HOFFMANN MINERAL
Unternehmensgruppe Hoffmann

Neuburg Siliceous Earth

in high consistency silicone rubber

(HTV, HCR)

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Content

Abstract

Benefits of Aktisil Q loaded compounds in comparison with –

Silicone base compounds (without addtional fillers):

- favorable extrusion properties with very good collapse resistance and reduced surface sticking
- high tensile moduli
- low tensile and compression set without post-cure, up to 75 phr even better than the base compound
- comparably favorable aging properties
- markedly improved oil resistance
- reduction or even absence of blooming when working with Bis-(2.4-dichlorobenzoyl-peroxide

Compounds loaded with vinylsilane treated quartz flour:

- higher hardness, 75 phr Aktisil Q = 100 phr quartz flour
- lower abrasivity / wear on processing machinery
- improved collapse resistance of extrusions
- reduced surface stickiness of uncured extrusions
- slightly improved oil resistance
- reduction or even absence of blooming when working with Bis-(2.4-
- dichlorobenzoyl)peroxide

Compounds loaded with diatomaceous earth:

- possibility of higher loadings, 75-100 phr Aktisil Q = 50 phr diatomaceous earth
- smoother edges of extruded sections
- markedly lower compression set
- markedly better oil resistance

Special benefits of Aktisil Q in combination with curing agent
Bis-(2.4-dichlorobenzoyl) peroxide:

- no blooming with curing agent
- no surface stickiness of uncured extrusions
- much improved collapse resistance of extrusions

1 Introduction

High consistency silicone rubbers (HTV, HCR) are extensively used for the manufacture of molded articles, e.g. for the automotive industry or technical applications, as well as in extruded goods such as cables and hose.

The manifold applications of these polymers are based on

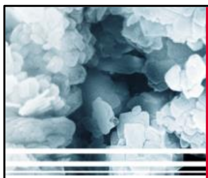
- easy processing
- outstanding general mechanical properties
- excellent compression set
- very good chemical and thermal resistance

In general, for cost reasons inactive fillers such as quartz flour or diatomaceous earth are added to the base compounds, which allows an additional optimization of their processing properties. The mechanical properties are largely maintained, in some cases even improved.

The objective of the present work was to demonstrate the effects of Neuburg Siliceous Earth in HTV silicone rubber compounds, and thus to open the way to novel applications.

2 Experimental

2.1 Fillers used and their characteristic properties



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Characteristic Values of Fillers

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		Functionalization	PSD d_{50} [µm]	PSD d_{97} [µm]	Oil Absorption [g/100g]	BET Surface [m²/g]	Abrasivity index (*) [-]
QF	Quartz flour	None	2.8	12.0	32	3,8	100
QF vst	Quartz flour	Vinyl silane	3.4	12.7	32	3.2	k. A.
DE fc	Diatomaceous Earth. flux-calciniert	None	11.9	32.7	116	1.5	100
Sillitin Z 86	NSE	None	1.7	7,9	51	11.0	k. A.
Sillitin Z 89	NSE	None	2.0	8.6	49	10.1	k. A.
Sillitin V 85	NSE	None	3.7	15,6	45	8.0	k. A.
Sillitin V 88	NSE	none	4.0	17.0	45	7.4	k. A.
Aktisil MAM	NSE	Methacryl	3.6	15.6	41	6.6	k. A.
Aktisil Q	NSE	Methacryl	4.2	17.0	42	6.5	50

(*) based on Einlehner test

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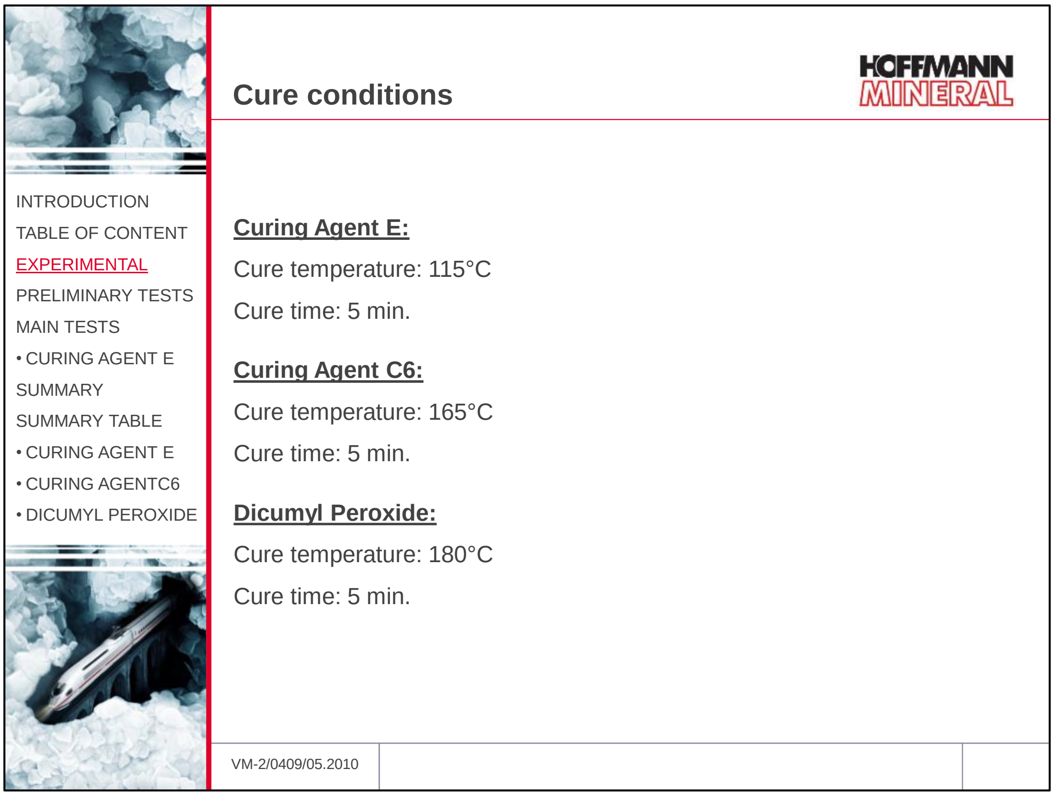
The table above lists the fillers used in the tests and their typical properties as determined by Hoffmann Mineral.

With respect to particle size distribution, quartz flour and Neuburg Siliceous Earth are situated in a comparable range, while the flux-calcined diatomaceous earth comes out somewhat coarser. But this filler despite of markedly higher oil absorption has only a very low BET surface area. The quartz flour has a lower oil absorption than Neuburg Siliceous Earth, the BET surface area here again is lower.

As also indicated, Aktisil Q is about 50 percent less abrasive compared with quartz flour or diatomaceous earth. This property was determined according to the Einlehner test whose objective is to give an indication of the wear of processing equipment etc.

2.2 Preparation of test compounds and test methods

The compounds were mixed on a laboratory mill at a roll temperature of 20 °C for approx. 10 minutes. Sample sheets and specimens were cured in a press for 5 min at temperatures varying with the curing agent used, as indicated in the table.



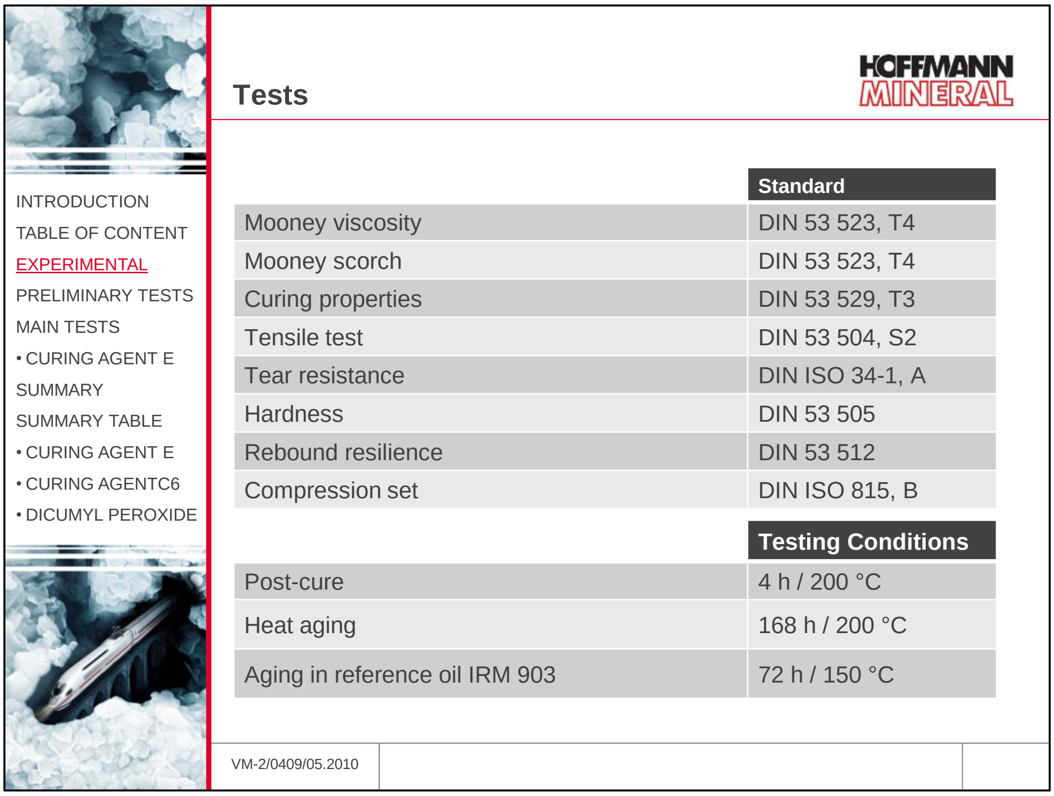
Cure conditions

Curing Agent E:
Cure temperature: 115°C
Cure time: 5 min.

Curing Agent C6:
Cure temperature: 165°C
Cure time: 5 min.

Dicumyl Peroxide:
Cure temperature: 180°C
Cure time: 5 min.

The following table lists the tests carried out along with the respective DIN or DIN ISO standards.



Tests

	Standard
Mooney viscosity	DIN 53 523, T4
Mooney scorch	DIN 53 523, T4
Curing properties	DIN 53 529, T3
Tensile test	DIN 53 504, S2
Tear resistance	DIN ISO 34-1, A
Hardness	DIN 53 505
Rebound resilience	DIN 53 512
Compression set	DIN ISO 815, B

	Testing Conditions
Post-cure	4 h / 200 °C
Heat aging	168 h / 200 °C
Aging in reference oil IRM 903	72 h / 150 °C

3 Preliminary tests

3.1 Compound formulations

In the preliminary test series, a natural and a surface treated quartz flour plus a flux-calcined diatomaceous earth were compared with several Neuburg Siliceous Earth grades.

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Preliminary Tests

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The filler loading is 100 phr:

Reference fillers
- Quartz flour (QF)
- Quartz flour silane treated (QF vst)
- Diatomaceous Earth flux-calcined (DE fc), loading 50 phr

Neuburg Siliceous Earth
- Sillitin Z 86
- Sillitin Z 89
- Sillitin V 85
- Sillitin V 88
- Aktisil MAM
- Aktisil Q

Definition
The compound without additional filler mixed in, is called „Base cpd.“ in the pilot tests and in the main tests.

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Compound Formulations (phr)

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Elastosil R401/40	Polymer	100	100	100
	Filler	25 - 100	25 - 100	25 - 100
Bis-(2,4-dichlorobenzoyl)-peroxide (50 %) Elastosil AUX Curing Agent E	Curing Agent	1.5	-	-
2,5-Bis-(t-butylperoxy)-2,5-di-methylhexane (45 %) Elastosil AUX Curing Agent C6	Curing Agent	-	1.2	-
Dicumyl peroxide (40 %) Perkadox BC-40S-ps	Curing Agent	-	-	0.99

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A heat-curing silicone rubber compound for hardness 40 Shore A was selected as the base because of its universal modification possibilities (e.g., for hardness).

In order to create several hardness levels and for reinforcing purposes, the polymer manufacturers add silica to the silicone rubber in the production process. In the following, the compounds without additional fillers mixed in by Hoffmann Mineral, will be called "base compound".

Bis-(2.4-dichlorobenzoyl) peroxide (*Elastosil AUX Curing Agent E*) was included as a typical curing agent for extrusion compounds.

2.5-Bis-(tert.butylperoxy)-2.5-dimethylhexane (*Elastosil AUX Curing Agent C6)* and dicumyl peroxide (*Perkadox BC-40-ps*) are widely used in the manufacture of molded articles.

Diatomaceous earth and quartz flour represent typical fillers for silicone rubber compounds. Some selected grades were, therefore, included for comparison purposes.

In the preliminary tests, the filler loading was 100 phr (except for the diatomaceous earth at 50 phr).

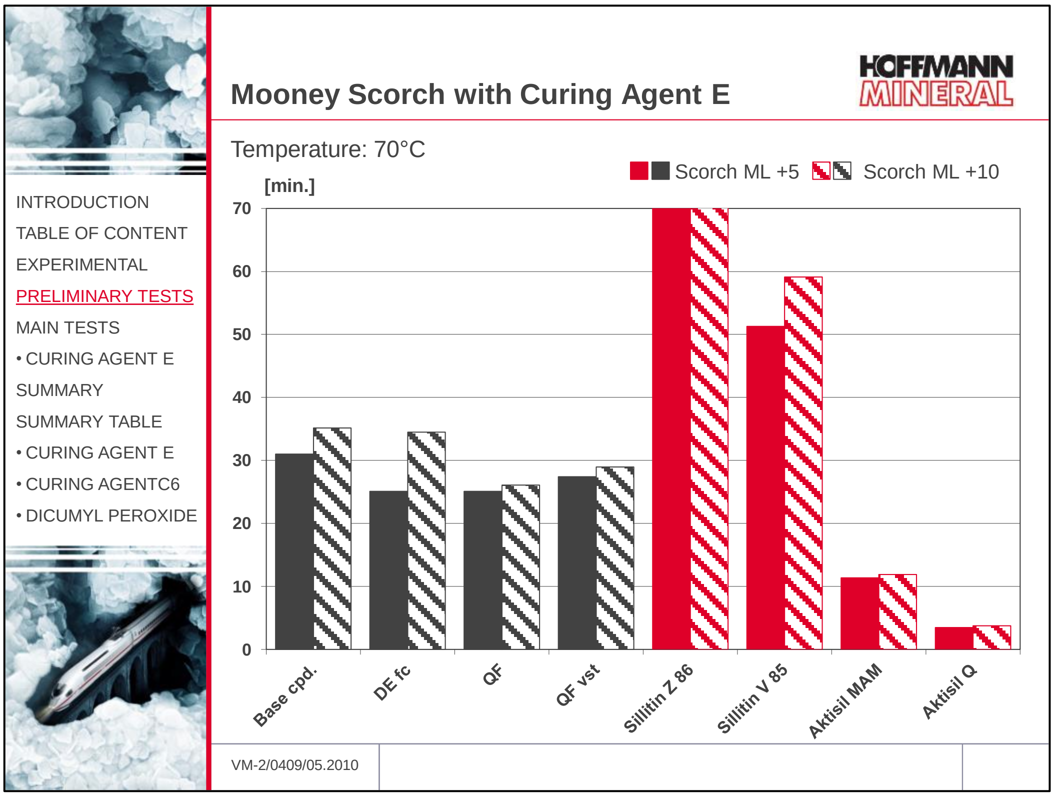
3.2 Scorch time and curing profiles

Mooney scorch

With Curing Agent E, a test temperature of 70 °C was chosen, as higher temperatures lead to very fast full cure, which does not allow any longer to differentiate between the individual compounds.

The tests with Curing Agent C6 and dicumyl peroxide were run at 120 °C.

Curing Agent E



The use of diatomaceous earth and quartz flour (untreated or treated) does not give rise to significant changes in the scorch properties compared with the base compound without further added fillers. By contrast, Sillitin leads to markedly longer scorch times. With the untreated fillers such as quartz flour and Sillitin, no onset of cure can be observed. Aktisil MAM and Aktisil Q show a distinctly shortened scorch time. The individual results are given in the Appendix.

Curing Agent C6

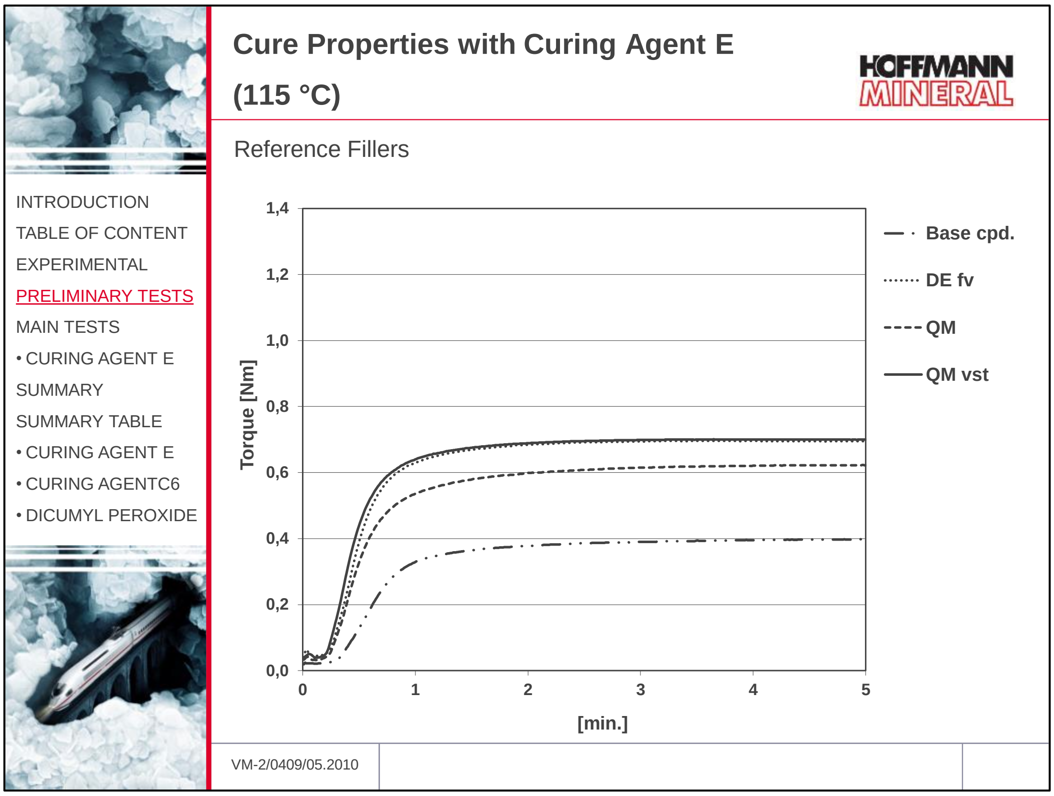
Flux-calcined diatomaceous earth and silanized quartz flour lead to somewhat shorter scorch times compared with the base compound with no additional fillers
(its level is comparable with Curing Agent E). With the untreated fillers like quartz flour and Sillitin, an onset of cure does not take place, while Aktisil MAM and Aktisil Q give rise to markedly shorter scorch times. Again, individual results are given in the Appendix.

Dicumyl Peroxide

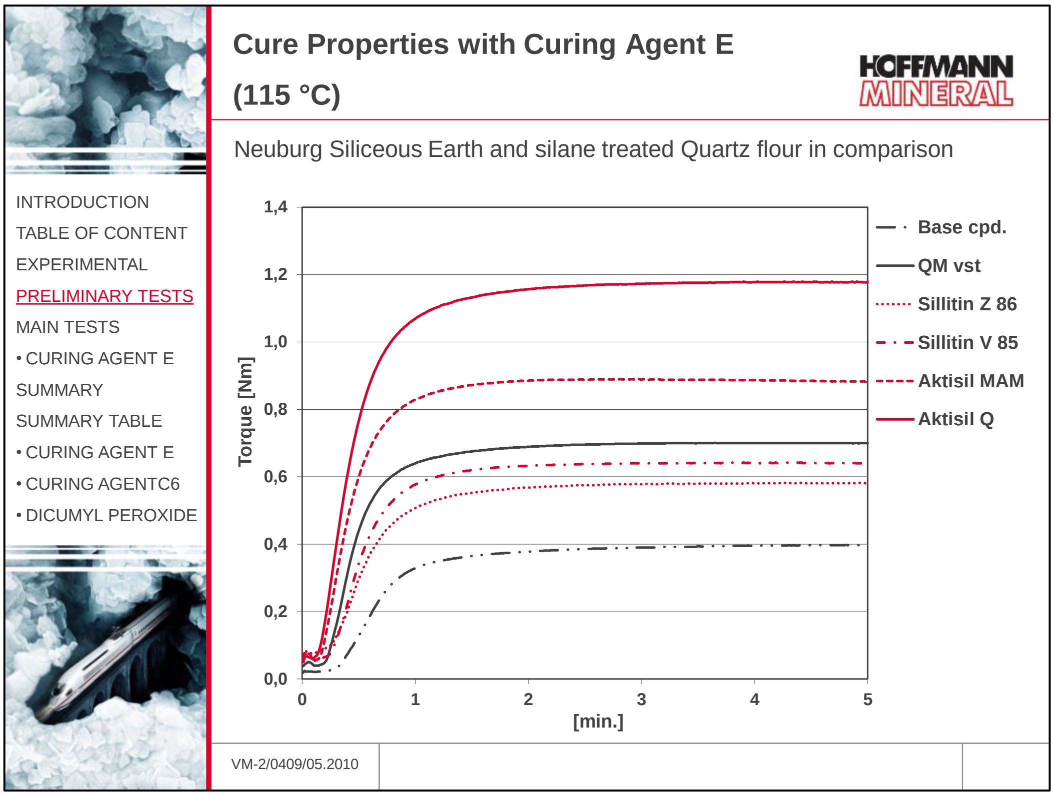
The scorch time of the base compound without additional fillers again is comparable with the level with Curing Agent E.
Untreated fillers such as natural quartz flour or Sillitin, do not bring about any onset of cure. Flux-calcined diatomaceous earth and silanized quartz flour lead to somewhat shortened scorch times. The tendency of Aktisil MAM and Aktisil Q to markedly reduced scorch times is also found with dicumyl peroxide as curing agent. Again, individual results can be consulted in the Appendix.

