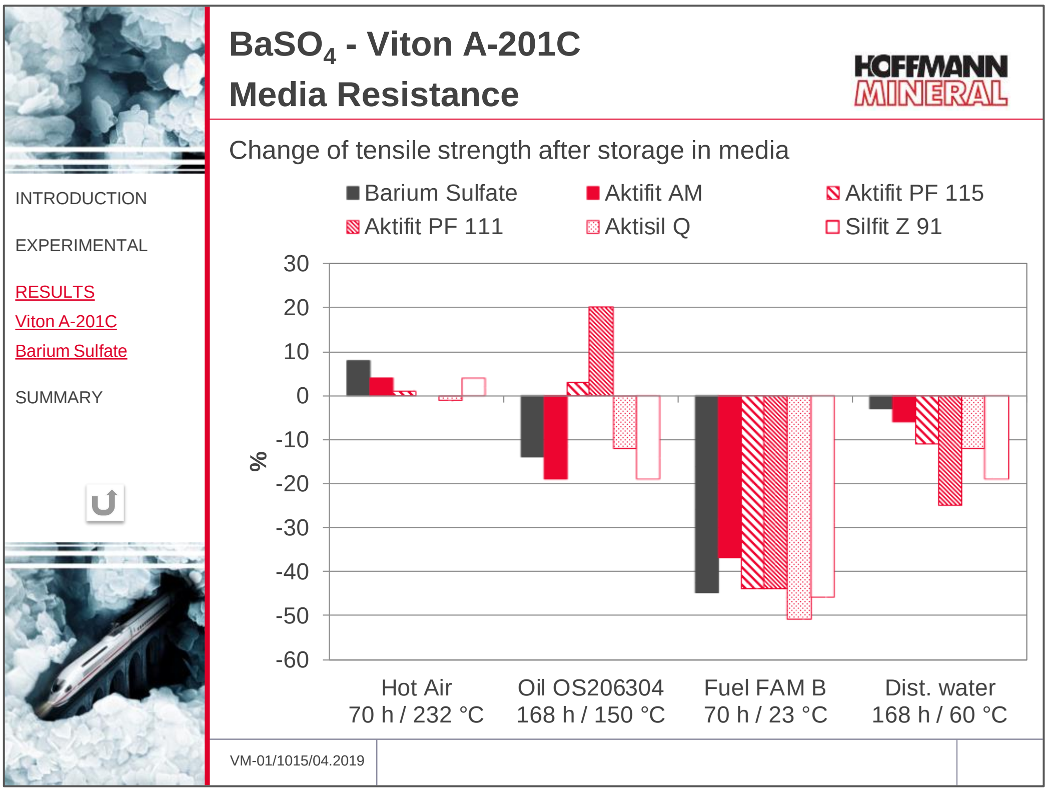
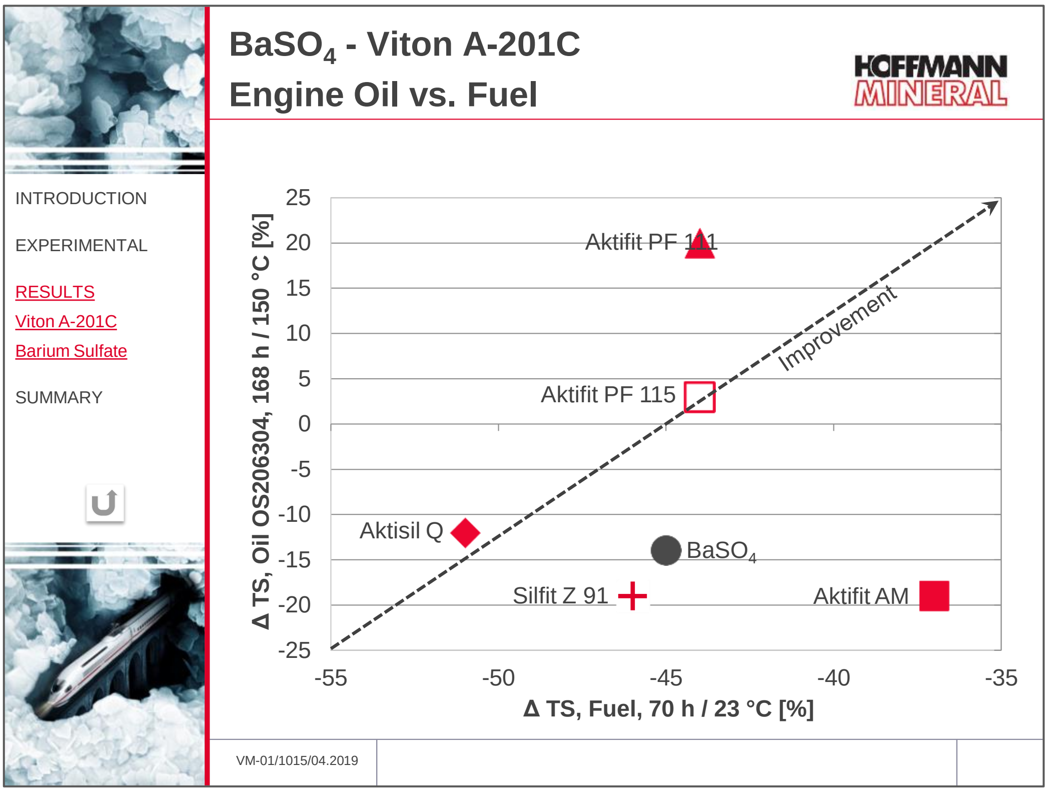
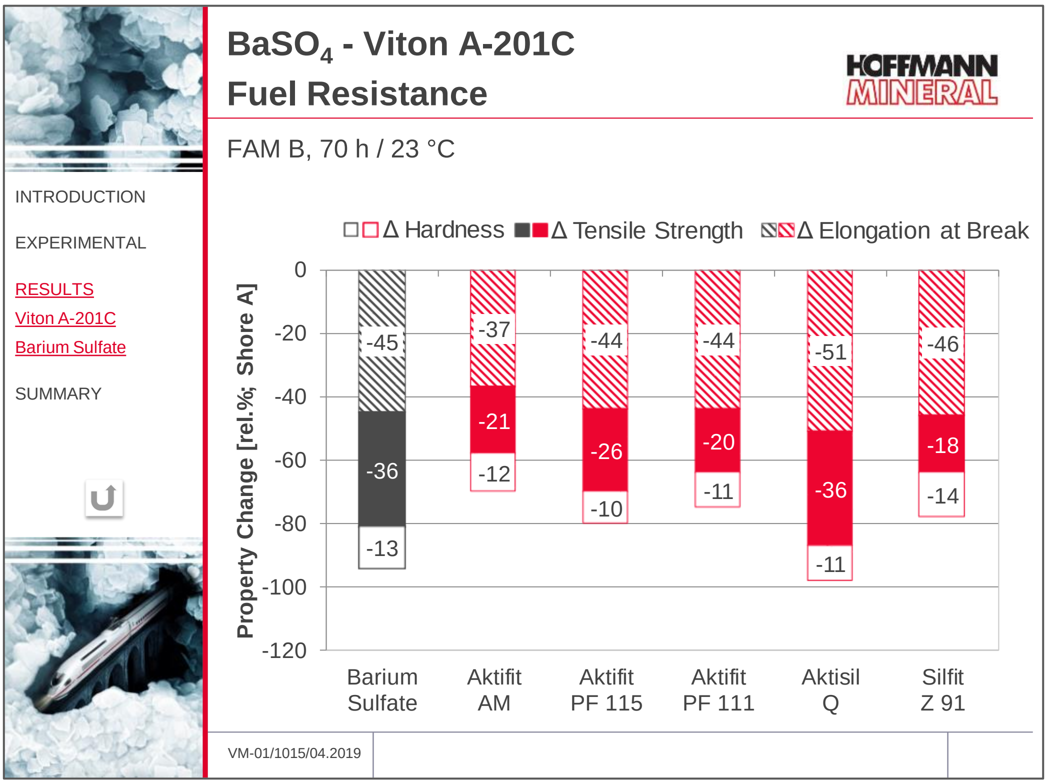