Curing profiles

Curing Agent E

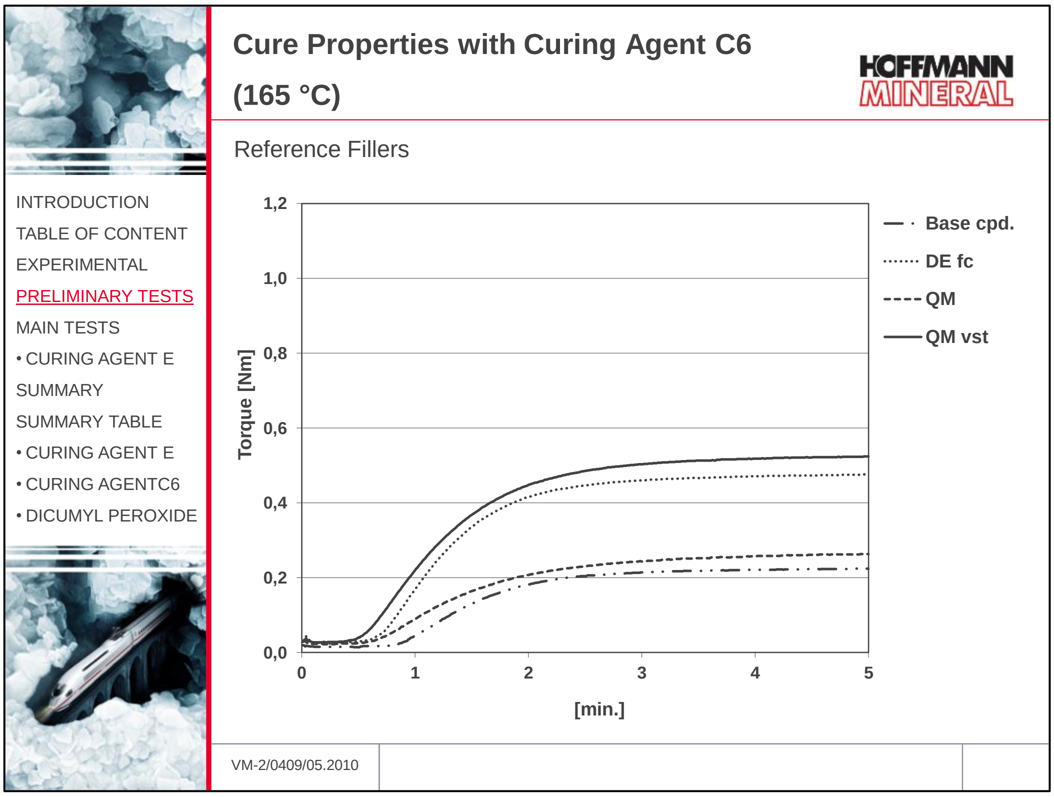


The addition of quartz flour gives rise to a marked increase of the Rheometer torque above the base compound. Surface treatment of the quartz flour leads to a further increase. Diatomaceous earth behaves similar to the treated quartz flour.

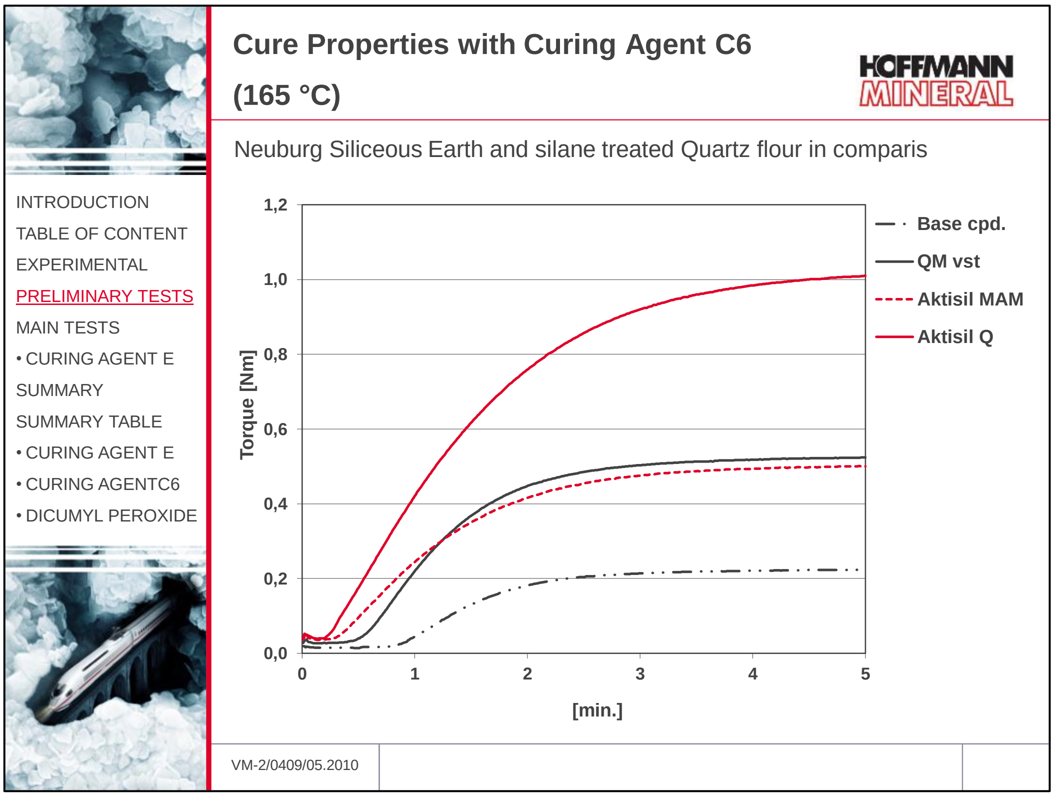


Also Sillitin V 85 and Z 86 cause a higher torque compared to the base compound without additional fillers; the level, however, remains somewhat below the silanized quartz flour. A torque increase above quartz flour is observed with Aktisil MAM, which in turn is even surpassed with Aktisil Q.

Curing Agent C6

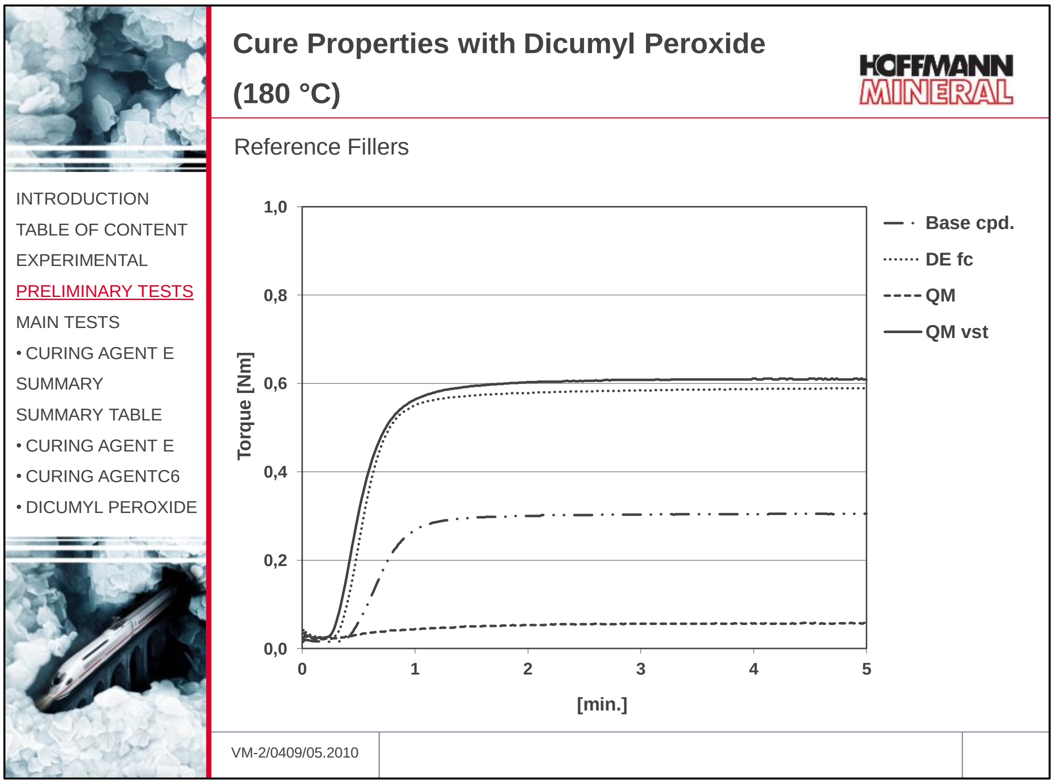


Quartz flour slightly increases the torque compared with the base compound; surface treatment brings about a marked increase. Diatomaceous earth comes out somewhat below the silanized quartz flour.

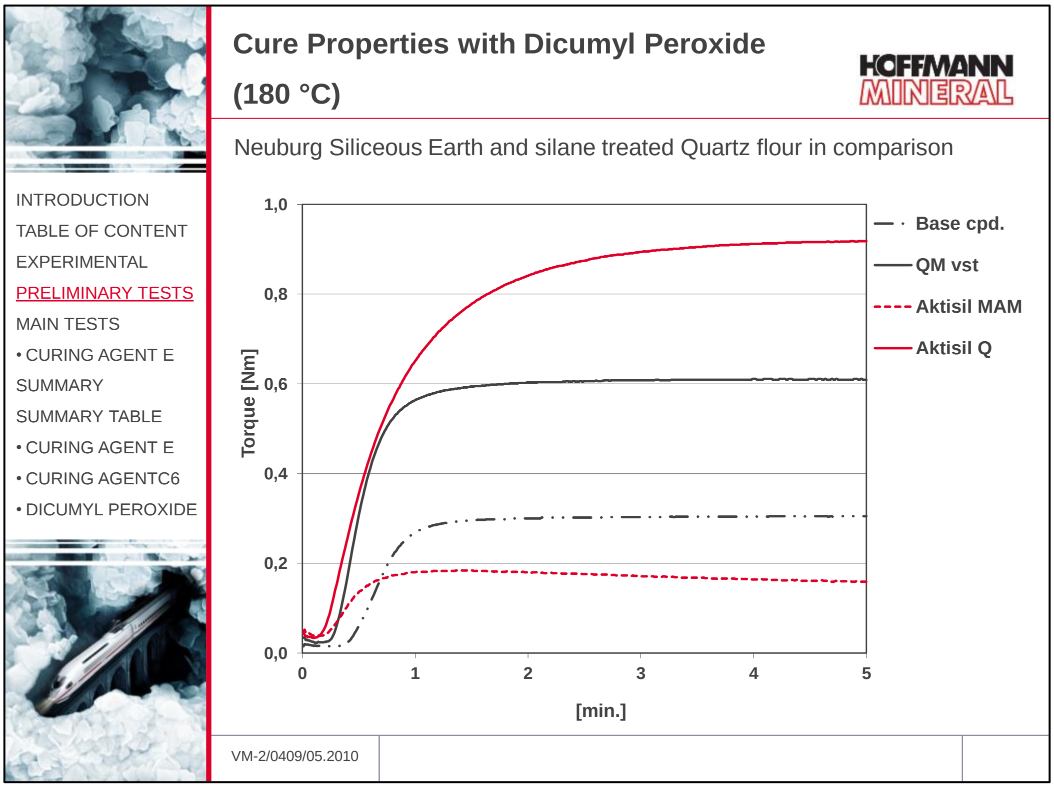


The use of Sillitin grades gives rise to unsatisfactory crosslinking, therefore these fillers will not be shown here. Aktisil MAM makes it possible to attain the torque of silanized quartz flour. Aktisil Q again shows a marked torque increase compared with the base compound or to the compound with silanized quartz flour.

Dicumyl Peroxide



As evident from this graph, the use of untreated quartz flour with dicumyl peroxide will inhibit the crosslinking process. Quartz flour can only be used in its surface treated version. Then there is no difference in crosslinking effects with the flux-calcined diatomaceous earth, in so far as both fillers increase the torque of the base compound by a factor of two.

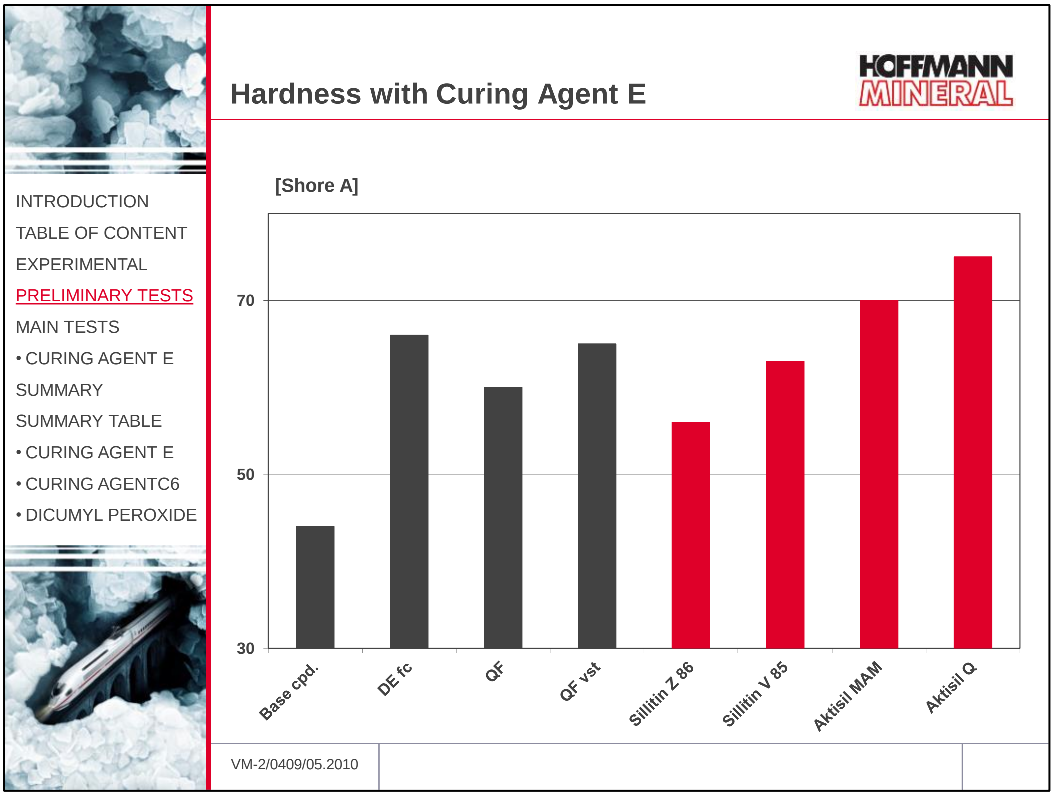


Sillitin too inhibits any crosslinking by dicumyl peroxide. This effect is not shown here. As seen in the graph, with Aktisil MAM a certain degree of crosslinking takes place, but this is not sufficient for technical purposes (the comparatively high value for the loss angle tan δ at the end of the test, not shown here, confirms this assumption). Aktisil Q, by contrast, allows a crosslinking to a much higher torque maximum than silanized quartz flour, as already shown with the two other curing agents.

3.3 Cured rubber properties

Hardness

Curing Agent E



The addition of further fillers to the base compound, as expected, will increase the hardness level. Untreated fillers – quartz flour and Sillitin grades – impart about equal hardness levels. The surface treatment of quartz flour tends to cause a slight further increase of the hardness, which becomes comparable with the effect of flux-calcined diatomaceous earth. Surface treatment of Sillitin, by contrast, increases the hardness even more, as evidenced by Aktisil MAM. This level will even be surpassed when using Aktisil Q.

Curing Agent C6

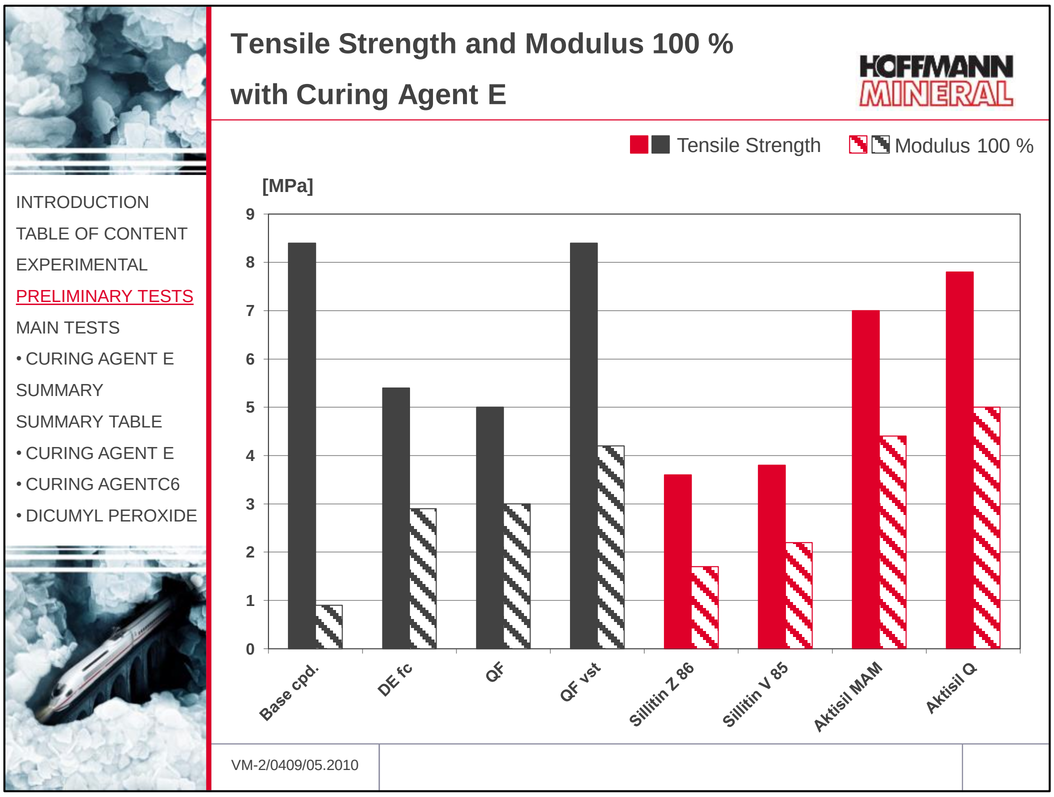
The 33 Shore A hardness of the base compound will be increased by 10 units with untreated quartz flour. The flux-calcined diatomaceous earth, the silanized quartz flour as well as Aktisil MAM come out around 60 Shore A, while the highest level will be obtained with Aktisil Q at about 70 Shore A.

Dicumyl Peroxide

The flux-calcined diatomaceous earth and the silanized quartz flour here give rise to an increase of 20 points above the base compound with no additional fillers, which is situated at around 40 Shore A. Again, Aktisil Q leads to a more pronounced increase towards 70 Shore A.

Tensile strength and 100 % modulus

Curing Agent E



The tensile strength levels attained are a definite function of the fillers used. With Sillitin, the tensile strength falls off most of all, in total a negative effect. Also the untreated quartz flour and the flux-calcined diatomaceous earth give rise to a slight decrease. Surface treatment of Sillitin brings about a marked improvement, as shown with Aktisil MAM. Aktisil Q is able to further increase the tensile figures nearly up to the level of the base compound without additional fillers, or the compound with the treated quartz flour.

The very low 100 % modulus of the base compound is already slightly increased with Sillitin, while untreated quartz flour and flux-calcined diatomaceous earth come out somewhat higher. The modulus figures with silanized quartz flour and Aktisil MAM are relatively high, but they are still surpassed with Aktisil Q.

Curing Agent C6

Here the tensile strength of about 10 MPa of the base compound is brought down most by untreated quartz flour, to 4 MPa. Aktisil MAM at 5 MPa only brings about a minor improvement. The use of flux-calcined diatomaceous earth, which reaches 6 MPa, appears more favorable with Curing Agent C6 than Aktisil MAM, a difference to the situation with Curing Agent E. The best tensile strength figures with almost 8 MPa can be obtained with the silanized quartz flour or with Aktisil Q.

The untreated quartz flour only brings up the low 100 % modulus of 0.6 Mpa of the base compound to 1.1 MPa. The silanized quartz flour, the flux-calcined diatomaceous earth and Aktisil MAM, by contrast, increase the modulus somewhat more, to roughly 2 MPa, with hardly any difference to find between these fillers. Again, Aktisil Q gives rise to the highest 100 % modulus of nearly 3 MPa.