Fig. 67



BaSO$_4$ - Viton A-201C
Engine Oil vs. Fuel
HOFFMANN MINERAL
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Barium Sulfate
SUMMARY
Δ TS, Oil OS206304, 168 h / 150 °C [%]
Δ TS, Fuel, 70 h / 23 °C [%]
Aktifit PF 111
Aktifit PF 115
Improvement
Aktisil Q
BaSO$_4$
Silfit Z 91
Aktifit AM
VM-01/1015/04.2019

Fig. 68



BaSO$_4$ - Viton A-201C
Fuel Resistance
HOFFMANN MINERAL
FAM B, 70 h / 23 °C
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Barium Sulfate
SUMMARY
Δ Hardness
Δ Tensile Strength
Δ Elongation at Break
Property Change [rel.%; Shore A]
Barium Sulfate
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
-45
-36
-13
-37
-21
-12
-44
-26
-10
-44
-20
-11
-51
-36
-11
-46
-18
-14
VM-01/1015/04.2019

Fig. 69

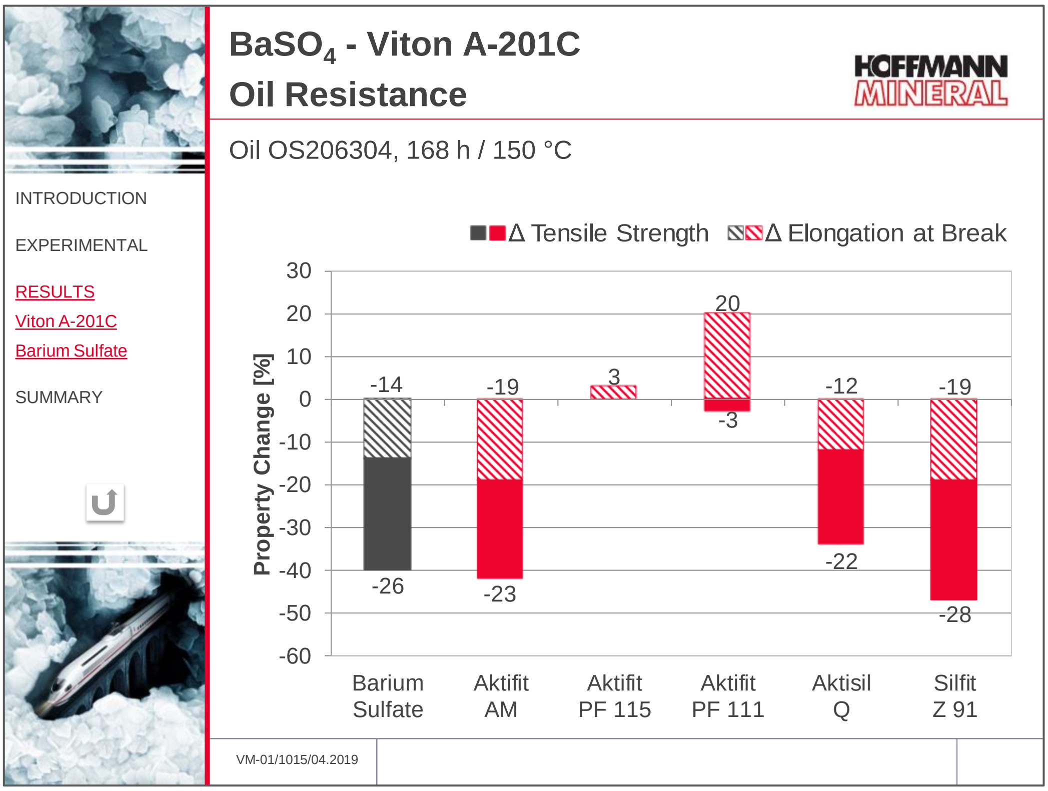
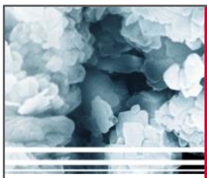

BaSO4 - Viton A-201C
Oil Resistance
HOFFMANN MINERAL
Oil OS206304, 168 h / 150 °C
INTRODUCTION
EXPERIMENTAL
RESULTS
Viton A-201C
Barium Sulfate
SUMMARY
Δ Tensile Strength
Δ Elongation at Break
Property Change [%]
30
20
10
0
-10
-20
-30
-40
-50
-60
-14
-26
-19
-23
3
20
-3
-12
-22
-19
-28
Barium Sulfate
Aktifit AM
Aktifit PF 115
Aktifit PF 111
Aktisil Q
Silfit Z 91
VM-01/1015/04.2019

Fig. 70

4.4.3 Evaluation of the results

Various properties and property combinations, often even of contradictory nature, can be positively influenced by the NSE grades. This is very evident from the following assessment survey.



Evaluation
NSE vs. Barium Sulfate

HOFFMANN MINERAL

Viton A-201C	Aktifit AM	Aktifit PF 115	Aktifit PF 111	Aktisil Q	Silfit Z 91
Tensile Strength	+	+	+	+	+
Elong. at Break					=
CS ISO 232 °C				=	+
CS ISO 200 °C	+	n.d.	+	+	+
Abrasion Resist.	+	+	+	+	+
Hot Air Resistance	=	=	=	=	=
Water Resistance	=				
Fuel Resistance	+	+	+	=	+
Oil Resistance	=	+	+	=	=
Cure Speed	+	=		=	
Viscosity / M_{min}	=	+	=	+	

VM-01/1015/04.2019

Fig. 71

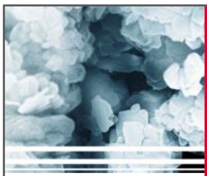
Fig. 71 indicates which NSE grade improves a particular property (+) over the barium sulfate or comes out at an equal level (=). Red colored + signs point to the products which among the NSE grades give rise to the very best results.

Aktifit AM is distinguished by a higher cure rate than the other NSE grades and the barium sulfate. The lowest viscosity levels, even below the results imparted by the barium sulfate, are obtained with Aktifit PF 115 and Aktisil Q. This means, these products offer a viscosity more favorable for processing by injection molding.

5 Application examples

In order to give more color to the results enumerated so far, in the following some examples for potential applications are summarized.

Automotive industry: Road vehicles – Fuel hose, DIN 73379



INTRODUCTION

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Automotive Sector
DIN 73379

HOFFMANN MINERAL

* 70 h / 232 °C ** FAM B, 70 h / 23 °C		DIN 73379	45 phr Aktifit PF 111 *D. FC 2181Z*	45 phr Aktisil Q *D. FC 2181Z*
Properties of cured compounds				
Hardness	Shore A	75 ± 5	79	75
Tensile Strength	MPa	min. 8	19.8	17.7
Elongation at Break	%	min. 200	215	242
Tear Resistance Trouser Tear	N/mm	min. 4	4	4
Compression Set 22 +2 h / 150 °C	%	max. 70	33 *	30 *
Resistance to gasoline 168 h / 23 °C – no redrying				
Hardness	Shore A	bis -20	-11 **	-11 **
Tensile Strength	MPa	min. 5	10.2 **	9.9 **
Elongation at Break	%	min. 150	222**	205 **
Weight Change	%	max. +20	+5.6 **	+5.9 **
suitable for DIN 73379			✓	✓

VM-01/1015/04.2019

Fig. 72

The initial properties required in DIN 73379 can be met with 45 phr Aktifit PF 111 or Aktisil Q in Dyneon FC 2181Z (Fig. 72).

The test conditions for compression set in our study were markedly more stringent than specified in this standard. The limits of DIN 73379 can, therefore, be met without any problems.

The starting point for the manufacture of fuel hoses according to DIN 73379 with NSE grades appears fully realistic, above all when turning to Aktifit PF 111 or Aktisil Q.

Oil industry: Stators in eccentric screw pumps

No concrete requirement standards are known from the oil recovery industry. Generally, the compound is put to work which offers the optimum property profile.

Here should, therefore, the best combination of abrasion, water, oil and also fuel resistance offer an advantage in particular for stators in the pumps used.

In Fig. 73, the property profiles of the amino functional NSE grades Aktifit AM and Aktifit PF 115 at a loading of 45 phr are plotted in comparison with 30 phr N990 in Dyneon FC 2181Z. These filler loadings give rise to cured compounds of the same hardness.

The best balanced product here is Aktifit PF 115, but also Aktifit AM comes out on a very good level. Both grades allow to markedly improve the abrasion resistance vs. the carbon black, while the media resistance remains comparable or is also improved.

Of course, for pracitical purposes in final applications further tests have to be carried out, but these two grades offer already a good starting point.

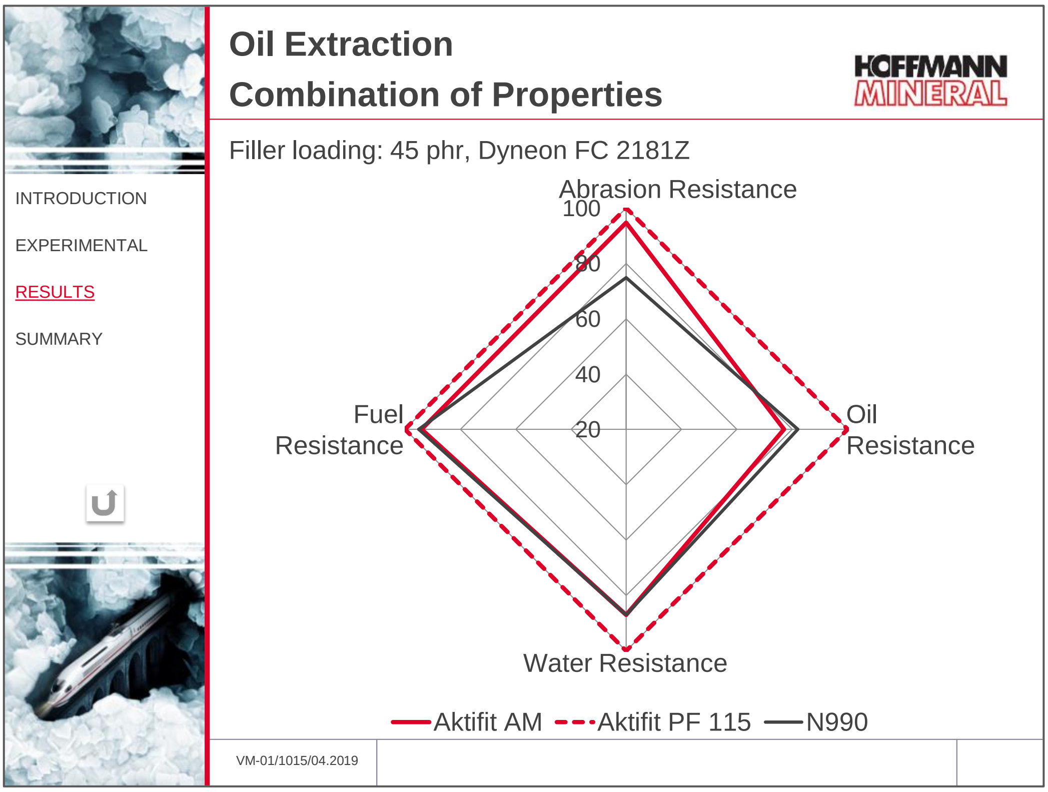

Fig. 73

Aircraft and aerospace industry: Fluorocarbon rubber, low compression set DIN EN 2798

Aerospace
DIN EN 2798

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* Shore A		DIN EN 2789	45 phr Silfit Z 91 *Viton A-201C*	45 phr Aktifit PF 111 *Viton A-201C*
Properties of cured compounds				
Hardness	IRHD	76 - 85	80 *	83 *
Tensile Strength	MPa	min. 11	12.2	14.5
Elongation at Break	%	min. 120	213	174
Compression Set 70 h / 200 °C	%	max. 25	17	17
Basic requirement of DIN EN 2798 further tests necessary for a complete evaluation			✓	✓

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Fig. 74

The combination of low compression set and high elongation at break makes 45 phr Silfit Z 91 or Aktifit PF 111 in Viton A-201C particularly attractive for applications which have to meet the specifications of DIN EN 2798 (Fig. 74).

Here too, further tests will be required in order to verify the service properties, but fundamental conditions can already be met with Silfit Z 91 or Aktifit PF 111.