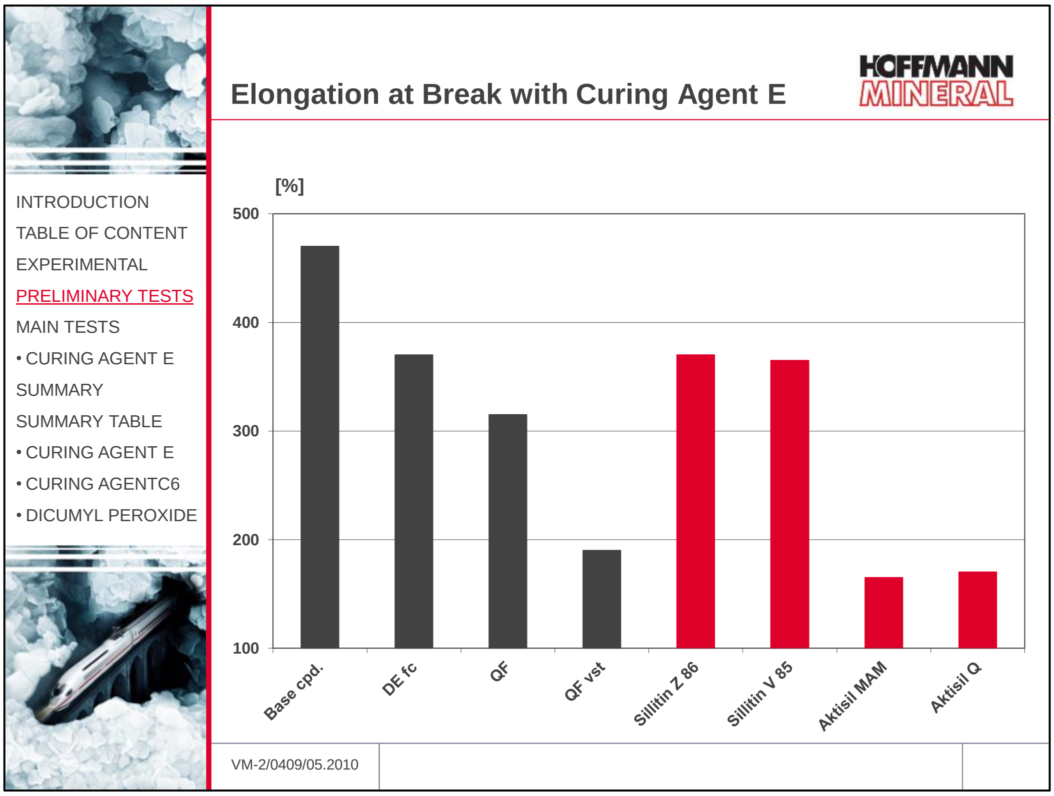
Dicumyl Peroxide

The tensile strength figures with Aktisil Q and with flux-calcined diatomaceous earth reach a level around 7 MPa, somewhat below the silanized quartz flour (8 MPa). The high level of 11 MPa for the base compound without additional fillers cannot be reached with any of the fillers tested.

The low 100 % modulus of 0.7 MPa of the base compound is increased by the flux-calcined diatomaceous earth and the silanized quartz flour up to around 2 MPa, with Aktisil Q still higher at 3 MPa.

Elongation at break

Curing Agent E



The initial elongation at break of the base compound is reduced by all fillers added. The flux-calcined diatomaceous earth, Sillitin Z 86 and Sillitin V 85 come out closest to those levels, followed by the untreated quartz flour. A surface treatment of the fillers, in HTV silicone rubber like in most other elastomers, leads to a reduced elongation at break, as confirmed by the figures for quartz flour, Aktisil MAM and Aktisil Q.

Curing Agent C6

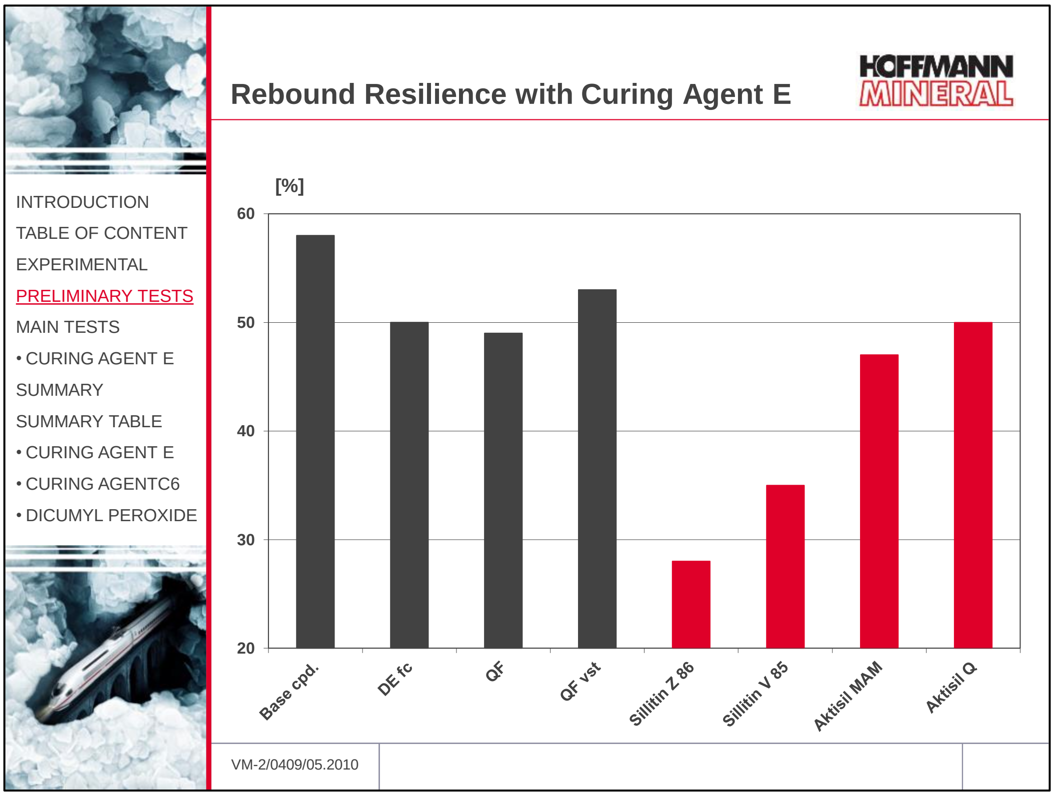
In this series, only the flux-calcined diatomaceous earth attains the 600 % of the base compound, shortly followed by the untreated quartz flour at 540 %. The surface treatment of the quartz flour causes the elongation to go down to just above 300 %, at level with Aktisil MAM. The silanization of Aktisil Q leads to a somewhat stronger reduction of the elongation at break (220 %) compared with these two fillers.

Dicumyl Peroxide

Working with flux-calcined diatomaceous earth here gives origin to a slight reduction of the very high elongation at break of the base compound, i.e. from 700 % to about 590 %. The silanized quartz flour brings down the elongation to almost 300 %, while Aktisil Q reaches just 230 %.

Rebound resilience

Curing Agent E



Diatomaceous earth, the quartz flours and Aktisil Q allow to almost match the high rebound of the base compound with no additional fillers. Aktisil MAM comes out somewhat lower than the other fillers, the two Sillitin grades are still further down.

Curing Agent C6

The 40 % rebound resilience of the base compound will be increased by above 5 points by adding flux-calcined diatomaceous earth, surface treated quartz flour or Aktisil Q. Aktisil MAM, by contrast, brings the level down by about 10 points, but not quite as much as the untreated quartz flour to 25 %.

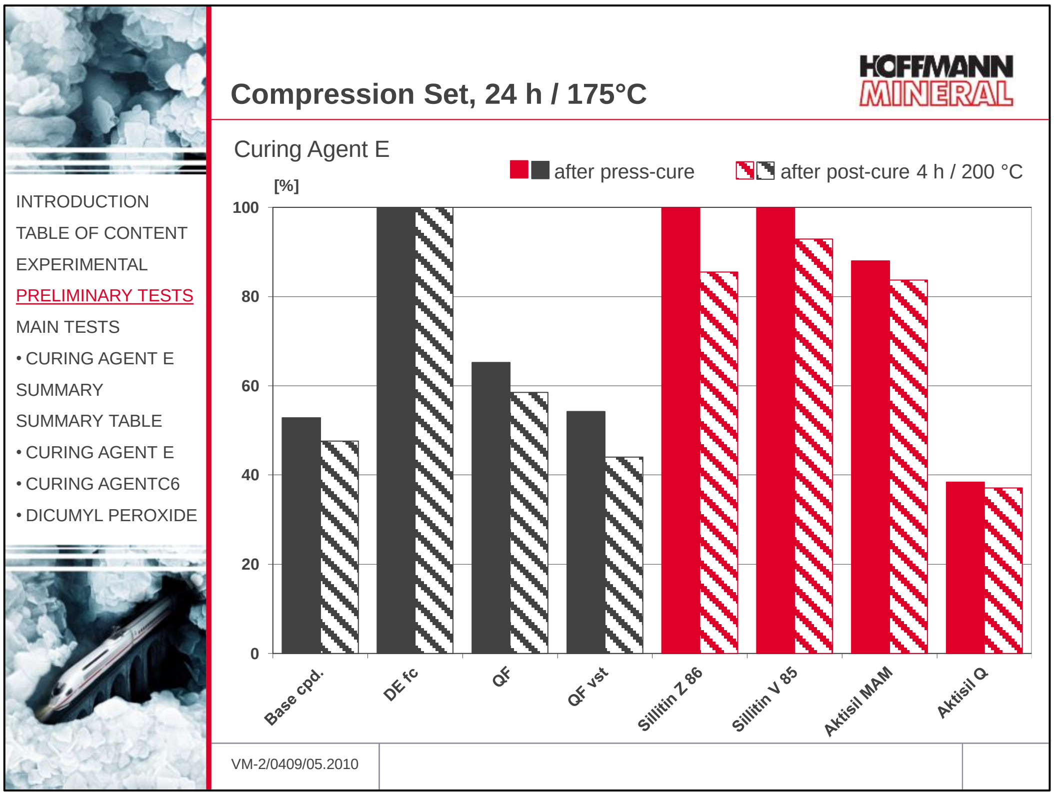
Dicumyl Peroxide

With this curing agent, there is hardly any difference between the base compound and the compounds loaded with silanized quartz flour or Aktisil Q (close to 50 %). Flux-calcined diatomaceous earth, at 45 %, comes out somewhat lower.

Compression set

The compression set (24 h / 175 °C) was determined prior to and after post-cure of samples.

Curing Agent E



The attractive compression set of the base compound cannot be equalled neither with Sillitin grades nor with Aktisil MAM, or with diatomaceous earth. The untreated quartz flour imparts a lower compression set than those fillers, but is also unable to reach the good level of the base compound without any added fillers. Only the silanized quarts flour comes out at the level of the base compound. As shown in the graph, Aktisil Q allows to go before post-cure already below the level of the base compound after post-cure. Post-curing the Aktisil Q compound does not give rise to much change, in other words with this filler a post-cure is not mandatory.

Curing Agent C6

The low compression set (33 %) of the base compound will be increased by a factor of two with flux-calcined diatomaceous earth, untreated quartz flour and Aktisil MAM. Post-cure tempering causes the compression set with diatomaceous earth and quartz flour to go down somewhat more than with Aktisil MAM, but they remain still largely higher than in the base compound. In the base compound without added fillers, the post-cure reduces the compression set to 25 %. The compounds with silanized quartz flour and Aktisil Q are roughly comparable with the base compound, and this prior to and after post-cure. Before post-cure, the compression set with Aktisil Q comes out slightly lower than with silanized quarts flour, but after post-cure the figures come close to each other.
With Aktisil Q, evidently, the post-cure step can be left out.

Dicumyl Peroxide

The silanized quartz flour and Aktisil Q attain a comparable level with the base compound with no added fillers (about 18 %), while the diatomaceous earth compound shows a marked increase of the compression set, which is reduced by post-cure tempering, but still remains way above of the other compounds. The post-cure tends to slightly increase the compression set of the Aktisil Q compound. The base compound and the silanized quartz flour compound show hardly any effects. In consequence, also here post-cure can be eliminated.

3.4 Cured rubber properties after hot air aging

The heat aging was run for 168 h at 200 °C on S2 dumbbell samples post-cured for 4 h at 200 °C.

The following comments refer to the property changes caused by the aging in hot air. Individual test results are compiled in the Appendix.

Working with untreated Sillitin grades in combination with Curing Agent E is principally possible, but the very poor aging resistance of such compounds does not advocate their use.

Flux-calcined diatomaceous earth with Curing Agent E similarly gives just a moderate aging resistance, while such compounds with Curing Agents C6 or dicumyl peroxide come out rather poor. Untreated quartz flour likewise leads only to a moderate hot air aging resistance.

The surface treated version of quartz flour, by contrast, presents itself rather positively with respect to heat aging properties.

Aktisil MAM also shows deficits regarding the hot air resistance; these can be overcome, however, with Aktisil Q. This grade, similar to the silanized quartz flour, gives excellent mechanical results after the hot air aging test.

The favorable aging properties of the base compound without additional fillers can, therefore, be nearly matched with silanized quartz flour or Aktisil Q.

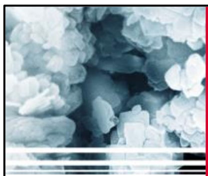
3.5 Conclusions from the preliminary tests

The surface treated quartz flour as well as Aktisil Q allow to reach good mechanical properties. The latter in addition imparts a higher degree of cure, higher hardness and more favorable compression set.

In the main test series, therefore, loading variations were run with these two fillers in comparison.

4 Main tests

4.1 Compound formulations



Curing Agent E

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Formulation, loading in phr

Elastosil R 401/40	100	100	100	100	100	100	100	100
Elastosil AUX Curing Agent E	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
QF vs		25	50	100				
Aktisil Q					25	50	75	100

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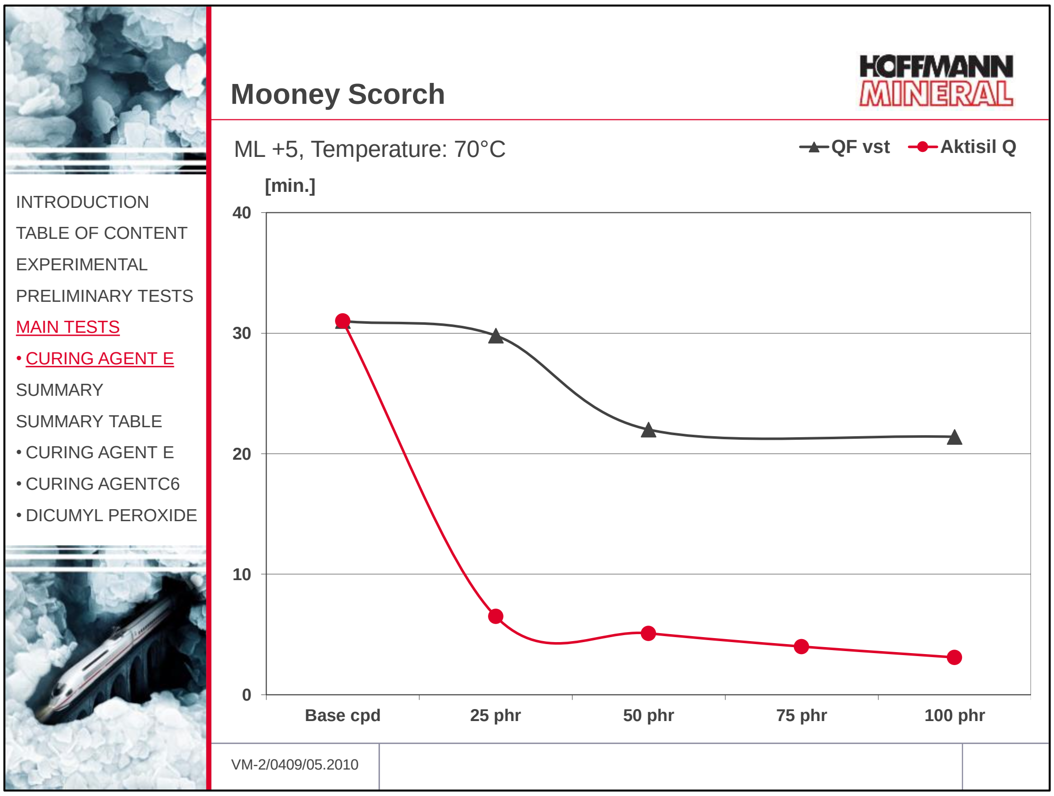
Silanized quartz flour and Aktisil Q were used at loadings of 25, 50 and 100 phr. With Aktisil Q, also a loading of 75 phr was included, because in the preliminary tests at 100 phr Aktisil Q had led to higher hardness vs. the treated quartz flour.

The following will highlight the loading variatons with silanized quartz flour and Aktisil Q in combination with Curing Agent E.

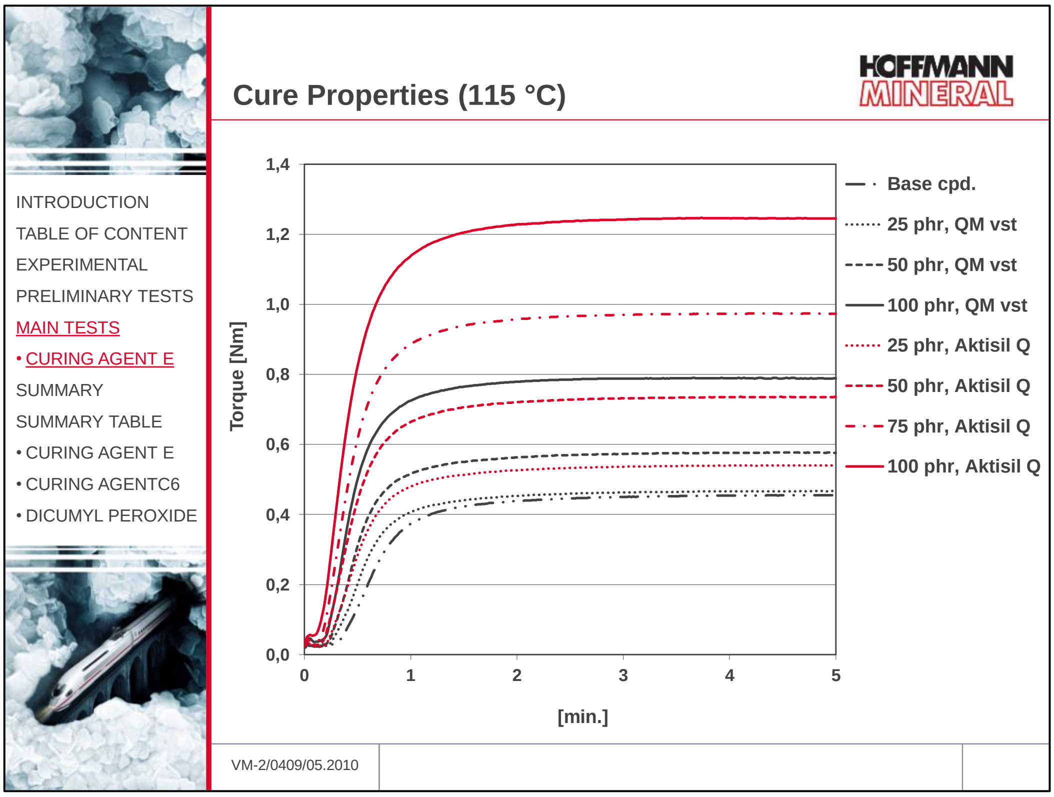
4.2 Scorch time and curing profiles

Scorch time



The graph shows that scorch times are becoming shorter with increasing filler addition. As already seen in the preliminary tests, this effect is highly pronounced with Aktisil Q, so here the lowest possible processing temperature should be applied. The storage stability of the compounds, however, remains ensured (see below, item “Change of curing profiles upon storage at room temperature”).