6 Benefits of the individual Neuburg Siliceous Earth grades

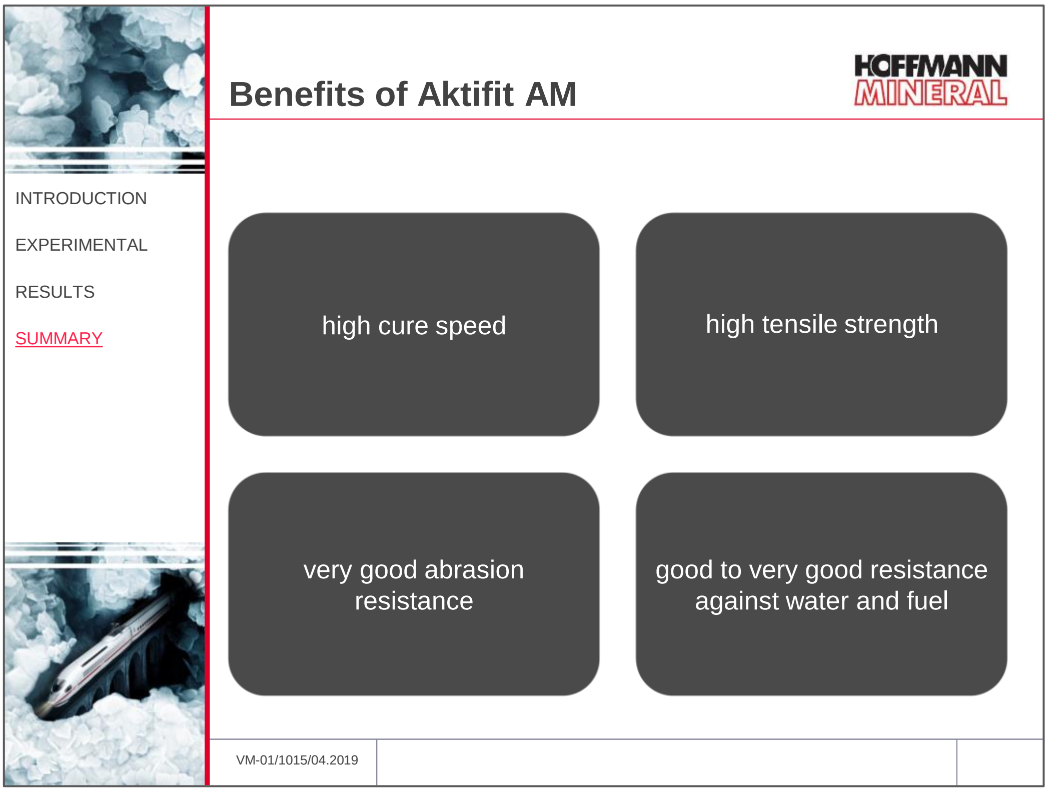


Fig. 75

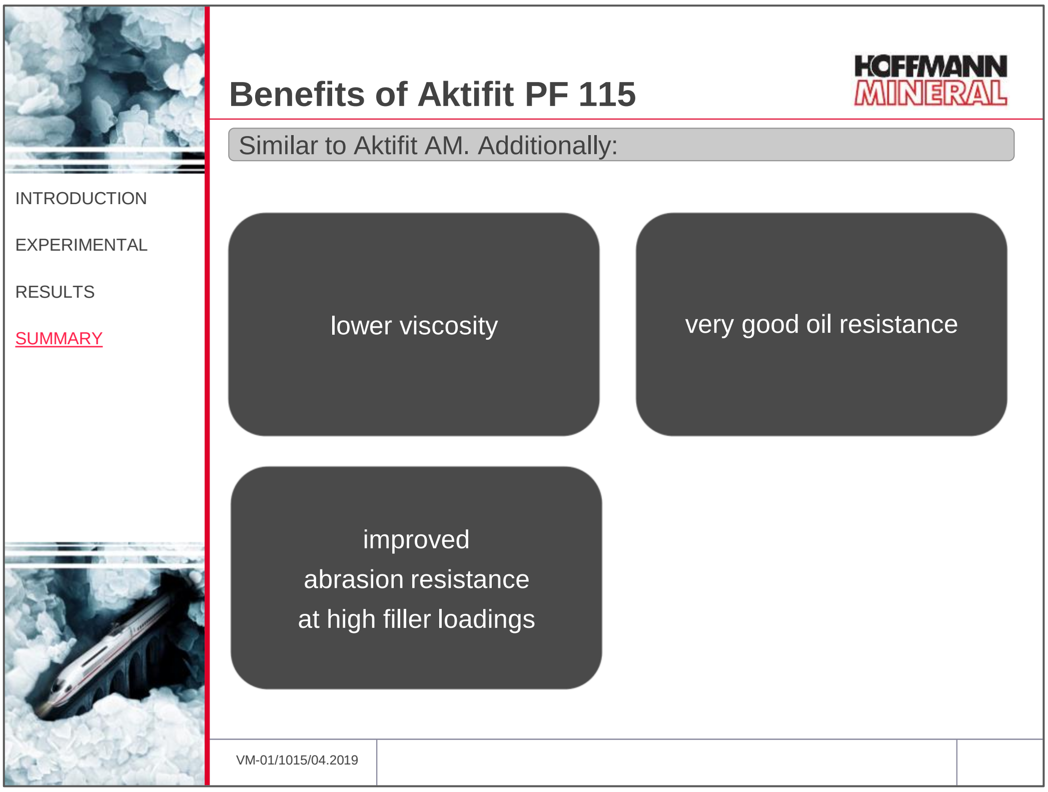
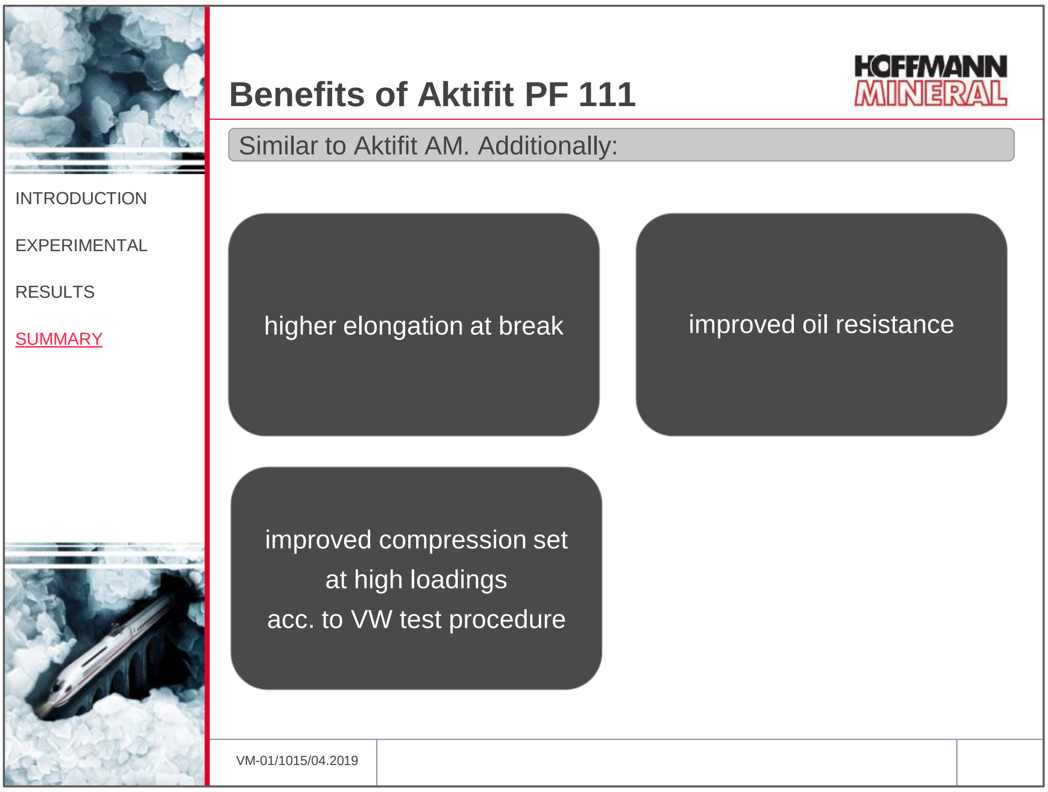


Fig. 76


Benefits of Aktifit PF 111
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Similar to Aktifit AM. Additionally:
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higher elongation at break
improved oil resistance
improved compression set at high loadings acc. to VW test procedure
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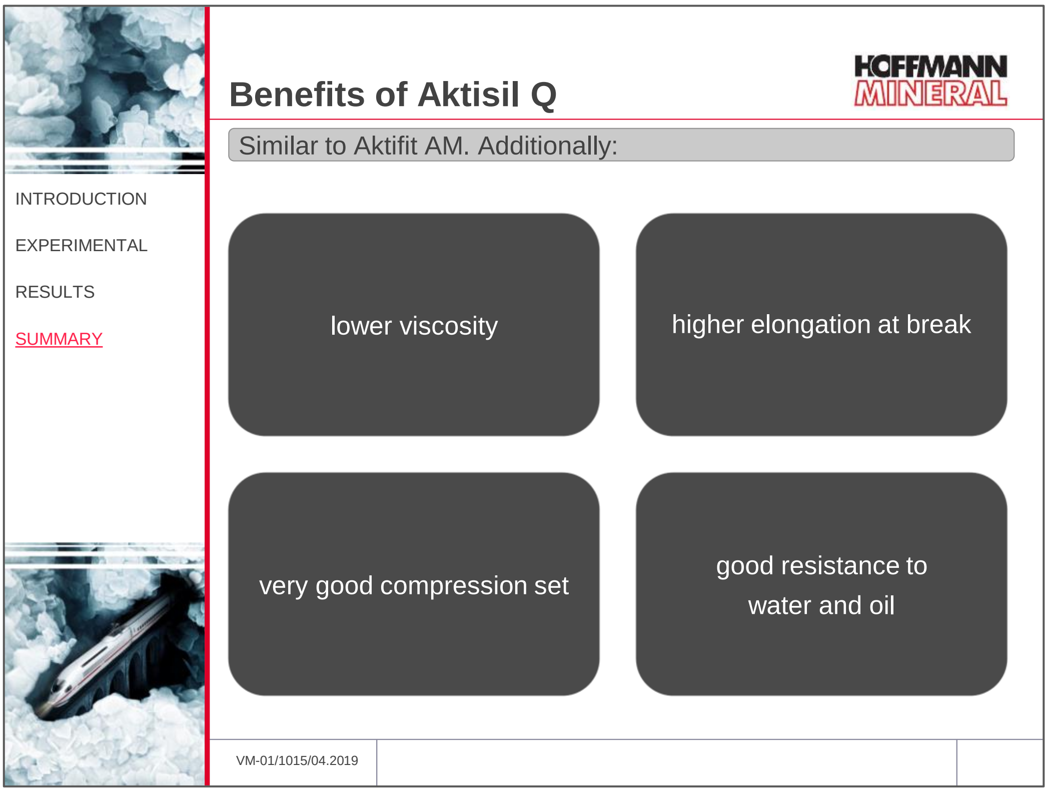
Fig. 77


Benefits of Aktisil Q
HOFFMANN MINERAL
Similar to Aktifit AM. Additionally:
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lower viscosity
higher elongation at break
very good compression set
good resistance to water and oil
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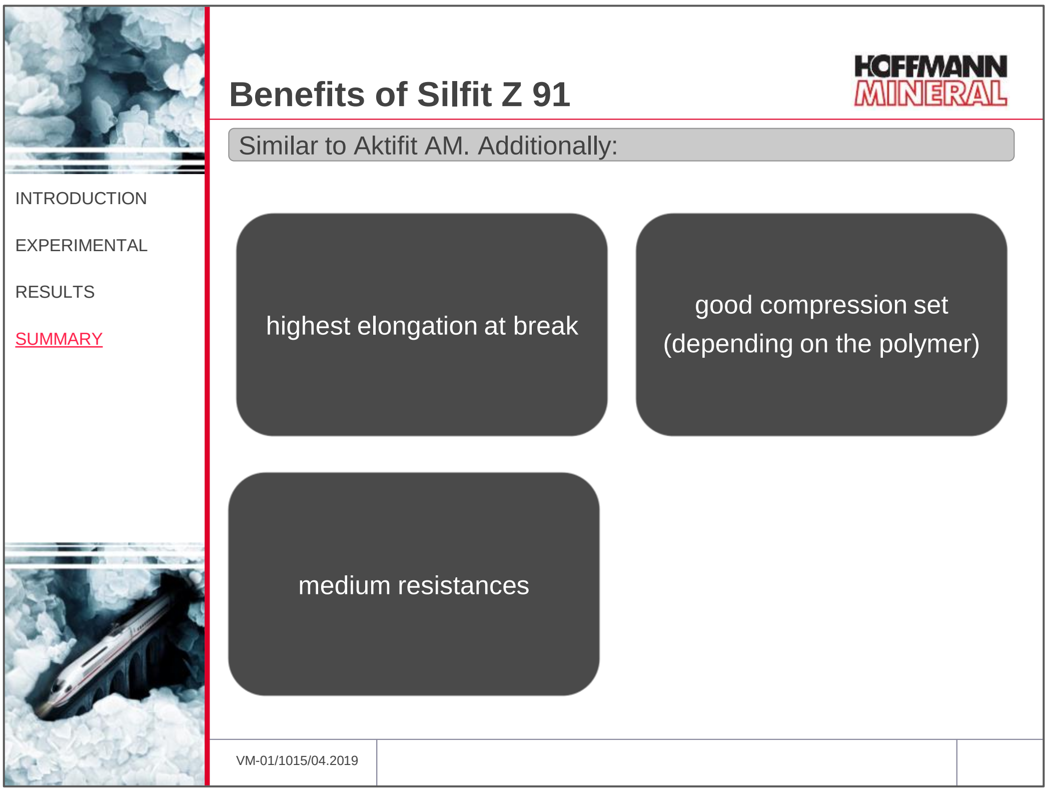
Fig. 78


Benefits of Silfit Z 91
HOFFMANN MINERAL
Similar to Aktifit AM. Additionally:
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highest elongation at break
good compression set (depending on the polymer)
medium resistances
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Fig. 79

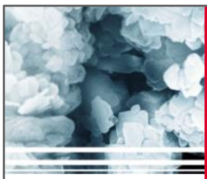
7 Summary

The study has shown that Neuburg Siliceous Earth grades are able to improve the properties of FKM compounds over carbon black and other mineral fillers.