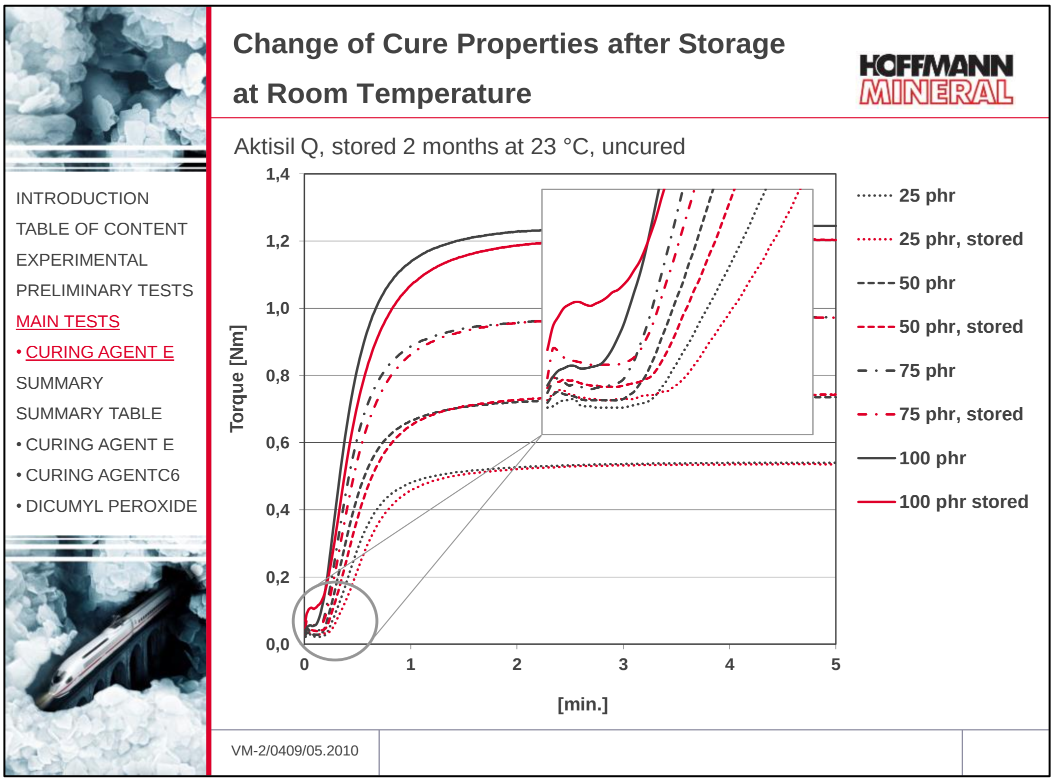
Curing profiles



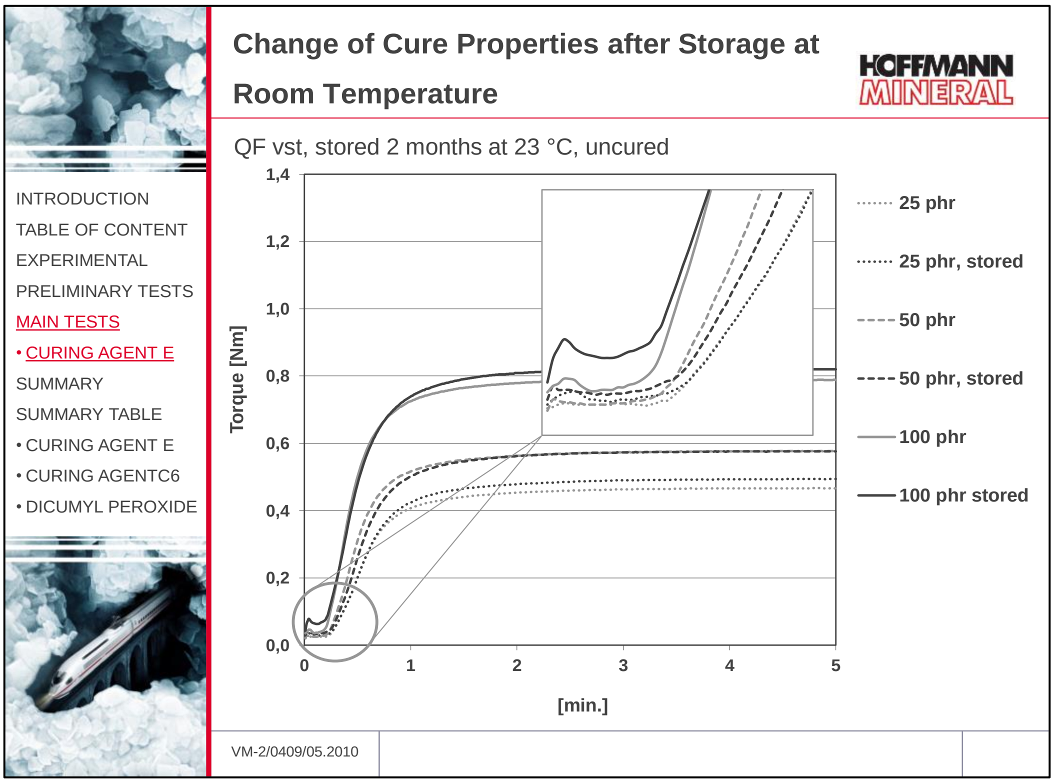
As little as 25 phr Aktisil Q almost come up to the maximum torque which will be attained with 50 phr silanized quartz flour. The graph also indicates that the torque maximum with 100 phr treated quartz flour is exceeded with 75 phr Aktisil Q.

Change of the curing profiles upon storage at room temperature

In view of the much shorter Mooney scorch times when working with Aktisil Q, the raw compounds were again checked for their curing characteristics after about 2 months of storage at 23 °C, in order to define their storage stability.



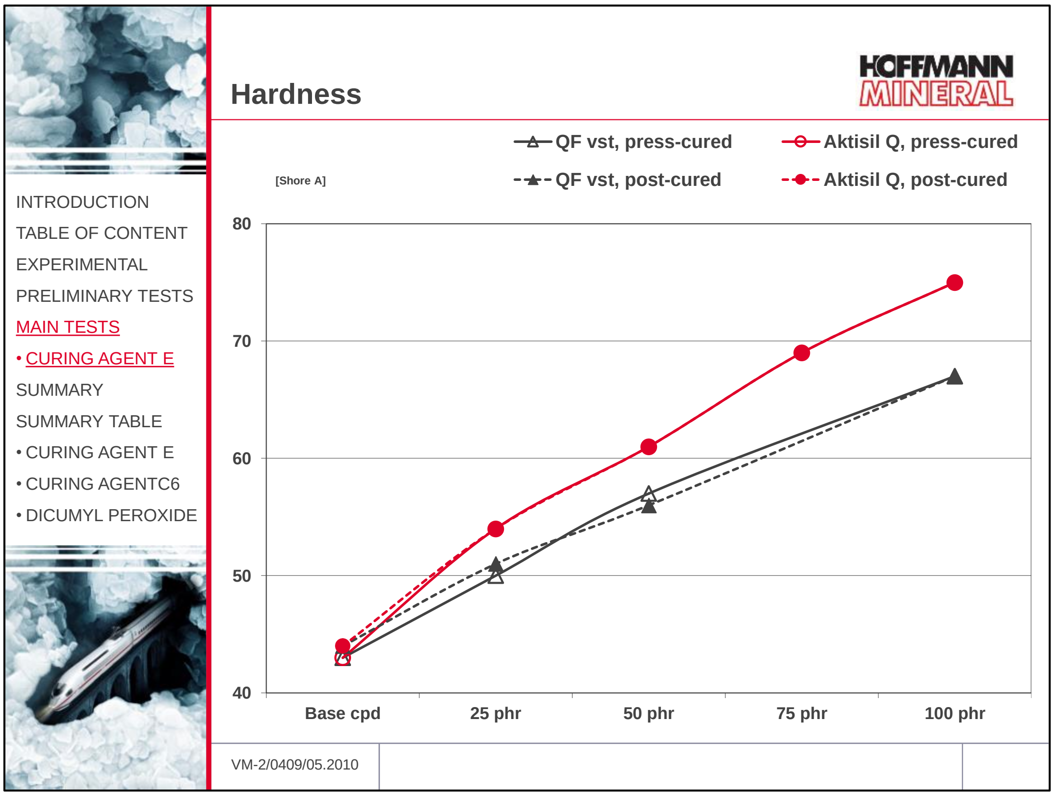
Loadings up to 75 phr Aktisil Q do not cause any significant changes in the uncured compounds. Above this loading, there is a slight decrease of the maximum torque. whereas the minimum torque increses, as shown with the 100 phr compound. In other words, a storage stability at ambient temperature (23 °C) is assured up to loadings of 75 phr.



An increase of the torque minimum with 100 phr is also seen for the silanized quartz flour. In addition, there is a trend towards an increased maximum torque.

4.3 Cured rubber properties

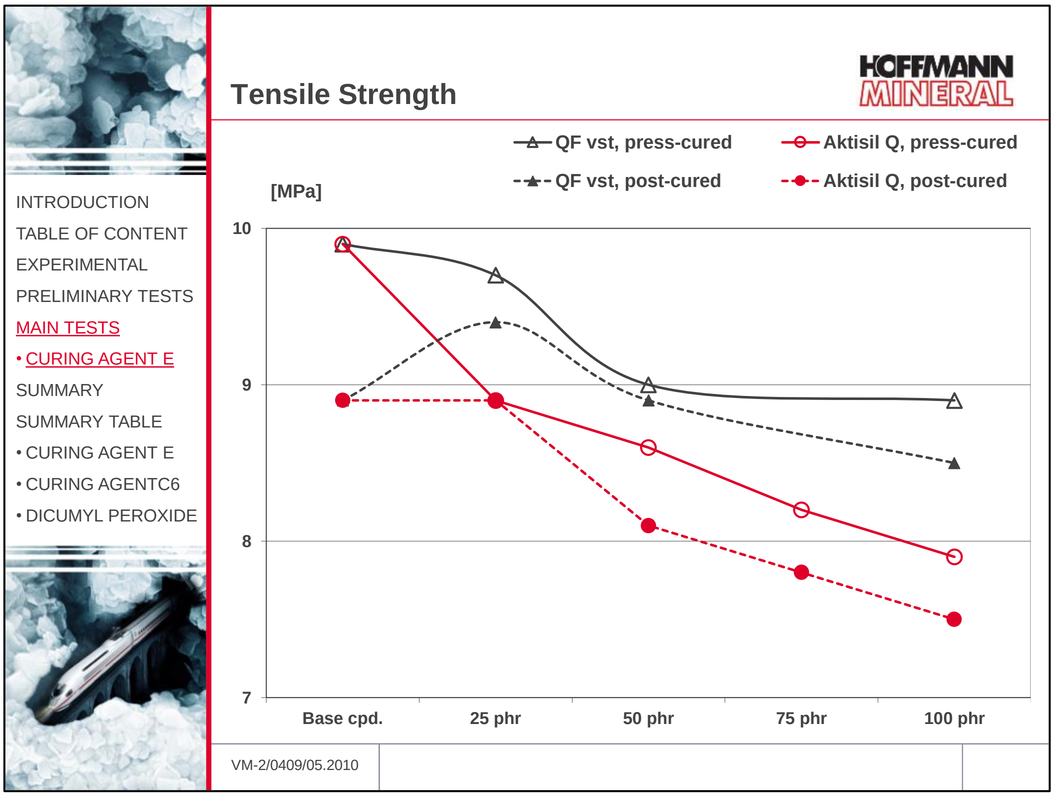
Hardness



At equal loadings, Aktisil Q always leads to higher hardness than the treated quartz flour. It is clearly evident that 75 phr Aktisil Q are able to match the hardness with 100 phr of the silanized quartz flour.

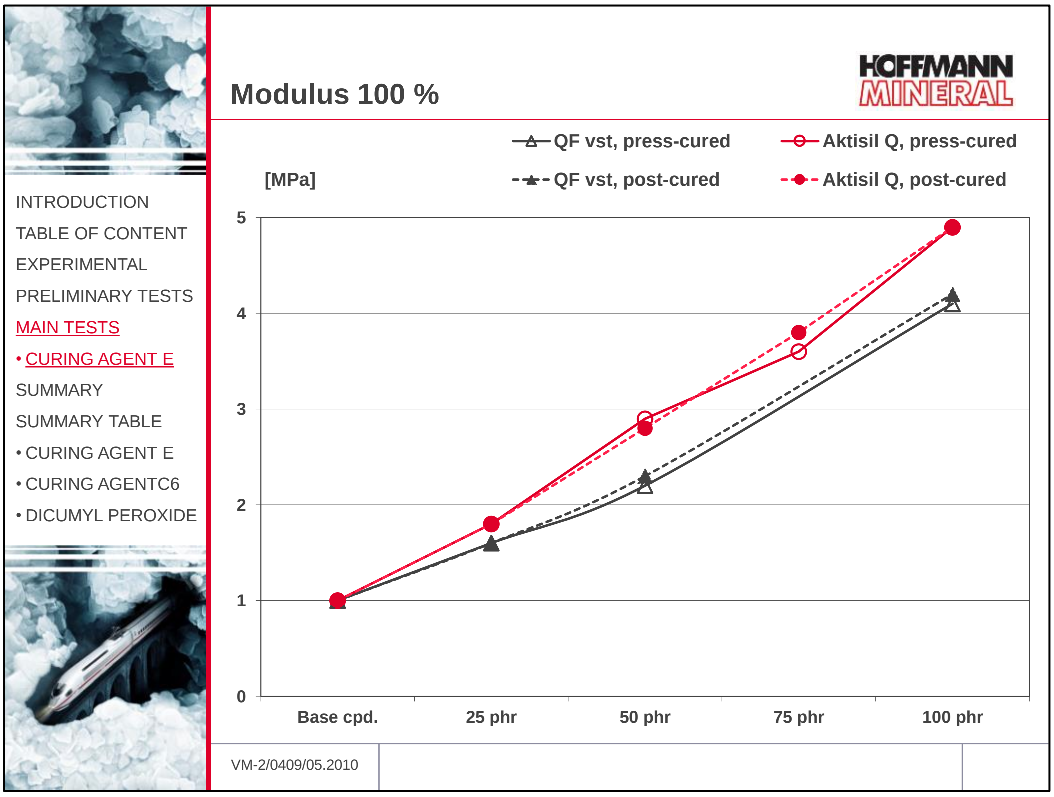
As clearly shown in the graph, a post-cure (tempering) does not exert any influence on the hardness levels.

Tensile strength



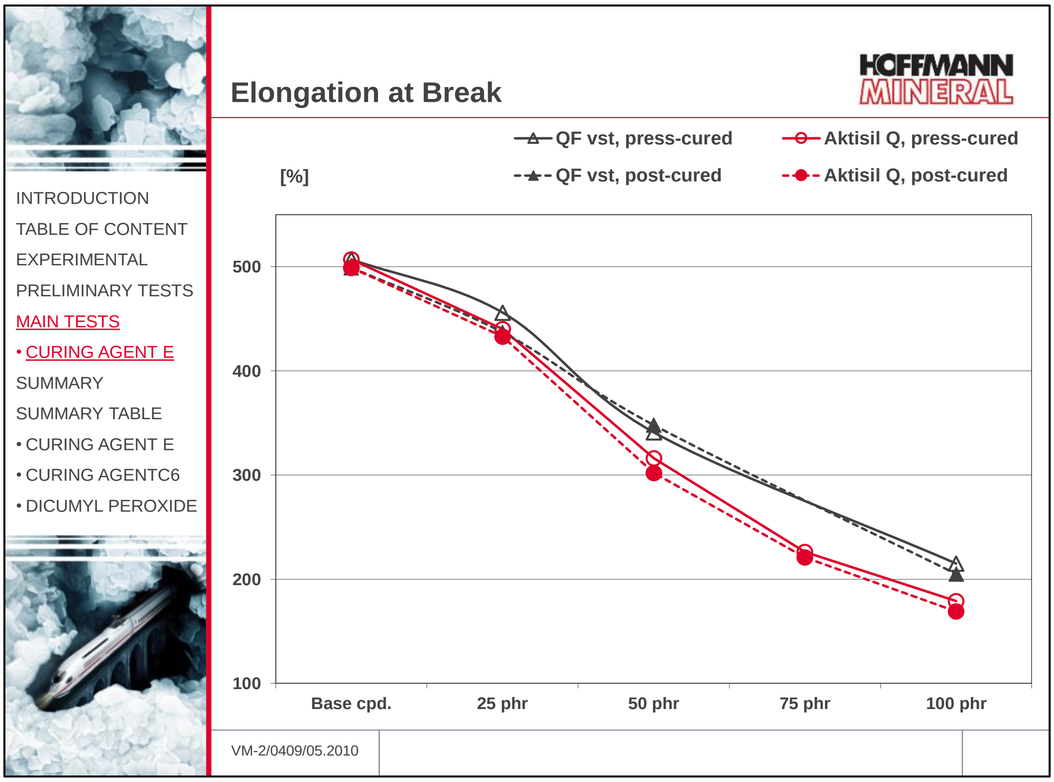
Higher filler loadings give rise to slightly reduced tensile strength. Aktisil Q at equal loadings comes out just below the silanized quartz flour. Post-cure causes an increase of tensile strength with the base compound, while the compounds with added fillers rather show a slight decrease.

100 % modulus



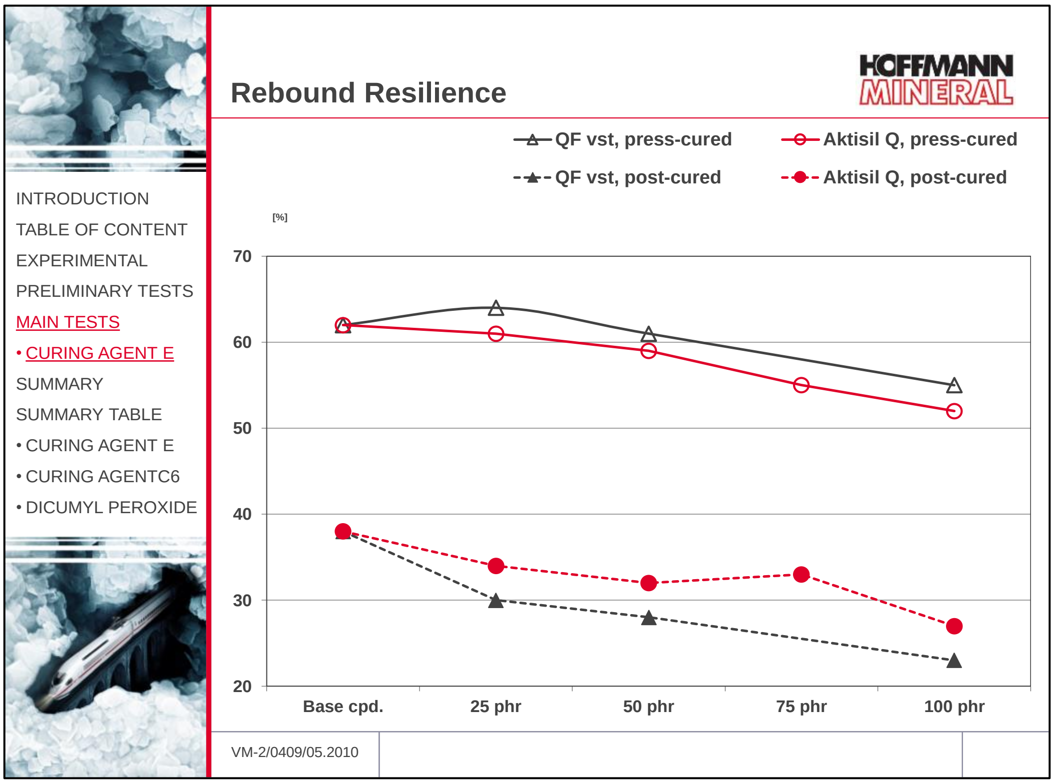
A modulus increase is more pronounced with Aktisil Q than with silanized quartz flour. Here again, hardly any influence of post-curing can be observed.

Elongation at break



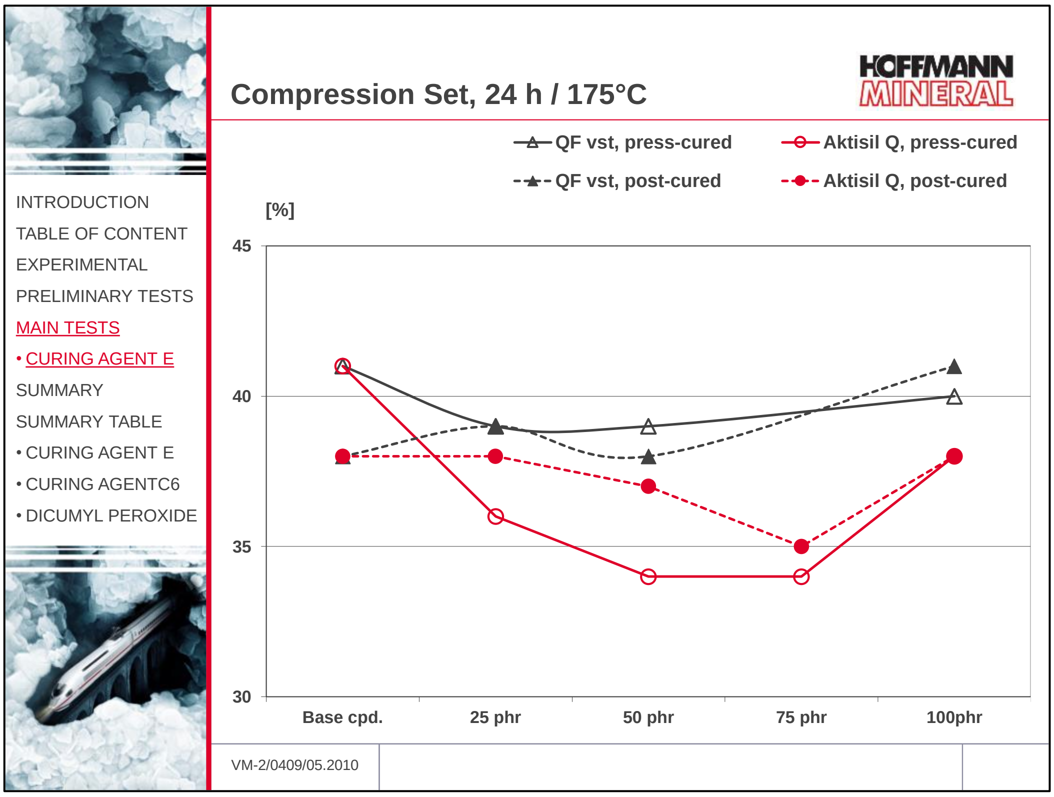
Addition of fillers causes the elongation at break to fall off, and this all the more the higher the filler loading. The graph shows that the elongation decrease is somewhat more pronounced with Aktisil Q compared to the silanized quartz flour at equal loading. When comparing the 75 phr Aktisil Q compound with the 100 phr quartz flour compound (equal hardness), the elongation at break is found on an equal level. A post-cure does not have any effects on the elongation.

Rebound resilience



With increasing filler loadings, the rebound resilience will go down slightly. As also evident from the graph, a post-cure causes the rebound to drop off. This effect is somewhat less pronounced with Aktisil Q than with silanized quartz flour.

Compression set



Prior to post-cure, the silanized quartz flour compound gives a compression set lower than the base compound without additional fillers prior to post-cure. However, the low level of the post-cured base compound will not be matched, even with post-cure. In total, post-curing does not show very big effects on the compression set with silanized quartz flour.

As shown in the graph, Aktisil Q distinctly remains under the compression set figures obtained with silanized quartz flour. Similarly, with 25 phr Aktisil Q the compression set of the base compound will already be improved. Increasing the Aktisil Q loading up to 75 phr results in a further decrease and attains a minimum. At still higher loadings there comes about a slight new increase, however, just to the level of the post-cured base compound. In general, a post-cure in Aktisil Q compounds has rather negative effects, insofar as the compression set goes up somewhat.