Apart from the possibility to offer colored compounds, also compound costs can be optimized.

A general recommendation of individual NSE grades is difficult as in each special case particular requirements have to be met.

The large scope of the present study should, however, allow to identify an optimally suited filler to guide the property profile in the correct direction.



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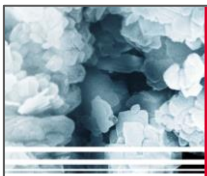
	phr	Aktifit AM		Aktifit PF 115		Aktifit PF 111	
		30	45	30	45	30	45
Rheology							
Mooney Viscosity, ML Min., 120 °C	MU	99	122	85	102	88	107
Rotorless Curemeter M_{min} 177 °C	Nm	0.101	0.140	0.084	0.112	0.090	0.116
Rotorless Curemeter V_{max} 177 °C	Nm/min.	1.76	1.51	1.82	1.84	1.03	0.54
Rotorless Curemeter t_{90} 177 °C	min.	1.6	1.4	1.4	1.2	2.2	2.9
Mechanical Properties – Cure Conditions 7 min. at 177 °C, Post-cure 16 h at 230 °C							
Hardness	Sh. A	69	77	69	77	70	79
Tensile Strength	MPa	16.6	18.2	15.8	16.8	15.5	19.8
Modulus 50 %	MPa	2.15	3.67	2.06	3.44	2.32	3.80
Modulus100 %	MPa	5.0	8.5	4.6	7.8	5.3	8.1
Elongation at Break	%	229	187	250	194	224	215
Tear Resistance	N/mm	3.6	3.4	3.9	3.6	3.9	3.8
CS ISO 70 h / 200 °C, 25 % Def.	%	18	21	n.d.	n.d.	18	21
CS ISO 70 h / 232 °C, 25 % Def.	%	36	35	36	37	34	33
CS VW PV3307 22 h / 150 °C, 50 % Def.	%	43	53	47	45	45	41
Abrasion Loss	mm³	122	132	139	125	131	144



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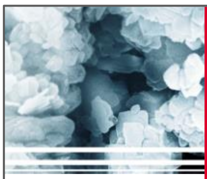
	phr	Aktisil Q		Silfit Z 91		N990	Woll. AST	Woll. EST	$BaSO_4$
		30	45	30	45	30	45	45	74
Rheology									
Mooney Viscosity, ML Min., 120 °C	MU	86	101	90	114	88	94	93	93
Rotorless Curemeter M_{min} 177 °C	Nm	0.088	0.105	0.100	0.140	0.113	0.103	0.101	0.094
Rotorless Curemeter V_{max} 177 °C	Nm/min.	0.71	0.14	0.66	0.13	1.63	2.06	1.83	2.02
Rotorless Curemeter t_{90} 177 °C	min.	2.8	7.5	3.1	7.1	1.6	1.5	1.4	1.5
Mechanical Properties – Cure Conditions 7 min. at 177 °C, Post-cure 16 h at 230 °C									
Hardness	Sh. A	69	75	69	78	81	72	71	72
Tensile Strength	MPa	15.8	17.7	15.3	17.0	16.0	17.3	15.3	9.1
Modulus 50 %	MPa	2.07	3.07	2.21	3.26	3.67	3.09	3.29	2.21
Modulus 100 %	MPa	4.7	6.9	4.4	6.3	6.6	8.3	8.6	3.7
Elongation at Break	%	242	242	289	241	223	192	183	271
Tear Resistance	N/mm	3.9	4.0	4.8	4.7	5.1	3.3	3.6	5.1
CS ISO 70 h / 200 °C, 25 % Def.	%	16	17	21	23	22	16	16	17
CS ISO 70 h / 232 °C, 25 % Def.	%	34	30	37	36	41	34	35	36
CS VW PV3307 22 h / 150 °C, 50 % Def.	%	37	42	55	51	46	37	37	42
Abrasion Loss	mm³	154	151	141	137	167	138	138	248



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		Aktifit AM		Aktifit PF 115		Aktifit PF 111	
	phr	30	45	30	45	30	45
Hot Air Aging, 70 h at 232 °C							
Hardness	Sh. A	69	78	69	77	70	80
Tensile Strength	MPa	17.8	17.9	16.9	17.9	17.8	18.0
Elongation at Break	%	242	200	258	197	245	198
Δ Hardness	Sh. A	0	+1	0	0	0	+1
Δ Tensile Strength	%	+8	-2	+7	+6	+15	-9
Δ Elongation at Break	rel.%	+5	+7	+3	+1	+9	-8
Storage in Distilled Water, 168 h at 60 °C							
Hardness	Sh. A	68	77	68	77	68	77
Tensile Strength	MPa	13.5	15.0	14.1	16.0	10.6	10.5
Elongation at Break	%	265	231	279	225	321	287
Δ Hardness	Sh. A	-1	0	-1	0	-2	-2
Δ Tensile Strength	%	-19	-18	-11	-5	-32	-47
Δ Elongation at Break	rel.%	+16	+24	+12	+16	+44	+34
Δ Weight	%	+0.7	+0.8	+0.5	+0.5	+0.7	+0.9
Δ Volume	%	+0.8	+0.9	+0.2	+0.3	+0.6	+1.0

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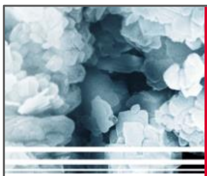

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		Aktisil Q		Silfit Z 91		N990	Woll. AST	Woll. EST	$BaSO_4$
	phr	30	45	30	45	30	45	45	74
Hot Air Aging, 70 h at 232 °C									
Hardness	Sh. A	68	75	70	78	82	71	71	72
Tensile Strength	MPa	13.8	16.8	16.0	16.5	16.3	15.8	15.5	9.5
Elongation at Break	%	210	233	238	232	202	164	201	242
Δ Hardness	Sh. A	-1	0	+1	0	+1	-1	0	0
Δ Tensile Strength	%	-13	-5	+4	-3	+2	-9	+2	+3
Δ Elongation at Break	rel.%	-13	-4	-18	-4	-9	-15	+10	-11
Storage in Dist. Water, 168 h at 60 °C									
Hardness	Sh. A	67	74	68	74	80	70	69	68
Tensile Strength	MPa	12.2	13.1	9.9	9.5	13.2	12.1	10.5	7.4
Elongation at Break	%	301	288	385	403	241	243	271	357
Δ Hardness	Sh. A	-2	-1	-1	-4	-1	-2	-2	-4
Δ Tensile Strength	%	-23	-26	-36	-44	-18	-30	-31	-20
Δ Elongation at Break	rel.%	+24	+19	+33	+67	+8	+26	+48	+32
Δ Weight	%	+0.8	+1.0	+0.9	+1.1	+0.5	+0.7	+0.8	+0.8
Δ Volume	%	+0.6	+1.0	+0.9	+1.5	+0.5	+0.5	+0.8	+1.2

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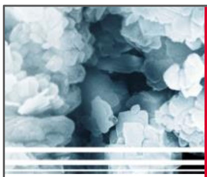

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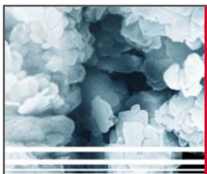
		Aktifit AM		Aktifit PF 115		Aktifit PF 111	
	phr	30	45	30	45	30	45
Storage in FAM B, 70 h at 23 °C							
Hardness	Sh. A	58	66	58	67	58	68
Tensile Strength	MPa	10.3	12.1	10.0	12.3	8.4	10.2
Elongation at Break	%	195	179	201	183	242	222
Δ Hardness	Sh. A	-11	-11	-11	-10	-12	-11
Δ Tensile Strength	%	-38	-33	-37	-27	-46	-48
Δ Elongation at Break	rel.%	-15	-4	-19	-6	+8	+3
Δ Weight	%	+6.1	+5.6	+6.2	+5.0	+7.0	+5.6
Δ Volume	%	+15	+14	+15	+12	+17	+14
Storage in Engine Oil OS206304, 168 h at 150 °C							
Hardness	Sh. A	68	76	67	76	69	77
Tensile Strength	MPa	16.7	13.3	15.9	17.5	16.8	19.1
Elongation at Break	%	227	130	240	191	255	211
Δ Hardness	Sh. A	-1	-1	-2	-1	-1	-2
Δ Tensile Strength	%	+1	-27	0	+4	+8	-3
Δ Elongation at Break	rel.%	-1	-30	-4	-1	+14	-2
Δ Weight	%	+0.6	+0.6	+0.4	+0.5	+0.6	+0.6
Δ Volume	%	+0.9	+0.9	+0.8	+0.8	+1.0	+0.8



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		Aktisil Q		Silfit Z 91		N990	Woll. AST	Woll. EST	$BaSO_4$
	phr	30	45	30	45	30	45	45	74
Storage in Fuel FAM B, 70 h at 23 °C									
Hardness	Sh. A	57	64	57	64	71	62	60	58
Tensile Strength	MPa	7.7	9.9	7.8	8.2	10.9	9.8	9.0	4.7
Elongation at Break	%	185	205	340	390	223	146	167	263
Δ Hardness	Sh. A	-12	-11	-12	-14	-10	-10	-11	-14
Δ Tensile Strength	%	-51	-44	-49	-52	-32	-43	-41	-49
Δ Elongation at Break	rel.%	-24	-15	+18	+62	0	-24	-8	-3
Δ Weight	%	+6.5	+5.9	+6.8	+5.8	+5.4	+5.5	+5.8	+5.3
Δ Volume	%	+16	+15	+17	+14	+12	+14	+15	+16
Storage in Engine Oil OS206304, 168 h at 150 °C									
Hardness	Sh. A	67	74	69	77	80	70	70	70
Tensile Strength	MPa	13.5	16.9	14.9	16.2	12.5	15.8	14.6	9.8
Elongation at Break	%	208	216	290	256	245	178	180	329
Δ Hardness	Sh. A	-2	-1	0	-1	-1	-2	-1	-2
Δ Tensile Strength	%	-15	-5	-3	-5	-22	-8	-4	+8
Δ Elongation at Break	rel.%	-14	-11	0	+6	+10	-7	-1	+21
Δ Weight	%	+0.6	+0.6	+0.5	+0.5	+0.6	+0.5	+0.5	+0.4
Δ Volume	%	+0.9	+0.6	+0.8	+0.8	+0.9	+0.6	+0.6	+0.7

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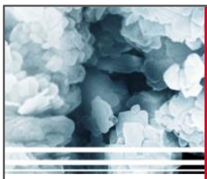

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		Aktifit AM		Aktifit PF 115		Aktifit PF 111	
	phr	30	45	30	45	30	45
Rheology							
Mooney Viscosity, ML Min., 120 °C	MU	53	67	49	60	51	63
Rotorless Curemeter M_{min} 177 °C	Nm	0.039	0.057	0.028	0.043	0.034	0.046
Rotorless Curemeter V_{max} 177 °C	Nm/min.	2.25	2.77	1.66	2.54	1.46	1.64
Rotorless Curemeter t_{90} 177 °C	min.	1.8	1.5	2.3	1.8	3.0	2.8
Mechanical Properties – Cure Conditions 10 min. at 177 °C, Post-cure 24 h at 232 °C							
Hardness	Sh. A	72	81	71	81	72	83
Tensile Strength	MPa	14.3	13.9	14.9	16.2	13.2	14.5
Modulus 50 %	MPa	2.69	4.62	2.72	4.55	2.86	4.68
Modulus100 %	MPa	6.5	10	7.0	10	6.2	9.0
Elongation at Break	%	185	134	181	149	206	174
Tear Resistance	N/mm	3.3	3.4	3.6	3.5	3.9	4.0
CS ISO 70 h / 200 °C, 25 % Def.	%	13	18	n.b.	n.b.	13	17
CS ISO 70 h / 232 °C, 25 % Def.	%	37	39	38	38	39	40
CS VW PV3307 22 h / 150 °C, 50 % Def.	%	41	43	40	40	36	34
Abrasion Loss	mm³	167	170	156	152	172	180

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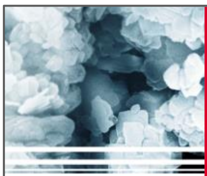

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		Aktisil Q		Silfit Z 91		N990	Woll. AST	Woll. EST	$BaSO_4$
	phr	30	45	30	45	30	45	45	74
Rheology									
Mooney Viscosity, ML Min., 120 °C	MU	48	59	53	66	47	55	55	56
Rotorless Curemeter M_{min} 177 °C	Nm	0.032	0.042	0.038	0.057	0.031	0.034	0.033	0.034
Rotorless Curemeter V_{max} 177 °C	Nm/min.	1.69	1.44	1.51	1.60	2.16	2.04	1.80	1.71
Rotorless Curemeter t_{90} 177 °C	min.	3.4	3.1	2.9	2.7	2.1	2.0	2.1	2.2
Mechanical Properites – Cure Conditions 10 min. at 177 °C, Post-cure 24 h at 232 °C									
Hardness	Sh. A	71	79	73	80	77	71	72	71
Tensile Strength	MPa	12.3	15.2	11.6	12.2	12.1	15.7	15.3	7.8
Modulus 50 %	MPa	2.87	4.47	2.76	4.17	3.32	4.24	4.39	2.24
Modulus100 %	MPa	6.6	9.4	5.3	7.4	6.0	11	11	3.4
Elongation at Break	%	177	165	242	213	192	147	157	254
Tear Resistance	N/mm	3.4	3.5	4.0	4.9	4.3	2.9	3.6	3.6
CS ISO 70 h / 200 °C, 25 % Def.	%	14	18	12	17	18	15	n.d.	17
CS ISO 70 h / 232 °C, 25 % Def.	%	35	34	32	32	35	32	39	34
CS VW PV3307 22 h / 150 °C, 50 % Def.	%	29	33	36	33	44	26	24	30
Abrasion Loss	mm³	196	180	181	182	186	140	153	286