4.4 Cured rubber properties after hot air aging and immersion in Reference Oil IRM 903

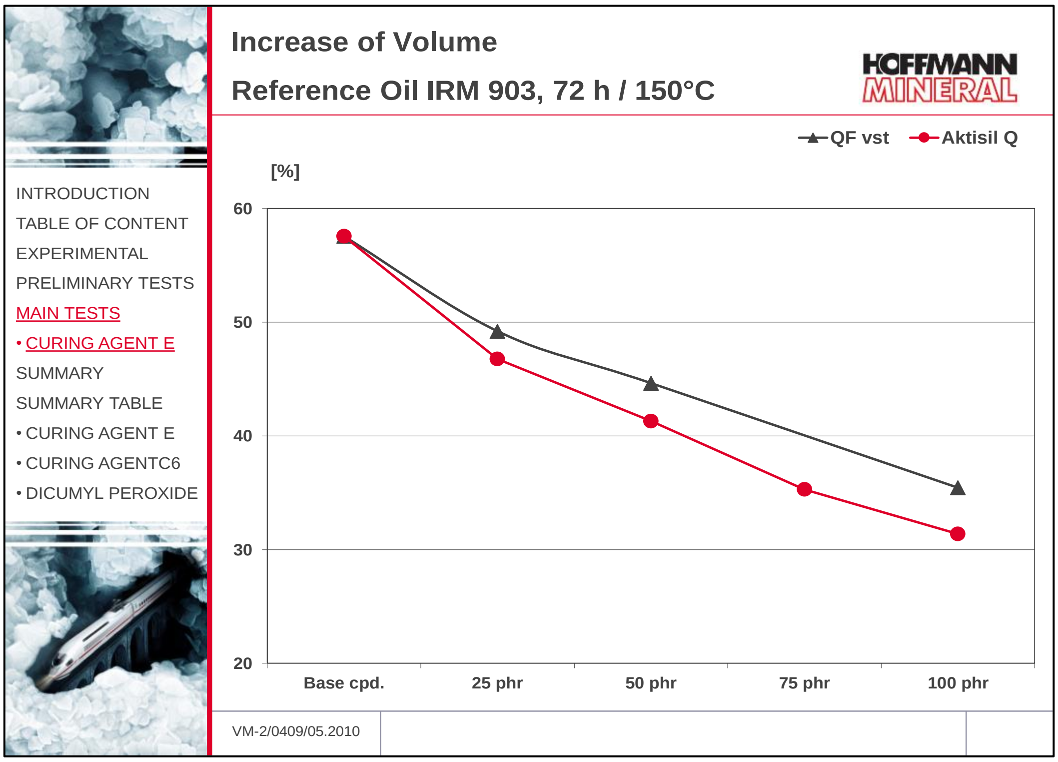
Hot air aging

Heat aging was run for 168 h at 200 °C on S2 dumbbells after post-cure for 4 hours at 200 °C.

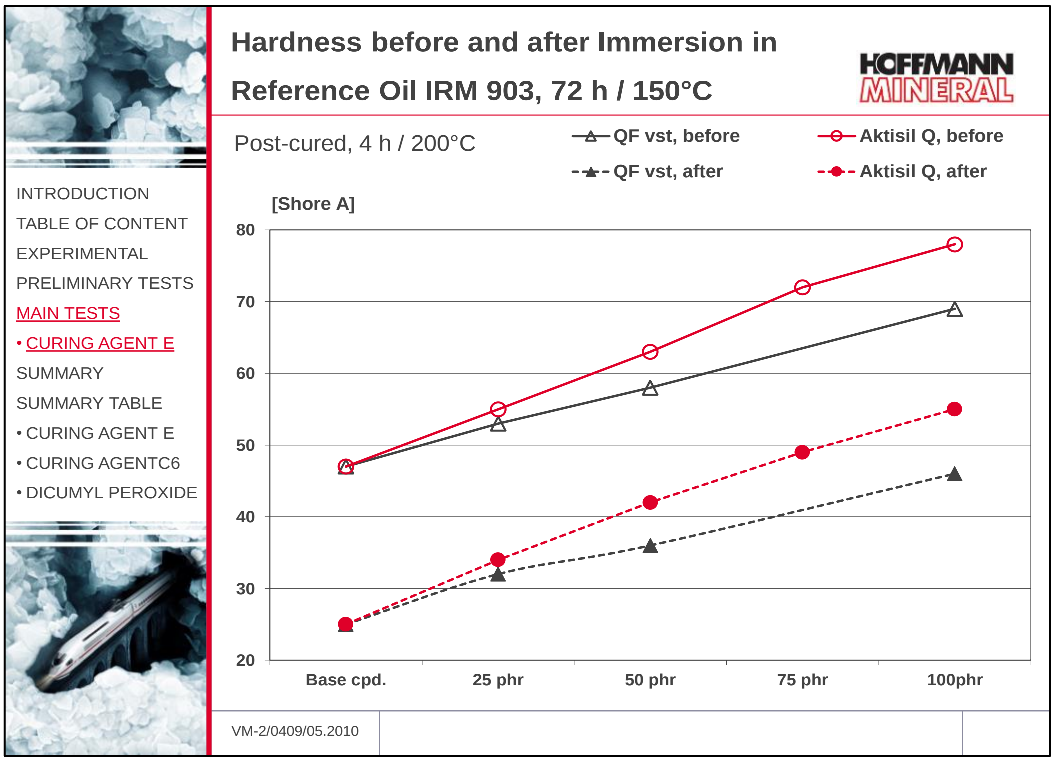
No significant difference could be seen in the heat aging resistance between the base compound and the compounds with additional fillers. Therefore, the results will not be presented here, but individual figures can be consulted in the Appendix.

Immersion in Reference Oil IRM 903

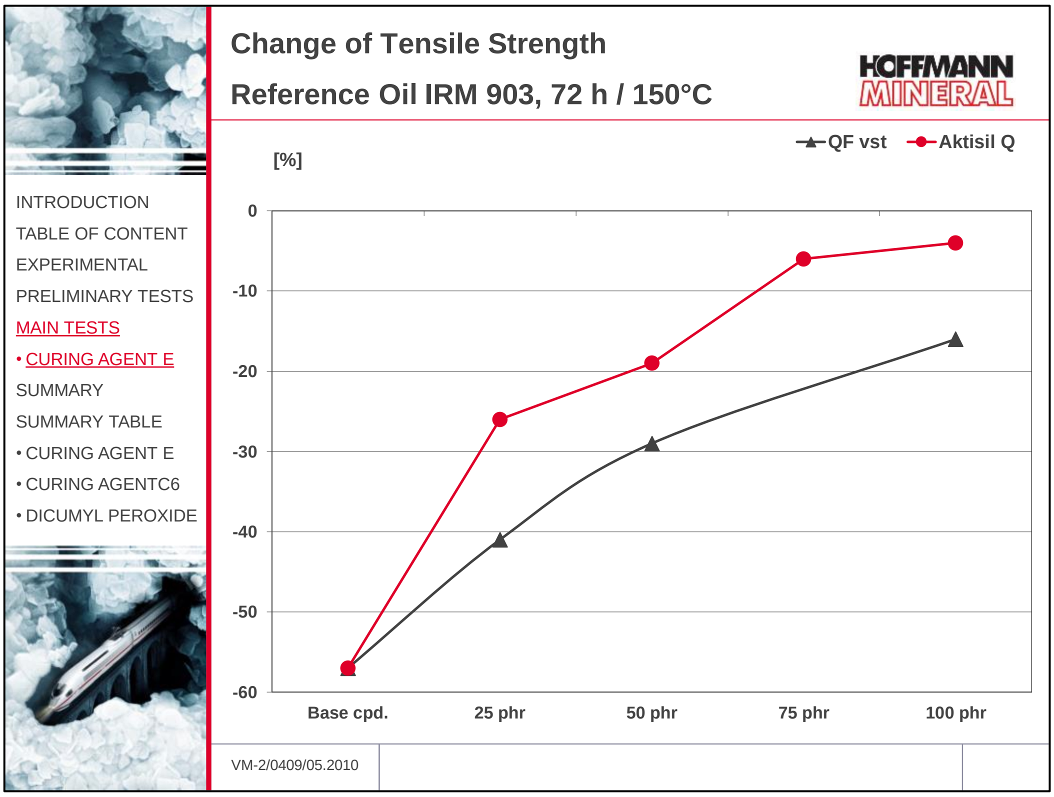
The immersion test was run on S2 dumbbells for 72 h at 150 °C.



The addition of fillers is able to markedly reduce the volume increase. As seen in the graph, Aktisil Q has a more favorable effect as it causes a lower volume increase than the silanized quartz flour. Already with 75 phr Aktisil Q a comparable volume increase as with 100 phr quartz flour is obtained, and 100 phr Aktisil Q come out again lower. Analogous effects are found for the weight increase which, therefore, will not be illustrated here. Without post-cure, Aktisil Q attains a marginally higher increase of volume and weight of about 1 to 2 %.



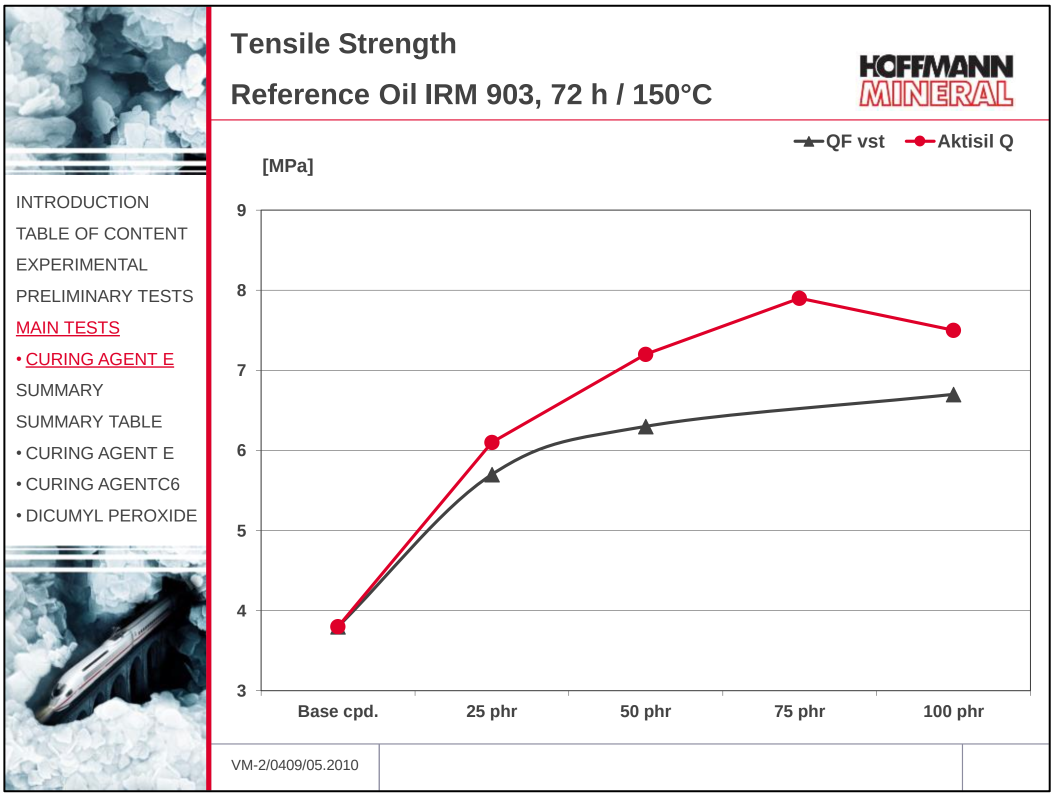
The hardness changes upon immersion in the Reference Oil are practically the same for all compounds tested. This means that the higher Shore A level with Aktisil Q is maintained also after the immersion test. This is also valid for compounds that have not been post-cured.



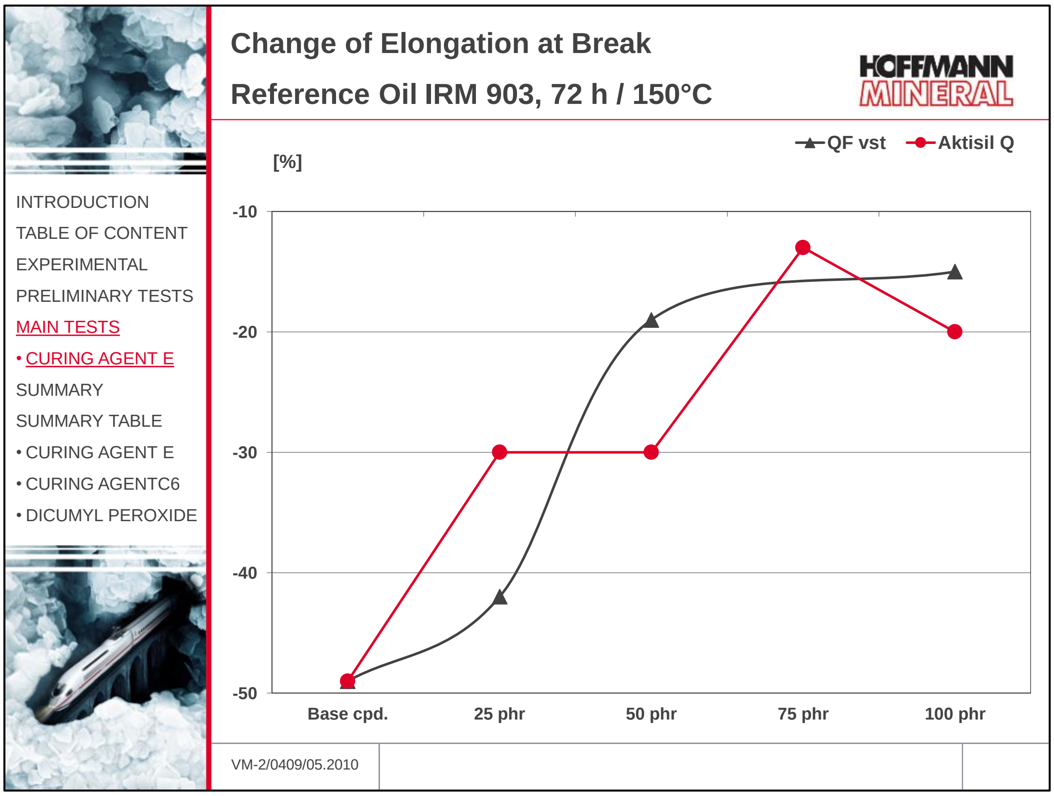
Upon immersion in Reference Oil IRM 903, the tensile strength of the base compound drops off considerably. The addition of further fillers is able to markedly reduce this effect.

The graph shows Aktisil Q to cause a markedly lower decrease of the tensile strength compared with the silanized quartz flour. Already 50 phr Aktisil Q impart a tensile strength reduction comparable with 100 phr silanized quartz flour. Further increases of the Aktisil Q loading lead to a further reduced effect of the Reference Oil.
Even without post-cure lower changes of the tensile strength are obtained with Aktisil Q.

In summary, as evident from the graph below, the absolute tensile strength figures are higher with Aktisil Q compared to the treated quartz flour, and also to the base compound with no further fillers added. A loading of 75 phr Aktisil Q imparts the highest tensile strength obtainable.



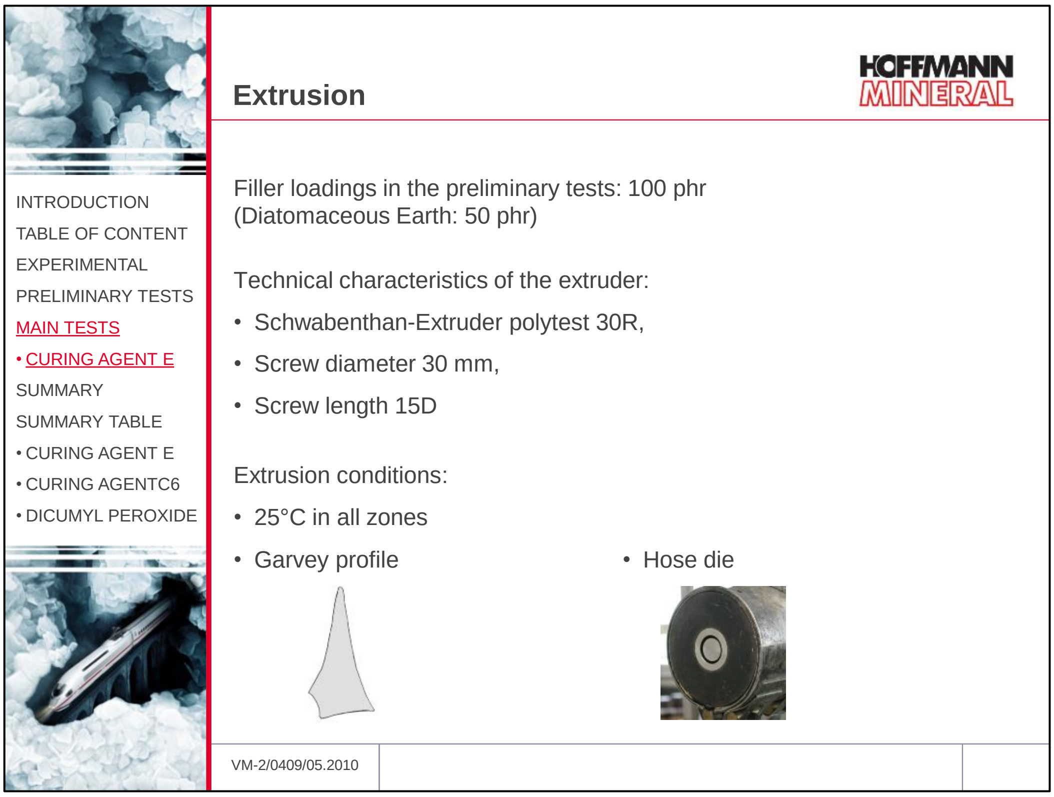
Without post-cure, the absolute values of the tensile strength with Aktisil Q are comparable to the values of the treated quartz flour.



As shown in this graph, higher filler loadings tend to minimize the reducing effect on the elongation at break of the immersion in the Reference Oil.
Without post-cure this statement is also valid.

4.5 Extrusion

The extrusion tests were carried out within the Preliminary Test series, with the fillers used there.



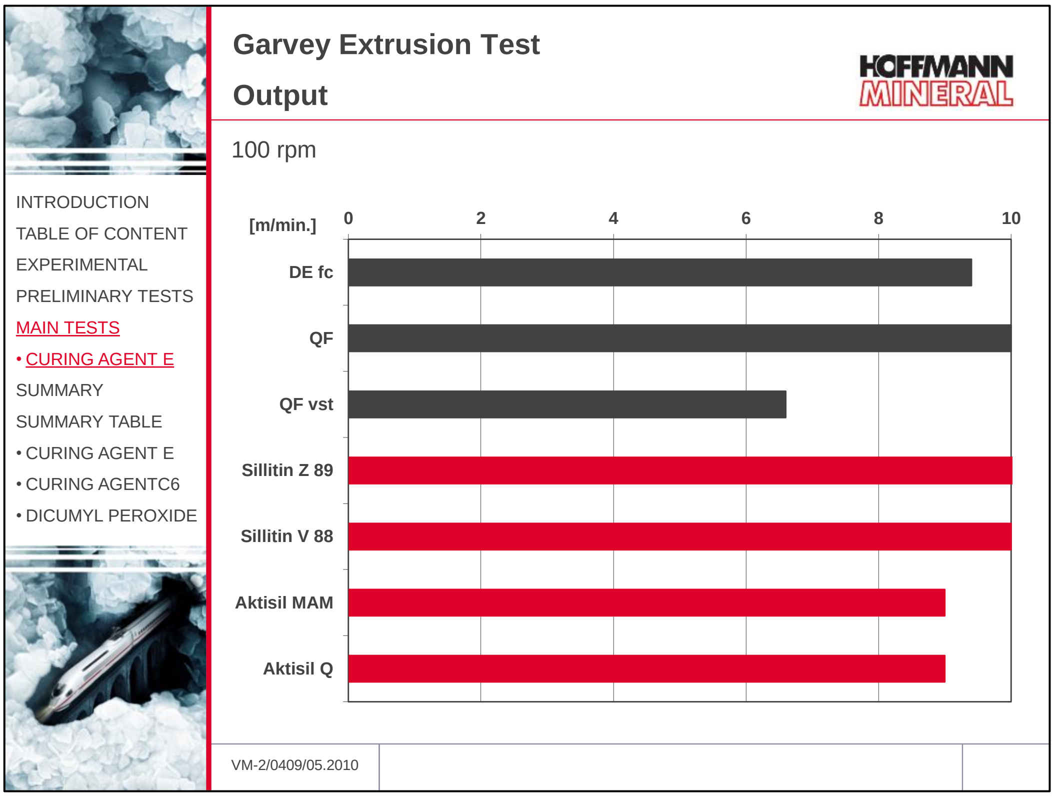
Garvey extrusion

In order to start with qualitative indications, at first extrusion tests were run with the Garvey die. Besides the usual results for output or haul-off speed, the special geometry of the die orifice allows to assess simultaneously edge quality, surface appearance and die swell of the extrudates.

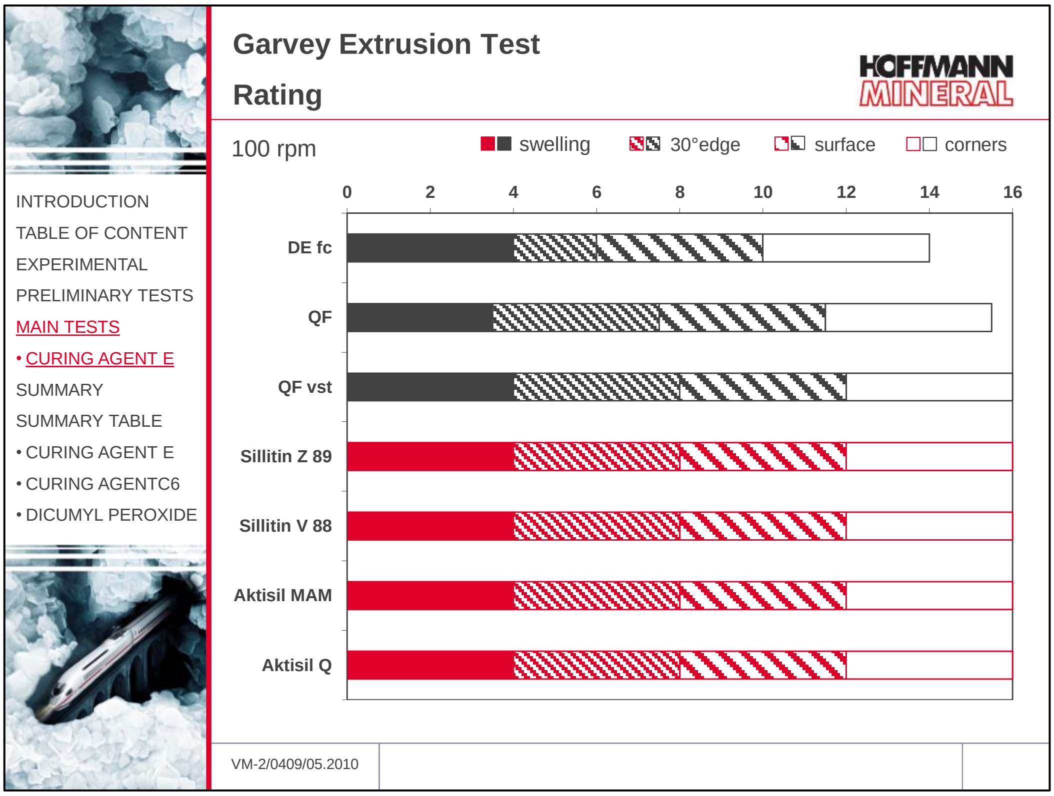
First of all, it was tried to establish the maximum haul-off speed for a “4444” rating of the compound with Sillitin V 88 (4 is the highest individual Garvey rating, “4444” therefore means excellent die swell, 30° edge, surface appearance and corners). However, it turned out to be impossible to obtain a haul-off speed higher than indicated in the following graphs, as the laboratory extruder could only be run up to 100 rpm. For the other compounds, therefore, the screw speed was kept constant, and the resulting output was measured.

The qualitative assessment was based on uncured profiles according to ASTM D 2230-96. With one exception, the cured profiles gave identical results: the Sillitin Z 89 compound developed blisters on the surface.

For curing, profile sections were laid onto glass plates and heated for 7 minutes at 200 °C in a hot air oven.



For all fillers used, the output at a screw speed of 100 rpm is found between 9 and 10 m/min, excepted the compound with silanized quartz flour, which only arrives at a much lower figure.

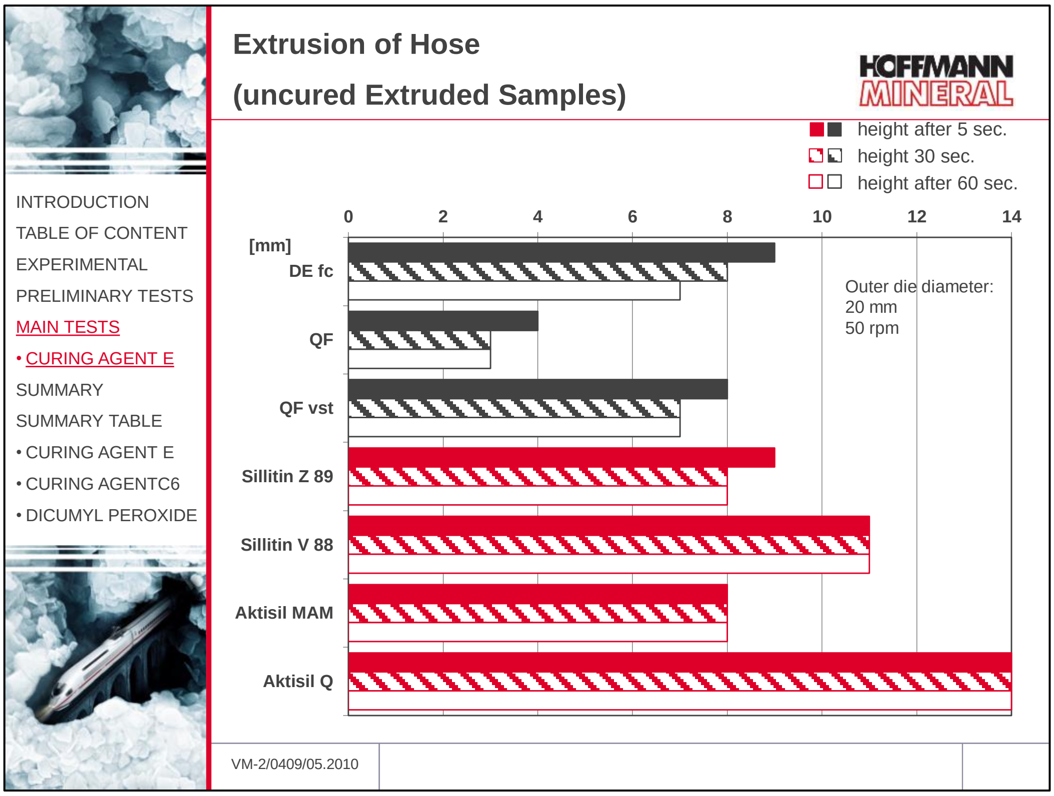


The qualitative extrusion properties of the fillers tested must be judged throughout as good. Only the flux-calcined diatomaceous earth shows a deficit in the 30° edge formation. The quality of the profile with silanized quartz flour is quite good, but as already shown in the graph above, the output is much reduced. The best results, qualitative as well as quantitative, are obtained with the Sillitin and Aktisil grades.

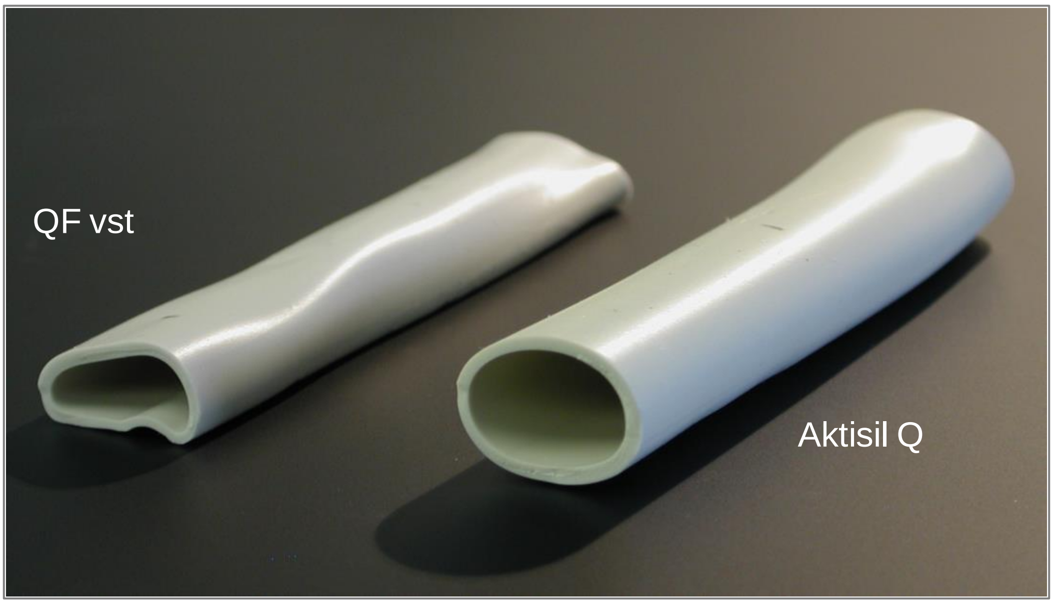
Hose extrusion

For assessing the collapse resistance of the compounds, besides the Garvey profiles also hose profiles were extruded. The process parameters were kept equal to the Garvey tests, just for easier handling the screw speed was reduced to 50 rpm.

The height of the hose sections was measured 5; 30 resp. 60 seconds after exiting from the die orifice (outer diameter: 20 mm).



The hose section filled with untreated quartz flour shows the lowest height, which further goes down in subsequent seconds. Flux-calcined diatomaceous earth, silanized quartz flour, Silltin Z 89 and Aktisil MAM all give comparable results after 60 seconds. By contrast, the Sillitin V 88 compound comes out with a constant height over the whole test period, and this at a somewhat higher level than the other fillers mentioned before. With Aktisil Q the highest hose profile will be obtained, whose height will not diminish over the time period observed, which means this filler undoubtedly is able to ensure the best collapse resistance or dimensional stability.



4.6 Appearance of extrusions and cured samples

Stickiness of extruded sections

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Stickiness of the Uncured Extruded Compound

HOFFMANN MINERAL

	Stickiness
Diatomaceous Earth, fluxcalcined	None
Quartz flour	Yes
Quartz flour, vinylsilane treated	Yes
Sillitin Z 89	None
Sillitin V 88	None
Aktisil MAM	None
Aktisil Q	None

VM-2/0409/05.2010

The uncured extrusions filled with quartz flour tend to exhibit a markedly higher surface stickiness, independent of a surface treatment of the filler. The diatomaceous earth and all Sillitin and Aktisil grades leave the extruded compounds free from surface stickiness.

Color

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Color of Cured Compound

HOFFMANN MINERAL

	① QF vst	② Aktisil Q
L*	78.7	79.7
a*	0.9	0.6
b*	6.3	11.6

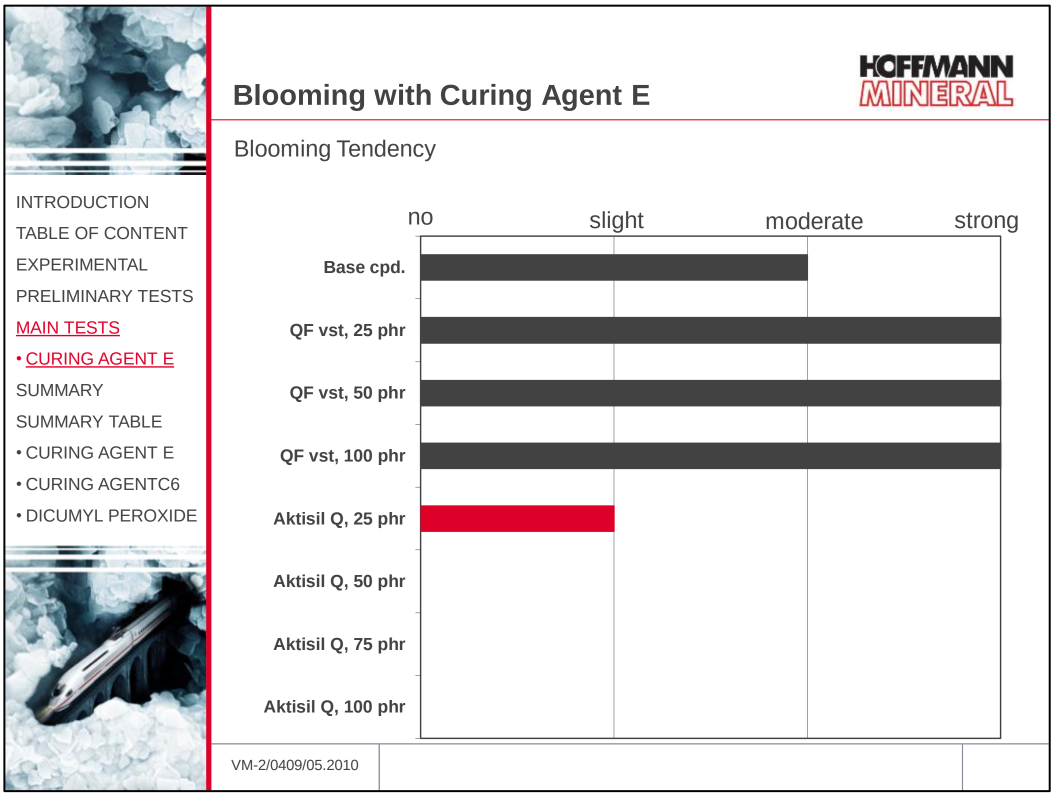
Filler loading: 25 phr

VM-2/0409/05.2010

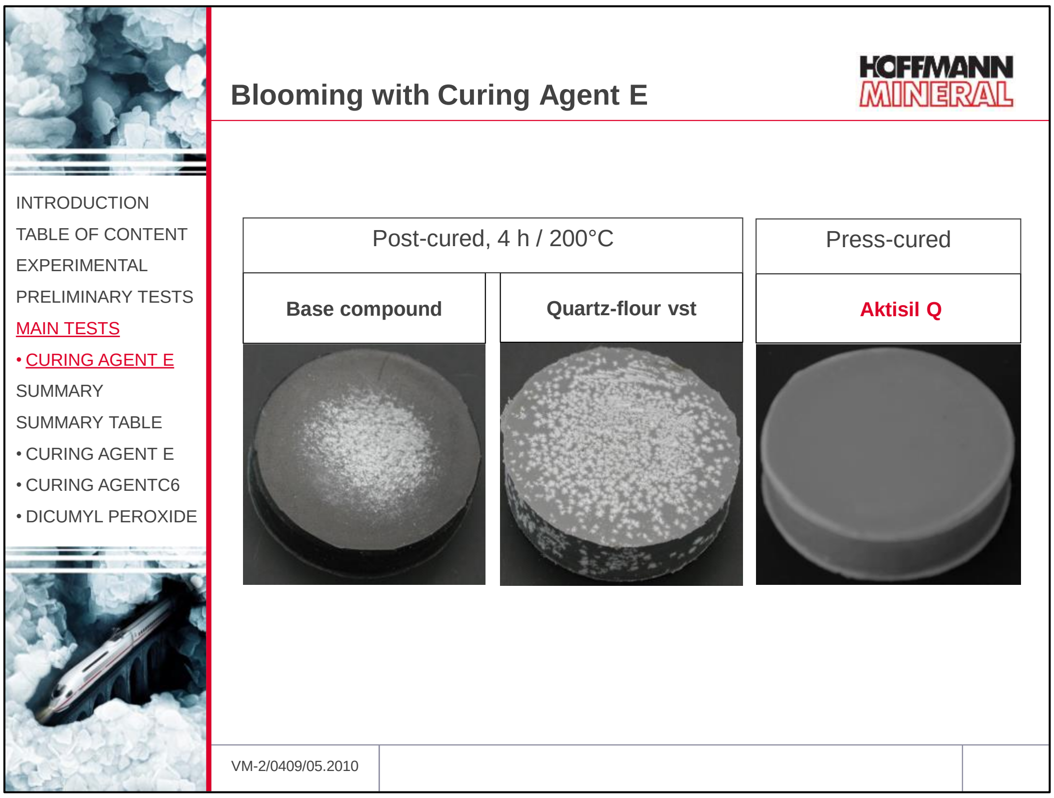
Compared with quartz flour, the compounds filled with Aktisil Q are characterized by a slight yellowish tint, identifiable by the higher b*-value.

Blooming with Curing Agent E

After some days of storage, post-cured samples crosslinked with Bis-(2.4-dichlorobenzoyl)-peroxide often tend to exhibit a blooming of benzoic acid derivates on their surface. The following graph illustrates the blooming tendency with different loadings of the two fillers.



Evidently, surface treated quartz flour promotes the blooming effect. By contrast, just 25 phr of Aktisil Q are able to minimize this tendency, and higher loadings prevent a blooming completely.
Furthermore, this is valid for Aktisil Q compounds without post-cure, whereas blooming occurs intensified with the base cpd. and especially with the treated quartz flour.



4.7 Loading variations with Curing Agent C6 and dicumyl peroxide

The following will discuss the essential results of the main test series with varied filler loading and the Curing Agent C6 and dicumyl peroxide. Individual test results can be consulted in the Appendix.

Compound formulations

The compound formulations are the same as with Curing Agent E. The concentrations of the curing agents also correspond to the Preliminary Tests.

Scorch time and curing profiles

The pronounced shortening of the scorch time with Aktisil Q is also found with Curing Agent C6 and dicumyl peroxide. Therefore, lower processing temperatures should be observed also here.

With Curing Agent C6, also the silanized quartz flour at higher loadings gives rise to a shorter Mooney scorch time, but this effect is not very pronounced.

With dicumyl peroxide and in part also with Curing Agent C6, the silanized quartz flour exhibits in the beginning a plateau effect for the torque, and not like in the base compound a steady “sneaking” increase. This results in longer time periods for the viscosity increase by 5 Mooney units, while the later rapid viscosity increase results in shorter ML+10 figures.

In general Curing Agent C6 and dicumyl peroxide give similar effects on the curing profiles as with Curing Agent E. With these two curing agents, the torque of the 25 phr Aktisil Q compound is at the same level as with the 50 phr silanized quartz flour compound. Likewise, with 75 phr Aktisil Q the torque maximum of the 100 phr quartz flour compound will be exceeded.

Hardness

Also with the Curing Agent C6 and dicumyl peroxide, Aktisil Q gives rise to higher hardness levels; with 75 phr Aktisil Q, the same hardness will be attained as with 100 phr quartz flour.
In no case, post-cure exerts a significant effect on the hardness level.

Tensile strength

Post-cure of the base compound without additional fillers does not much affect the tensile strength, already at the high level of around 11 MPa.

When working with Curing Agent C6, addition of silanized quartz flour or Aktisil Q gives rise to a decrease in tensile strength. This effect initially is less pronounced with the quartz filler, but catches up to equal Aktisil Q at higher loadings. This way, the tensile strength of the 75 phr Aktisil Q compound, at 8.2 MPa, is higher by 0.5 MPa than the 100 phr quartz flour compound.

Post-cure of the filler loaded compounds leads to reduced tensile strength, an effect which is more pronounced with Aktisil Q compared with silanized quartz flour.

A comparable level of tensile strength results at equal filler loadings is obtained with dicumyl peroxide as curing agent. The figure of 7.7 MPa of the 100 phr quartz flour compound, however, is exceeded by the 75 phr Aktisil Q compound by 0.8 MPa. In the silanized quartz flour compounds, a post-cure shows no significant effect. In the Aktisil Q filled compounds, post-cure gives rise to slightly reduced tensile strength figures.

100 % modulus

The 100 % modulus with Curing Agent C6 or dicumyl peroxide and Aktisil Q is higher than with silanized quartz flour at equal loadings. With 75 phr Aktisil Q, the modulus of the 100 % quartz flour compound will be matched. With both curing agents, post-cure does not show any significant effect on the 100 % modulus.

Elongation at break

Here again, the elongation at break decreases with increasing filler addition. Up to a loading of 25 phr, both fillers stay at a comparable level. At higher loadings, the elongation drops off somewhat faster with Aktisil Q compared with the surface treated quartz flour, and this with both curing agents. The figures for the compounds with 75 phr Aktisil Q resp. 100 phr quartz flour (equal hardness) come out at the same level.

Post-curing the compounds hardly changes the elongation at break.

Rebound resilience

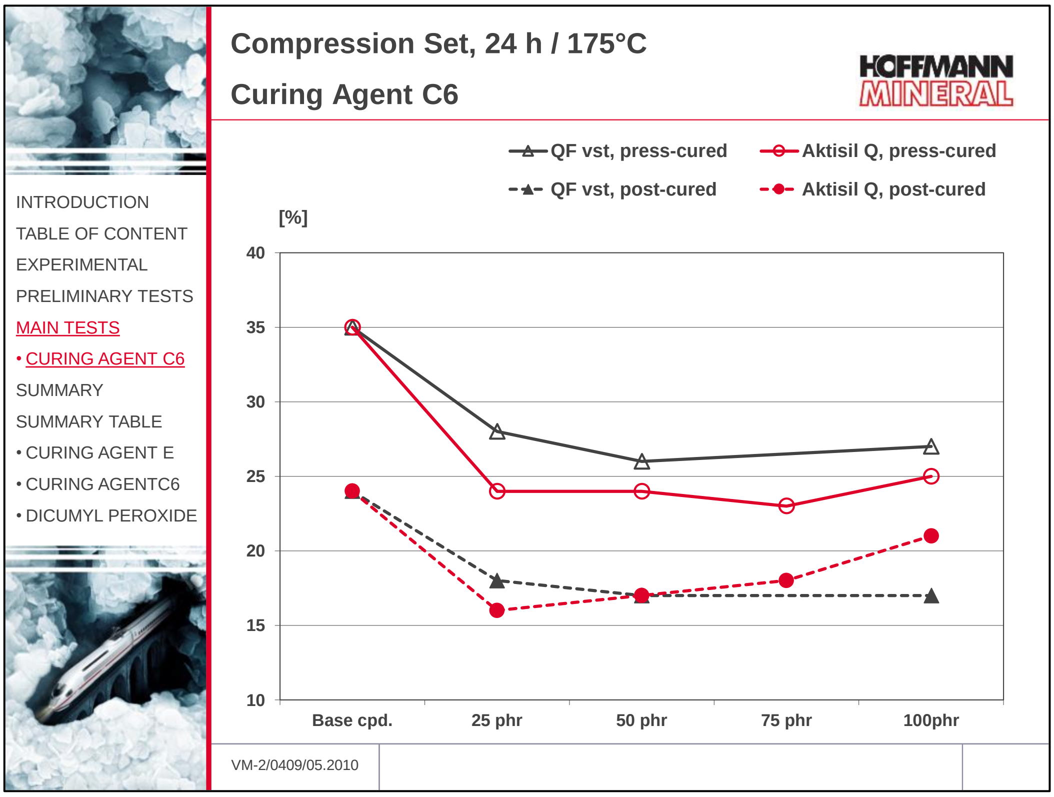
With Curing Agent C6, the addition of filler leads to higher rebound results, about the same for both fillers tested. Above a loading of 50 phr, the resilience will again go down a bit, but remains still higher than the level of the base compound.