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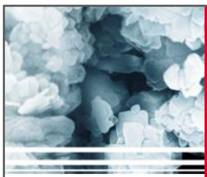

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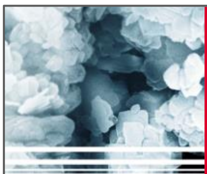
		Aktifit AM		Aktifit PF 115		Aktifit PF 111	
	phr	30	45	30	45	30	45
Hot Air Aging, 70 h at 232 °C							
Hardness	Sh. A	72	81	72	81	73	83
Tensile Strength	MPa	14.8	13.0	15.0	15.6	13.2	14.7
Elongation at Break	%	207	135	178	144	201	175
Δ Hardness	Sh. A	0	0	+1	0	+1	0
Δ Tensile Strength	%	+4	-6	+1	-4	0	+1
Δ Elongation at Break	rel.%	+12	+1	-2	-4	-2	0
Storage in dist. Water, 168 h at 60 °C							
Hardness	Sh. A	72	81	71	81	73	81
Tensile Strength	MPa	13.4	14.7	13.3	14.2	9.8	10.1
Elongation at Break	%	215	173	206	157	246	206
Δ Hardness	Sh. A	0	0	0	0	+1	-2
Δ Tensile Strength	%	-6	+6	-11	-12	-25	-30
Δ Elongation at Break	rel.%	+16	+30	+14	+5	+20	+18
Δ Weight	%	+0.5	+0.5	+0.5	-0.5	+0.6	+0.6
Δ Volume	%	+0.2	+0.1	+0.2	+0.2	+0.3	+0.4



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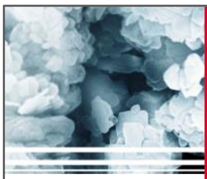
		Aktisil Q		Silfit Z 91		N990	Woll. AST	Woll. EST	$BaSO_4$
	phr	30	45	30	45	30	45	45	74
Hot Air Aging, 70 h at 232 °C									
Hardness	Sh. A	71	79	74	80	80	74	72	73
Tensile Strength	MPa	12.2	14.1	12.0	13.7	14.7	16.3	13.5	8.5
Elongation at Break	%	185	162	221	196	203	142	156	232
Δ Hardness	Sh. A	0	0	+1	0	+3	+3	0	+2
Δ Tensile Strength	%	-1	-7	+4	+13	+22	+4	-12	+8
Δ Elongation at Break	rel.%	+5	-2	-9	-8	+6	-4	-1	-9
Storage in dist. Water, 168 h at 60 °C									
Hardness	Sh. A	71	79	72	80	79	73	73	70
Tensile Strength	MPa	10.8	12.4	9.4	9.0	11.2	12.9	10.1	7.6
Elongation at Break	%	214	185	281	242	224	179	207	290
Δ Hardness	Sh. A	0	0	-1	0	+2	+2	+1	-1
Δ Tensile Strength	%	-12	-19	-19	-26	-7	-18	-34	-3
Δ Elongation at Break	rel.%	+21	+12	+16	+14	+16	+22	+31	+14
Δ Weight	%	+0.7	+0.7	+0.7	+0.8	+0.4	+0.6	+0.6	+0.7
Δ Volume	%	+0.4	+0.5	+0.5	+0.7	+0.2	+0.1	+0.2	+0.8



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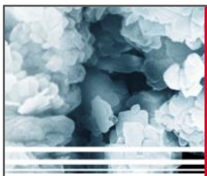
		Aktifit AM		Aktifit PF 115		Aktifit PF 111	
	phr	30	45	30	45	30	45
Storage in Fuel FAM B, 70 h at 23 °C							
Hardness	Sh. A	60	71	61	70	61	71
Tensile Strength	MPa	8.9	9.6	8.3	11.1	7.4	9.0
Elongation at Break	%	147	113	134	122	164	148
Δ Hardness	Sh. A	-12	-10	-10	-11	-11	-12
Δ Tensile Strength	%	-37	-31	-44	-32	-44	-37
Δ Elongation at Break	rel.%	-21	-15	-26	-18	-20	-15
Δ Weight	%	+7.2	+5.8	+7.0	+5.7	+7.6	+6.3
Δ Volume	%	+17	+14	+17	+14	+18	+15
Storage in Engine Oil OS206304, 168 h at 150 °C							
Hardness	Sh. A	68	79	70	78	69	82
Tensile Strength	MPa	11.5	12.5	15.3	17.3	15.8	16.7
Elongation at Break	%	143	112	182	151	199	151
Δ Hardness	Sh. A	-4	-2	-1	-3	-3	-1
Δ Tensile Strength	%	-19	-10	+3	+7	+20	+15
Δ Elongation at Break	rel.%	-23	-16	0	+1	-3	-14
Δ Weight	%	+0.7	+0.6	+0.5	+0.5	+0.5	+0.5
Δ Volume	%	+1.2	+0.7	+1.1	+1.0	+0.9	+0.7

VM-01/1015/04.2019



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		Aktisil Q		Silfit Z 91		N990	Woll. AST	Woll. EST	$BaSO_4$
	phr	30	45	30	45	30	45	45	74
Storage in Fuel FAM B, 70 h at 23 °C									
Hardness	Sh. A	60	68	59	68	65	62	62	58
Tensile Strength	MPa	6.1	7.6	6.3	7.0	7.8	8.4	6.9	4.3
Elongation at Break	%	113	105	198	197	165	103	108	162
Δ Hardness	Sh. A	-11	-11	-14	-12	-12	-9	-10	-13
Δ Tensile Strength	%	-51	-50	-46	-42	-35	-46	-55	-45
Δ Elongation at Break	rel.%	-36	-37	-18	-7	-14	-30	-32	-36
Δ Weight	%	+8.8	+7.7	+8.1	+7.0	+7.5	+6.5	+7.6	+5.8
Δ Volume	%	+21	+19	+20	+17	+17	+17	+19	+17
Storage in Engine Oil OS206304, 168 h at 150 °C									
Hardness	Sh. A	70	80	71	81	75	69	70	71
Tensile Strength	MPa	10.7	12.8	9.4	10.8	8.6	14.4	14.7	6.7
Elongation at Break	%	137	117	173	150	171	120	130	189
Δ Hardness	Sh. A	11	+1	-2	+1	-2	-2	-2	0
Δ Tensile Strength	%	-12	-16	-19	-12	-29	-8	-4	-14
Δ Elongation at Break	rel.%	-22	-29	-28	-29	-11	-18	-17	-26
Δ Weight	%	+0.7	+0.7	+0.7	+0.7	+0.6	+0.5	+0.5	+0.4
Δ Volume	%	+0.7	+0.6	+1.0	+0.8	+1.0	+0.7	+0.5	+0.6

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