Post-cure of the base compound and the other compounds with up to 25 phr filler gives rise to increased rebound resilience, which stays about unchanged with 50 resp. 75 phr filler, while still higher loadings rather cause a new decrease.

With dicumyl peroxide and without post-cure, filler additions up to 50 resp. 75 phr lead to a slight increase of the rebound resilience, and the two fillers tested do not show any difference. At a loading of 100 phr, rebound with both fillers comes out somewhat below the base compound.

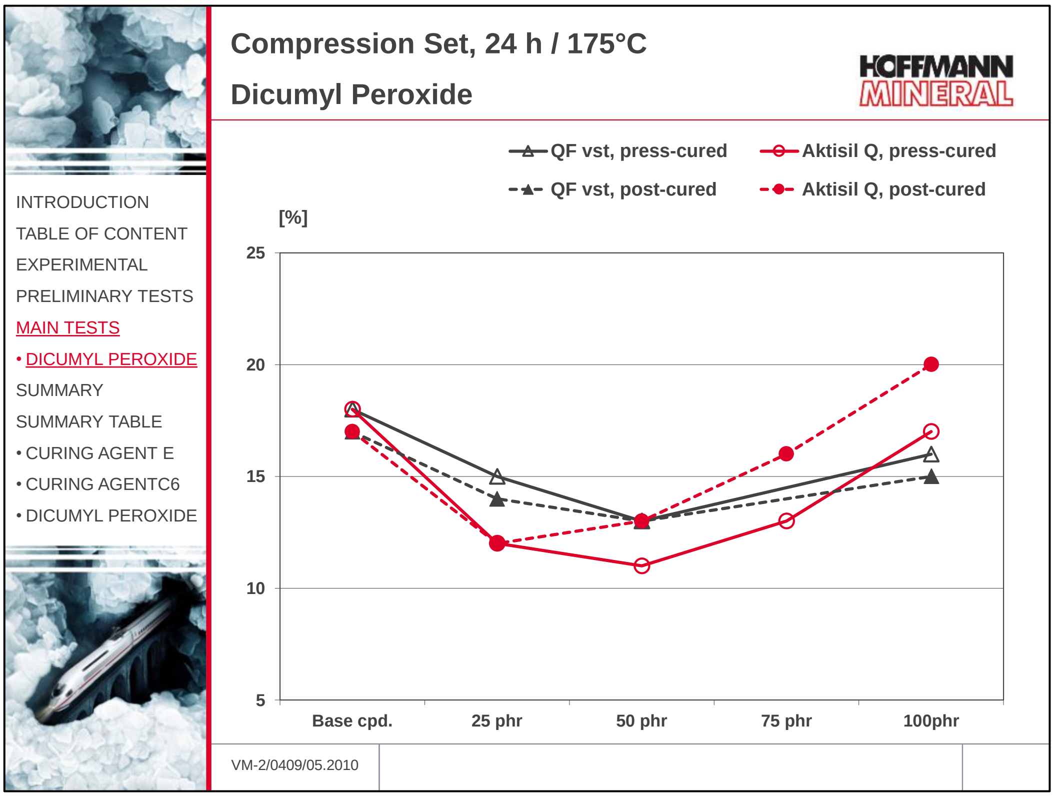
Post-cure here causes increased figures with the base compound, but a decrease is observed, independent of the filler used, in all filled compounds.

Compression Set



The addition of fillers results in lower compression set figures compared with the base compound. Without post-cure, Aktisil Q will give lower figures than silanized quartz flour. After tempering, 75 phr Aktisil Q come out at the same level with 100 phr silanized quartz flour. Up to 75 phr, both fillers are about equal, at 100 phr the compression set with Aktisil Q is slightly higher than with silanized quartz flour. All the same, 100 phr Aktisil still allow to obtain a lower figure than with the base compound after post-cure.

The influence of post-cure in association with Curing Agent C6 may be diminished by increasing the cure temperature of 165°C up to 180°C. By this measure, the other properties should not be influenced unfavorable.



With dicumyl peroxide too, the compression set of the base compound will be markedly reduced by the addition of fillers.
Up to a loading of 75 phr, without post-cure Aktisil Q offers the possibility to achieve a lower compression set than with silanized quartz flour. At still higher loadings, the two fillers come out at the same level. The graph shows Aktisil Q to attain the lowest compression set at the 50 phr loading, which represents the minimum of the whole series.

Post-cure does not show any big effects on the base compound or the silanized quartz compound. Contrary to expectations, the compression set with Aktisil Q comes out somewhat higher after post-cure. For this reason, a post-cure is not recommended for such compounds.

Cured rubber properties after heat aging

Upon hot air aging of filled compounds with Curing Agent C6, changes are less pronounced than for the base compound with no additional fillers. Aktisil Q gives rise to slightly smaller changes compared with the silanized quartz flour. As a result, the absolute figures of the tensile strength after heat aging come out at a similar level.

With dicumyl peroxide as curing agent, Aktisil Q upon hot air aging leads to somewhat higher changes of the tensile strength. For the other properties tested, there were no significant differences between the base compound and the filler loaded compounds.

Cured rubber properties after immersion in Reference Oil IRM 903

Like with Curing Agent E, the volume and weight increases when using Aktisil Q come out lower as compared with silanized quartz flour. With Curing Agent C6, the difference between the two fillers is about as large as with Curing Agent E. Dicumyl peroxide also shows differences, but not so much pronounced.
With both curing agents, a similar volume change is observed for the compounds with 75 phr Aktisil Q resp. 100 phr silanized quartz flour.
Without post-cure, the increase of volume and weight are marginally higher than with post-cure. This is valid for both curing agents, comparable to Curing Agent E.

Regarding hardness, compounds with Curing Agent C6 as well as dicumyl peroxide show a somewhat more pronounced decrease of the hardness with increasing levels of Aktisil Q, while the effects with silanized quartz flour or for the base compound are about comparable. All the same, after immersion the hardness with Aktisil Q remains higher than for the base compound or the compound filled with silanized quartz flour.
With Curing Agent C6 it occurs that without post-cure the values of the hardness changes are somewhat higher with the Base cpd. and with Aktisil Q than with the treated quartz flour. Nevertheless, without post-cure a higher hardness level is obtained with Aktisil Q.
With dicumyl peroxide also a higher hardness level is attained without post-cure.

The sharp decrease of tensile strength observed with the base compound upon immersion in Reference Oil IRM 903 is attenuated also with Curing Agent C6 and dicumyl peroxide through the addition of fillers. The tensile changes with both curing agents again come out with Aktisil Q lower than with silanized quartz flour. With Curing Agent C6, already with 50 phr Aktisil Q a tensile decrease is found comparable with 100 phr quartz flour, with dicumyl peroxide this is true for 75 phr Aktisil Q.
Even without post-cure lower changes of the tensile strength are obtained with Aktisil Q

This way, with these curing agents the absolute tensile strength figures after immersion in Reference Oil IRM 903 are higher than for the base compound. In a comparison with silanized quartz flour, the same is true up to 50 phr, and at 100 phr an almost equal level is obtained between Aktisil Q and the quartz flour. If the 75 phr Aktisil Q compound and the 100 phr compound are compared, evidently the level with Aktisil Q is higher than for the silanized quartz flour. With a loading of 75 phr the tensile maximum of Aktisil Q has been reached, and at higher loadings the tensile figures again tend to drop off.
Without post-cure the absolute tensile figures are reduced somewhat more with Aktisil Q than with the treated quartz flour with Curing Agent C6. With the dicumyl peroxide this tendency is still present but not as distinvt as with Curing Agent C6.

The fairly high change of the elongation at break of the base compound with both curing agents will be minimized with higher filler additions.
Without post-cure this statement is als valid.

Within the framework of these studies, also some compounds filled with diatomaceous earth were evaluated with respect to their properties after immersion in Reference Oil IRM 903. With compounds containing Curing Agent E no tensile tests could be carried out, as the sample dumbbells were damaged already by clamping them into the jaws of the tensile machine. When using this curing agent, the oil resistance of compounds with diatomaceous earth, therefore, has to be judged rather poor.

With Curing Agent C6 and dicumyl peroxide, the mechanical properties of the compounds filled with diatomaceous earth come out rather on the poor side, the figures diminish strongly.

5 Conclusion

Aktisil Q has been proven to be less abrasive than the quartz flour tested, and it causes a slight yellowish tint of the compounds.

In general, Aktisil Q leads to shorter Mooney scorch times. The degree of cure and the Shore A hardness are higher compared with silanized quartz flour: 75 phr Aktisil Q impart the same hardness as 100 phr quartz flour.

Up to 75 phr Aktisil Q is able to improve the compression set of the base compound (without further fillers added). As post-cure of Bis-(2.4-dichlorobenzoyl)-peroxide or dicumyl peroxide compounds gives rise to slightly negative or no effects at all, this process step can be eliminated when working with Aktisil Q.
The influence of post-cure in association with Curing Agent C6 may be diminished by increasing the cure temperature of 165°C up to 180°C. By this measure, the other properties should not be influenced unfavorable.

Another favorable point with respect to Aktisil Q is the improved aging resistance upon immersion in Reference Oil IRM 903, which underlines a better oil resistance of the compounds.

Furthermore, Aktisil Q minimizes the surface stickiness of uncured extrusion sections, and prevents the surface blooming of benzoic acid derivates when working with Bis-(2.4-dichlorobenzoyl)-peroxide (Curing Agent E). And last not least, Aktisil Q imparts a markedly improved collapse resistance or dimensional stability of extruded sections.

NSE in High Consistency Silicone Rubber - preliminary tests, curing agent E

		Base cpd.	DE fc	QF	QF vst	Sillitin Z 86	Sillitin V 85	Aktisil MAM	Aktisil Q
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Bis-(2,4-dichlorobenzoyl)-peroxide (50%)		1,50	1,50	1,50	1,50	1,50	1,50	1,50	1,50
DE fc			50,00						
QF				100,00					
QF vst					100,00				
Sillitin Z 86						100,00			
Sillitin V 85							100,00		
Aktisil MAM								100,00	
Aktisil Q									100,00
Mooney viscosity ML 1+4 70 °C	MU	15	40	18	31	14	15	33	62
Mooney scorch (ML) 5 ME 70 °C	min	31,0	25,1	25,1	27,4	90,0	51,3	11,4	3,5
Mooney scorch (ML) 10 ME 70 °C	min	35,2	34,5	26,1	29,0	90,0	59,1	11,9	3,8
Rotorless curemeter Mmin 115 °C	Nm	0,04	0,09	0,08	0,06	0,13	0,11	0,11	0,11
Rotorless curemeter Mmax 115 °C	Nm	0,40	0,70	0,70	0,62	0,60	0,65	0,89	1,27
Rotorless curemeter t_5 115 °C	min	0,3	0,3	0,2	0,2	0,2	0,3	0,2	0,2
Rotorless curemeter t_{90} 115 °C	min	1,4	1,0	1,0	1,3	1,3	1,1	0,9	1,0
tan.delta at the end of cure test	rad	0,03	0,06	0,04	0,06	0,13	0,12	0,08	0,04
cure time	min	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0
after press-cure									
Tensile strength	MPa	8,4	5,4	5,0	8,4	3,6	3,8	7,0	7,8
Elongation at break	%	470	375	315	190	370	365	165	170
Modulus 100 %	MPa	0,9	2,9	3,0	4,2	1,7	2,2	4,4	5,0
Hardness	Shore A	44	66	60	65	56	63	70	75
Tear resistance	N/mm	6,5	3,5	2,5	1,3	4,1	3,4	1,3	1,0
Rebound resilience	%	58	50	49	53	28	35	47	50
Compression set 24h/175°C	%	53	100	65	54	100	100	88	38

NSE in High Consistency Silicone Rubber - preliminary tests, curing agent E

		Base cpd.	DE fc	QF	QF vst	Sillitin Z 86	Sillitin V 85	Aktisil MAM	Aktisil Q
			50 phr	100 phr	100 phr	100 phr	100 phr	100 phr	100 phr
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Bis-(2,4-dichlorobenzoyl)-peroxide (50%)		1,50	1,50	1,50	1,50	1,50	1,50	1,50	1,50
after post-cure 4 h / 200°C									
Tensile strength	MPa	9,4	6,8	6,8	8,0	1,5	2,2	6,5	7,5
Elongation at break	%	445	175	210	170	14	80	165	155
Modulus 100 %	MPa	1,1	5,1	3,6	4,7			4,8	5,1
Hardness	Shore A	42	66	62	65	92	91	77	76
Tear resistance	N/mm	6,2	1,5	2,0	1,3		0,7	1,6	1,2
Rebound resilience	%	30	19	21	24	25	23	24	32
Compression set 24h/175°C	%	48	100	59	44	86	93	84	37
Δ Tensile strength	%	12	26	35	-4	-59	-42	-7	-4
Δ Elongation at break	%	-5	-53	-34	-12	-96	-79	0	-8
Δ Modulus 100%	%	23	79	21	12		51	10	2
Δ Hardness	Shore A	-2	0	2	0	36	28	7	1
Δ Tear resistance	%	-4	-56	-20	2		-81	22	14
Δ Rebound resilience	%	-46	-62	-57	-55	-11	-34	-49	-36
after post-cure 4 h / 200°C + heat ageing 168 h / 200°C									
Tensile strength	MPa	8,0	6,1	5,7	6,8	1,4	2,0	4,8	6,2
Elongation at break	%	335	160	145	180	4	20	60	150
Modulus 100 %	MPa	1,6	4,8	4,2	3,7				4,7
Hardness	Shore A	54	69	65	66	93	89	93	77
Tear resistance	N/mm	11,0	1,2	1,1	1,1			0,8	1,3
Rebound resilience	%	45	25	29	33		37	42	32
Δ Tensile strength	%	-16	-11	-17	-16	-7	-12	-26	-17
Δ Elongation at break	%	-24	-8	-32	6	-69	-75	-65	-1
Δ Modulus 100%	%	48	-6	16	-21				-8
Δ Hardness	Shore A	3	3	3	1	1	-2	16	1
Δ Tear resistance	%	77	-25	-48	-14			-49	5
Δ Rebound resilience	%	50	32	38	38		61	75	0

NSE in High Consistency Silicone Rubber - Extrusion, curing agent E		DE fc	QF	QF vst	Sillitin Z 89	Sillitin V 88	Aktisil MAM	Aktisil Q
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00
Bis-(2,4-dichlorobenzoyl)-peroxide (50%)		1,50	1,50	1,50	1,50	1,50	1,50	1,50
DE fc		50,00						
QF			100,00					
QF vst				100,00				
Sillitin Z 89					100,00			
Sillitin V 88						100,00		
Aktisil MAM							100,00	
Aktisil Q								100,00
Garvey extrusion								
Revolutions	rpm	100	100	100	100	100	100	100
Rating die swell		4	3,5	4	4	4	4	4
Rating 30° edge		2	4	4	4	4	4	4
Rating surface		4	4	4	4	4	4	4
Rating corners		4	4	4	4	4	4	4
Total rating		14,0	15,5	16,0	16,0	16,0	16,0	16,0
Output - length	m/min	9,4	10,0	6,6	10,4	10,0	9,0	9,0
Extrusion - Hose								
Revolutions	rpm	50	50	50	50	50	50	50
Outer die diameter	mm	20	20	20	20	20	20	20
Height after 5 s	mm	9	4	8	9	11	8	14
Height after 30 s	mm	8	3	7	8	11	8	14
Height after 60 s	mm	7	3	7	8	11	8	14

NSE in High Consistency Silicone Rubber - main tests, curing agent E		Base cpd.	QF vst			Aktisil Q			
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Bis-(2,4-dichlorobenzoyl)-peroxide (50%)		1,50	1,50	1,50	1,50	1,50	1,50	1,50	1,50
QF vst			25,00	50,00	100,00				
Aktisil Q						25,00	50,00	75,00	100,00
Mooney viscosity ML 1+4 70 °C	ME	15	18	17	27	18	26	46	75
Mooney scorch (ML) 5ME 70 °C	min	31,0	29,8	22,0	21,4	6,5	5,1	4,0	3,1
Mooney scorch (ML) 10ME 70 °C	min	35,2	31,1	27,9	23,9	7,1	5,5	4,4	3,4
Rotorless curemeter Mmin 115 °C	Nm	0,04	0,04	0,05	0,07	0,04	0,06	0,08	0,12
Rotorless curemeter Mmax 115 °C	Nm	0,46	0,47	0,58	0,79	0,54	0,74	0,98	1,25
Rotorless curemeter t_5 115 °C	min	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2
Rotorless curemeter t_{90} 115 °C	min	1,3	1,2	1,1	0,9	1,1	1,0	1,0	1,0
tan.delta at the end of cure test	rad	0,02	0,03	0,03	0,04	0,03	0,03	0,04	0,04
Cure time	min	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0
after press-cure									
Tensile strength	MPa	9,9	9,7	9,0	8,9	8,9	8,6	8,2	7,9
Elongation at break	%	505	454	340	215	440	315	225	180
Modulus 100 %	MPa	1,0	1,6	2,2	4,1	1,8	2,9	3,6	4,9
Hardness	Shore A	43	50	57	67	54	61	69	75
Tear resistance	N/mm	9,7	2,7	1,8	1,2	1,8	1,9	1,2	1,1
Rebound resilience	%	62	64	61	55	61	59	55	52
Compression set 24h/175°C	%	41	39	39	40	36	34	34	38

NSE in High Consistency Silicone Rubber - main tests, curing agent E		Base cpd.	QF vst			Aktisil Q			
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Bis-(2,4-dichlorobenzoyl)-peroxide (50%)		1,50	1,50	1,50	1,50	1,50	1,50	1,50	1,50
QF vst			25,00	50,00	100,00				
Aktisil Q						25,00	50,00	75,00	100,00
after post-cure 4 h / 200°C									
Blooming tendency of curing agent E		- -	- - -	- - -	- - -	-	none	none	none
Tensile strength	MPa	8,9	9,4	8,9	8,5	8,9	8,1	7,8	7,5
Elongation at break	%	500	435	350	205	435	300	220	170
Modulus 100 %	MPa	1,0	1,6	2,3	4,2	1,8	2,8	3,8	4,9
Hardness	Shore A	44	51	56	67	54	61	69	75
Tear resistance	N/mm	8,4	2,2	1,9	1,2	1,8	1,7	1,4	1,3
Rebound resilience	%	38	30	28	23	34	32	33	27
Compression set 24h/175°C	%	38	39	38	41	38	37	35	38
Δ Tensile strength	%	-10	-4	-1	-5	0	-6	-5	-5
Δ Elongation at break	%	-2	-4	2	-5	-1	-5	-2	-5
Δ Modulus 100%	%	-1	2	6	4	-2	-1	4	0
Δ Hardness	Shore A	1	1	-1	0	0	0	0	0
Δ Tear resistance	%	-14	-17	6	-1	-1	-11	17	12
Δ Rebound resilience	%	-39	-53	-54	-58	-44	-46	-40	-48
after post-cure 4 h / 200°C + heat ageing 168 h / 200°C									
Tensile strength	MPa	7,9	7,0	6,6	6,6	6,9	6,2	6,1	5,5
Elongation at break	%	450	380	290	185	435	265	195	140
Modulus 100 %	MPa	1,2	1,8	2,6	3,9	2,1	2,8	3,6	4,3
Hardness	Shore A	43	49	55	66	52	60	69	77
Tear resistance	N/mm	6,2	2,8	1,5	1,0	1,6	1,6	1,2	1,2
Rebound resilience	%	46	42	38	33	41	33	31	26
Δ Tensile strength	%	-11	-25	-25	-22	-22	-23	-22	-27
Δ Elongation at break	%	-10	-13	-17	-9	0	-13	-11	-17
Δ Modulus 100%	%	19	10	10	-7	17	-2	-4	-11
Δ Hardness	Shore A	-1	-2	-1	-1	-2	-1	0	2
Δ Tear resistance	%	-26	26	-17	-16	-11	-3	-17	-6
Δ Rebound resilience	%	21	40	36	43	21	3	-6	-4

NSE in High Consistency Silicone Rubber - main tests, curing agent E		Base cpd.	QF vst			Aktisil Q				DE fc
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Bis-(2,4-dichlorobenzoyl)-peroxide (50%)		1,50	1,50	1,50	1,50	1,50	1,50	1,50	1,50	1,50
QF vst			25,00	50,00	100,00					
Aktisil Q						25,00	50,00	75,00	100,00	
DE fc										50,00
after post-cure 4 h / 200°C + storage in reference oil IRM 903 72 h / 150°C										
(Immersion of the cured material: about 6 months; cured material was post-cured and afterwards immersed in oil;										
changes after immersion are related to the newly measured properties after post-cure)										
Tensile strength	MPa	3,8	5,7	6,3	6,7	6,1	7,2	7,9	7,5	
Elongation at break	%	250	250	230	170	240	200	190	130	
Modulus 100 %	MPa	1,1	1,8	2,4	4,2	2,0	3,0	4,4	5,9	
Hardness	Shore A	25	32	36	46	34	42	49	55	14
Δ Tensile strength	%	-57	-41	-29	-16	-26	-19	-6	-4	
Δ Elongation at break	%	-49	-42	-19	-15	-30	-30	-13	-20	
Δ Modulus 100%	%	-3	7	-8	-1	2	1	5	14	
Δ Hardness	Shore A	-22	-21	-22	-23	-21	-21	-23	-23	-52
Δ Weight	%	46,8	35,4	29,4	20,6	33,9	27,7	21,8	18,4	40,5
Δ Volume	%	57,6	49,2	44,6	35,4	46,8	41,3	35,3	31,4	60,8

NSE in High Consistency Silicone Rubber - preliminary tests, curing agent C6

		Base cpd.	DE fc	QF	QF vst	Sillitin Z 86	Sillitin V 85	Aktisil MAM	Aktisil Q
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
2,5-Bis-(t-butylperoxy)-2,5-di-methylhexane (45%)		1,20	1,20	1,20	1,20	1,20	1,20	1,20	1,20
DE fc			50,00						
QF				100,00					
QF vts					100,00				
Sillitin Z 86						100,00			
Sillitin V 85							100,00		
Aktisil MAM								100,00	
Aktisil Q									100,00
Mooney viscosity ML 1+4 120 °C	ME	12	27	4	17	14	16	24	37
Mooney scorch (ML) 5 ME 120 °C	min	> 90	29,5	> 90	35,7	76,9	74,7	10,3	3,3
Mooney scorch (ML) 10 ME 120 °C	min	> 90	47,8	> 90	37,6	> 90	> 90	> 90	3,9
Rotorless curemeter Mmin 165 °C	Nm	0,02	0,06	0,05	0,06	0,10	0,07	0,08	0,08
Rotorless curemeter Mmax 165 °C	Nm	0,23	0,51	0,29	0,49	0,28	0,25	0,51	1,04
Rotorless curemeter t_5 165 °C	min	0,8	0,7	0,7	0,6	0,7	0,6	0,3	0,3
Rotorless curemeter t_{90} 165 °C	min	2,7	3,2	4,3	2,6	12,8	4,0	2,7	3,2
tan.delta at the end of cure test	rad	0,07	0,06	0,14	0,06	0,25	0,19	0,11	0,05
Cure time	min	5,0	5,0	5,0	5,0	14,1	5,0	5,0	5,0
after press-cure									
Tensile strength	MPa	9,8	6,2	4,1	7,8	inefficient curing		4,9	7,8
Elongation at break	%	610	605	540	320			310	220
Modulus 100 %	MPa	0,6	2,0	1,1	2,1			1,7	3,3
Hardness	Shore A	33	59	44	59			58	71
Tear resistance	N/mm	8,1	6,6	9,9	2,1			2,7	1,3
Rebound resilience	%	40	44	26	46			31	45
Compression set 24h/175°C	%	33	72	71	36			68	30

NSE in High Consistency Silicone Rubber - preliminary tests, curing agent C6

		Base cpd.	DE fc	QF	QF vst	Sillitin Z 86	Sillitin V 85	Aktisil MAM	Aktisil Q
			50 phr	100 phr	100 phr	100 phr	100 phr	100 phr	100 phr
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
2,5-Bis-(t-butylperoxy)-2,5-di-methylhexane (45%)		1,20	1,20	1,20	1,20	1,20	1,20	1,20	1,20
after cure 4 h / 200°C									
Tensile strength	MPa	12,3	7,7	4,9	7,7	inefficient curing		4,6	7,0
Elongation at break	%	795	325	360	285			275	225
Modulus 100 phr	MPa	0,6	3,4	1,6	2,5			2,0	3,4
Hardness	Shore A	35	68	54	63			66	74
Tear resistance	N/mm	8,0	2,6	9,4	2,1			2,3	1,6
Rebound resilience	%	53	46	29	45			29	40
Compression set 24h/175°C	%	25	43	40	24			52	27
Δ Tensile strength	%	25	23	19	-2			-5	-10
Δ Elongation at break	%	30	-46	-33	-11			-11	1
Δ Modulus 100%	%	-2	76	39	17			21	3
Δ Hardness	Shore A	2	9	10	4			8	3
Δ Tear resistance	%	-1	-61	-6	0,5			-14	27
Δ Rebound resilience	%	33	5	12	-2			-6	-11
after post-cure 4 h / 200°C + heat ageing 168 h / 200°C									
Tensile strength	MPa	9,7	5,8	4,8	6,2	inefficient curing		4,3	5,8
Elongation at break	%	845	210	250	255			70	170
Modulus 100%	MPa	0,9	4,0	2,5	2,9				3,7
Hardness	Shore A	38	72	64	67			93	77
Tear resistance	N/mm	9,8	1,6	1,4	1,9			1,0	1,5
Rebound resilience	%	50	38	33	40			29	38
Δ Tensile strength	%	-21	-25	-3	-20			-7	-18
Δ Elongation at break	%	6	-35	-31	-9			-76	-23
Δ Modulus 100%	%	37	15	61	15				9
Δ Hardness	Shore A	3	4	12	4			27	3
Δ Tear resistance	%	23	-39	-85	-7			-56	-11
Δ Rebound resilience	%	-6	-17	14	-11			0	-5

NSE in High Consistency Silicone Rubber - main tests, curing agent C6

		Base cpd.	QF vt			Aktisil Q			
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
2,5-Bis-(t-butylperoxy)-2,5-di-methylhexane (45%)		1,20	1,20	1,20	1,20	1,20	1,20	1,20	1,20
QF vst			25,00	50,00	100,00				
Aktisil Q						25,00	50,00	75,00	100,00
Mooney viscosity ML 1+4 100 °C	ME	15	no measurement		22	16	18	22	29
Mooney scorch (ML) 5ME 100 °C	min	56,5			46,8	40,4	64,6	23,0	10,8
Mooney scorch (ML) 10ME 100 °C	min	> 90			> 90	> 90	> 90	29,9	16,8
Mooney viscosity ML 1+4 120 °C	ME	11	14	15	20	12	13	21	36
Mooney scorch (ML) 5ME 120 °C	min	38,3	32,8	58,9	38,4	11,1	7,1	4,9	3,3
Mooney scorch (ML) 10ME 120 °C	min	69,4	63,5	62,3	41,3	14,5	10,3	7,6	4,4
Rotorless curemeter Mmin 165 °C	Nm	0,02	0,03	0,03	0,05	0,03	0,04	0,05	0,07
Rotorless curemeter Mmax 165 °C	Nm	0,27	0,34	0,41	0,60	0,40	0,56	0,76	1,04
Rotorless curemeter t_5 165 °C	min	0,9	0,7	0,6	0,6	0,5	0,4	0,3	0,3
Rotorless curemeter t_{90} 165 °C	min	3,2	3,0	2,9	2,9	2,7	2,7	2,8	2,9
tan.delta at the end of cure test	rad	0,05	0,04	0,05	0,05	0,05	0,05	0,05	0,05
Cure time	min	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0
after press-cure									
Tensile strength	MPa	10,7	10,3	9,2	7,7	9,6	8,8	8,2	8,0
Elongation at break	%	800	590	475	265	610	430	315	235
Modulus 100 %	MPa	0,7	1,1	1,5	2,7	1,2	1,7	2,6	3,4
Hardness	Shore A	38	44	51	61	47	55	64	72
Tear resistance	N/mm	11,5	12,9	13,1	2,1	14,0	3,7	2,0	1,4
Rebound resilience	%	40	49	49	47	50	50	46	45
Compression set 24h/175°C	%	35	28	26	27	24	24	23	25

NSE in High Consistency Silicone Rubber - main tests, curing agent C6

		Base cpd.	QF vst			Aktisil Q			
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
2,5-Bis-(t-butylperoxy)-2,5-di-methylhexane (45%)		1,20	1,20	1,20	1,20	1,20	1,20	1,20	1,20
QF vst			25,00	50,00	100,00				
Aktisil Q						25,00	50,00	75,00	100,00
after post-cure 4 h / 200°C									
Tensile strength	MPa	11,2	10,1	8,4	7,3	8,8	7,5	6,8	6,7
Elongation at break	%	860	660	495	300	585	435	300	230
Modulus 100 %	MPa	0,7	1,0	1,5	2,6	1,1	1,8	2,5	3,2
Hardness	Shore A	40	46	52	63	48	57	66	74
Tear resistance	N/mm	12,2	16,7	4,7	2,0	12,8	4,2	2,3	1,6
Rebound resilience	%	53	55	49	44	52	49	45	42
Compression set 24h/175°C	%	24	18	17	17	16	17	18	21
Δ Tensile strength	%	5	-2	-8	-5	-8	-14	-18	-16
Δ Elongation at break	%	8	12	4	14	-4	1	-4	-3
Δ Modulus 100%	%	3	-8	2	-2	-4	6	-1	-5
Δ Hardness	Shore A	2	2	1	2	1	2	2	2
Δ Tear resistance	%	6	30	64	-1	-9	14	19	12
Δ Rebound resilience	%	33	12	0	-6	4	-2	-2	-7
after post-cure 4 h / 200°C + heat ageing 168 h / 200°C									
Tensile strength	MPa	7,7	8,1	6,4	5,7	7,7	6,0	5,7	5,3
Elongation at break	%	550	595	435	265	560	415	290	200
Modulus 100 %	MPa	1,0	1,3	1,8	3,0	1,4	2,0	2,7	3,3
Hardness	Shore A	43	45	53	65	50	60	69	78
Tear resistance	N/mm	9,4	15,7	3,0	1,8	8,3	2,9	2,1	1,5
Rebound resilience	%	50	46	44	41	46	44	41	37
Δ Tensile strength	%	-31	-20	-24	-23	-12	-21	-16	-20
Δ Elongation at break	%	-36	-10	-12	-12	-4	-5	-4	-13
Δ Modulus 100%	%	43	34	23	13	27	8	6	0
Δ Hardness	Shore A	3	-1	1	2	2	3	3	4
Δ Tear resistance	%	-23	-6	-36	-9	-35	-30	-11	-6
Δ Rebound resilience	%	-6	-16	-10	-7	-12	-10	-9	-12

NSE in High Consistency Silicone Rubber - main tests, curing agent C6										
		Base cpd.	QF vst			Aktisil Q				DE fc
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
2,5-Bis-(t-butylperoxy)-2,5-di-methylhexane (45%)		1,20	1,20	1,20	1,20	1,20	1,20	1,20	1,20	1,20
QF vst			25,00	50,00	100,00					
Aktisil Q						25,00	50,00	75,00	100,00	
DE fc										50,00
after post-cure 4 h / 200°C + storage in reference oil IRM 903 72 h / 150°C										
(Immersion of the cured material: about 6 months; cured material was post-cured and afterwards immersed in oil;										
changes after immersion are related to the newly measured properties after post-cure)										
Tensile strength	MPa	3,1	5,2	5,9	6,0	5,8	6,3	6,4	6,1	3,2
Elongation at break	%	320	360	340	250	350	340	280	200	210
Modulus 100 %	MPa	0,8	1,2	1,6	2,8	1,3	1,9	2,5	3,5	1,9
Hardness	Shore A	20	26	31	41	29	35	42	48	28
Δ Tensile strength	%	-72	-49	-32	-23	-41	-24	-16	-15	-57
Δ Elongation at break	%	-55	-41	-30	-10	-40	-21	-7	-11	-40
Δ Modulus 100%	%	-4	-1	0	-1	6	2	-2	8	-43
Δ Hardness	Shore A	-22	-22	-22	-24	-22	-25	-26	-27	-38
Δ Weight	%	52,0	40,9	33,0	23,4	39,1	30,7	25,0	22,0	37,9
Δ Volume	%	64,5	57,0	50,6	40,7	54,6	47,0	41,1	37,8	56,4

NSE in High Consistency Silicone Rubber - preliminary tests, dicumyl peroxide

		Base cpd.	DE fc	QF	QF vst	Sillitin Z 86	Sillitin V 85	Aktisil MAM	Aktisil Q
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Dicumyl peroxide (40 %)		0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99
DE fc			50,00						
QF				100,00					
QF vst					100,00				
Sillitin Z 86						100,00			
Sillitin V 85							100,00		
Aktisil MAM								100,00	
Aktisil Q									100,00
Mooney viscosity ML 1+4 120 °C	ME	14	26	11	18	13	16	25	35
Mooney scorch (ML) 5 ME 120 °C	min	30,0	21,7	> 90	45,5	> 90	> 90	8,7	3,6
Mooney scorch (ML) 10 ME 120 °C	min	66,5	33,1	> 90	48,0	> 90	> 90	> 90	4,5
Rotorless curemeter Mmin 180 °C	Nm	0,02	0,05	0,04	0,05	inefficient curing		0,08	0,07
Rotorless curemeter Mmax 180 °C	Nm	0,37	0,60	0,08	0,61			0,21	0,92
Rotorless curemeter t_5 180 °C	min	0,4	0,3	0,3	0,3			0,2	0,2
Rotorless curemeter t_{90} 180 °C	min	1,1	0,9	1,9	0,9			0,7	1,9
tan.delta at the end of cure test	rad	0,04	0,06	0,82	0,05			0,51	0,07
cure time	min	5,0	5,0	5,0	5,0			5,0	5,0
after press-cure									
Tensile strength	MPa	10,8	6,6	inefficient curing	8,1	inefficient curing			7,0
Elongation at break	%	700	585		295				225
Modulus 100 %	MPa	0,7	2,1		2,2				3,0
Hardness	Shore A	39	59		59				68
Tear resistance	N/mm	11,6	5,6		1,8				1,5
Rebound resilience	%	50	46		48				
Compression set 24h/175°C	%	18	51		16				17

NSE in High Consistency Silicone Rubber - preliminary tests, dicumyl peroxide

		Base cpd.	DE fc	QF	QF vst	Sillitin Z 86	Sillitin V 85	Aktisil MAM	Aktisil Q
			50 phr	100 phr	100 phr	100 phr	100 phr	100 phr	100 phr
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Dicumyl peroxide (40 %)		0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99
after post-cure 4 h / 200°C									
Tensile strength	MPa	11,1	7,0	inefficient curing	7,7	inefficient curing			6,4
Elongation at break	%	770	425		280				245
Modulus 100 %	MPa	0,8	3,1		2,2				2,7
Hardness	Shore A	40	67		62				69
Tear resistance	N/mm	10,2	3,9		2,0				1,6
Rebound resilience	%	54	45		44				
Compression set 24h/175°C	%	16	34		15				20
Δ Tensile strength	%	3	6		-5				-9
Δ Elongation at break	%	10	-28		-6				7
Δ Modulus 100%	%	3	45		0				-9
Δ Hardness	Shore A	1	8		3				1
Δ Tear resistance	%	-12	-31		10				9
Δ Rebound resilience	%	8	-2		-8				
after post-cure 4 h / 200°C + heat ageing 168 h / 200°C									
Tensile strength	MPa	9,5	6,9	inefficient curing	7,1	inefficient curing			5,0
Elongation at break	%	640	230		260				180
Modulus 100 %	MPa	0,9	4,1		2,8				3,3
Hardness	Shore A	43	72		67				74
Tear resistance	N/mm	11,5	1,8		1,9				1,4
Rebound resilience	%	56	39		42				
Δ Tensile strength	%	-14	-1		-8				-22
Δ Elongation at break	%	-17	-46		-6				-26
Δ Modulus 100%	%	20	32		29				21
Δ Hardness	Shore A	3	5		5				5
Δ Tear resistance	%	13	-53		-5				-13
Δ Rebound resilience	%	4	-13		-5				

NSE in High Consistency Silicone Rubber - main tests, dicumyl peroxide

		Base cpd.	QF vst			Aktisil Q			
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Dicumyl peroxide (40 %)		0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99
QF vst			25,00	50,00	100,00				
Aktisil Q						25,00	50,00	75,00	100,00
Mooney viscosity ML 1+4 100 °C	ME	14	no measurement		20	15	18	22	29
Mooney scorch (ML) 5ME 100 °C	min	> 90			> 90	21,7	62,2	23,4	11,8
Mooney scorch (ML) 10ME 100 °C	min	> 90			> 90	61,1	> 90	36,1	16,8
Mooney viscosity ML 1+4 120 °C	ME	14	14	13	17	14	14	26	41
Mooney scorch (ML) 5ME 120 °C	min	30,0	47,6	39,2	29,9	11,7	7,7	4,8	3,5
Mooney scorch (ML) 10ME 120 °C	min	66,5	50,8	42,6	32,3	15,0	11,7	6,4	4,3
Rotorless curemeter Mmin 180 °C	Nm	0,02	0,03	0,03	0,05	0,03	0,04	0,05	0,07
Rotorless curemeter Mmax 180 °C	Nm	0,37	0,42	0,50	0,68	0,47	0,62	0,80	1,03
Rotorless curemeter t_5 180 °C	min	0,4	0,4	0,3	0,3	0,3	0,3	0,2	0,2
Rotorless curemeter t_{90} 180 °C	min	1,1	1,1	1,0	1,3	1,1	1,1	1,3	1,4
tan.delta at the end of cure test	rad	0,04	0,04	0,04	0,05	0,04	0,04	0,05	0,06
Cure time	min	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0
after press-cure									
Tensile strength	MPa	10,8	9,4	9,0	7,7	9,5	8,9	8,5	8,2
Elongation at break	%	700	560	470	280	560	405	300	225
Modulus 100 %	MPa	0,7	1,1	1,5	2,8	1,2	1,9	2,8	3,8
Hardness	Shore A	39	46	51	63	49	56	64	73
Tear resistance	N/mm	11,6	15,1	3,6	1,6	3,7	2,7	1,6	1,3
Rebound resilience	%	50	55	54	48	54	52	52	47
Compression set 24h/175°C	%	18	15	13	16	12	11	13	17

NSE in High Consistency Silicone Rubber - main tests, dicumyl peroxide

		Base cpd.	QF vst			Aktisil Q			
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Dicumyl peroxide (40 %)		0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99
QF vst			25,00	50,00	100,00				
Aktisil Q						25,00	50,00	75,00	100,00
after post-cure 4 h / 200°C									
Tensile strength	MPa	11,1	9,6	8,7	8,0	8,7	8,5	8,0	7,2
Elongation at break	%	770	600	465	270	510	410	305	210
Modulus 100 %	MPa	0,8	1,1	1,6	2,9	1,3	1,9	2,9	3,4
Hardness	Shore A	40	46	54	64	50	57	65	73
Tear resistance	N/mm	10,2	13,0	3,9	1,7	4,4	2,9	1,9	1,6
Rebound resilience	%	54	53	51	46	54	50	47	41
Compression set 24h/175°C	%	17	14	13	15	12	13	16	20
Δ Tensile strength	%	2	2	-4	4	-9	-4	-6	-12
Δ Elongation at break	%	10	7	-2	-3	-8	2	1	-6
Δ Modulus 100%	%	3	3	9	3	3	-2	3	-9
Δ Hardness	Shore A	1	0	3	1	1	1	1	0
Δ Tear resistance	%	-12	-14	8	8	20	7	20	25
Δ Rebound resilience	%	8	-4	-6	-4	0	-4	-10	-13
after post-cure 4 h / 200°C + heat ageing 168 h / 200°C									
Tensile strength	MPa	9,5	8,6	7,3	6,7	8,2	6,7	6,0	5,7
Elongation at break	%	640	560	450	250	555	420	285	200
Modulus 100 %	MPa	0,9	1,3	1,9	3,2	1,4	2,3	2,9	3,5
Hardness	Shore A	43	50	57	67	52	61	70	76
Tear resistance	N/mm	11,5	6,6	2,8	1,8	5,1	2,7	2,0	1,7
Rebound resilience	%	56	45	44	41	49	44	41	35
Δ Tensile strength	%	-14	-10	-16	-16	-5	-21	-25	-21
Δ Elongation at break	%	-17	-7	-3	-7	8	2	-6	-5
Δ Modulus 100%	%	20	18	18	10	10	21	0	3
Δ Hardness	Shore A	3	4	3	3	2	4	5	3
Δ Tear resistance	%	13	-49	-27	5	15	-7	4	4
Δ Rebound resilience	%	4	-15	-14	-11	-9	-12	-13	

NSE in High Consistency Silicone Rubber - main tests, dicumyl peroxide										
		Base cpd.	QF vst			Aktisil Q				DE fc
Elastosil R401/40		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Dicumyl peroxide (40 %)		0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99
QF vst			25,00	50,00	100,00					
Aktisil Q						25,00	50,00	75,00	100,00	
DE fc										50,00
after post-cure 4 h / 200°C + storage in reference oil IRM 903 72 h / 150°C										
(Immersion of the cured material: about 6 months; cured material was post-cured and afterwards immersed in oil;										
changes after immersion are related to the newly measured properties after post-cure)										
Tensile strength	MPa	3,7	5,2	6,4	6,3	5,5	6,5	6,6	6,2	3,7
Elongation at break	%	320	350	310	220	311	290	250	180	210
Modulus 100 %	MPa	0,8	1,1	1,8	3,2	1,4	2,2	2,9	3,7	2,2
Hardness	Shore A	23	28	33	43	29	36	43	48	32
Δ Tensile strength	%	-69	-48	-24	-19	-43	-26	-16	-14	-52
Δ Elongation at break	%	-54	-40	-25	-6	-43	-27	-10	-7	-40
Δ Modulus 100%	%	-1	-1	7	3	2	6	3	1	-40
Δ Hardness	Shore A	-21	-20	-22	-22	-22	-23	-24	-26	-36
Δ Weight	%	52,1	39,3	31,2	22,7	38,9	30,6	25,2	21,7	35,8
Δ Volume	%	63,9	54,4	47,6	39,3	53,8	46,3	41,2	37,1	53,3