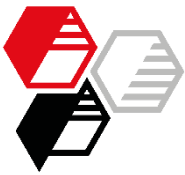




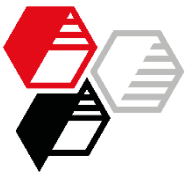
## Effect of Aktisil VM 56 in radiator hose according to VW TL 523 61

Author: Hubert Oggermüller



# Contents

- Introduction
- Experimental
- Results
  - Rheological properties
  - Mechanical properties
  - Hot air aging
  - Immersion in oil
  - Immersion in cooling fluid
  - Electrical properties
  - Extrusion properties
- Summary



# Status Quo

**HOFFMANN**  
**MINERAL®**

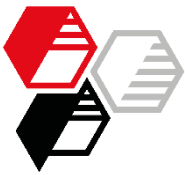
## INTRODUCTION

## EXPERIMENTAL

## RESULTS

## SUMMARY

- The VW specification TL 523 61 include very stringent requirements to radiator hose materials used. With aspect to a possible electrochemical corrosion process a low conductivity is of advantage. Therefore the application of an insulating filler is required.
- **Aktisil VM 56**, a **Neuburg Siliceous Earth** grade surface treated with a vinyl funktional group, offers itself in view of its outstanding extrusion and good mechanical properties in combination with carbon black for this application.



# Objectives

## INTRODUCTION

## EXPERIMENTAL

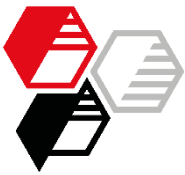
## RESULTS

## SUMMARY

- The major objective of this work was to investigate the principal effect of the partial replacement of carbon black with **AKTISIL VM 56** with respect to the requirements of the VW specification.

- Note:

The VW specification partly requires tests to be run on specimens obtained from industry manufactures radiator hose. The work reported here has been carried out according to DIN standards on press-cured samples. Therefore these results have to be considered as guide values only.



# Requirements

**HOFFMANN**  
**MINERAL®**

INTRODUCTION

EXPERIMENTAL

RESULTS

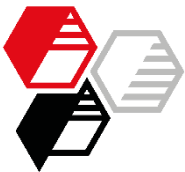
SUMMARY

Initial properties for inner and outer layer

- Hardness
- Tensile strength
- Elongation at break
- Modulus 100 %
- Compression set

additional properties inner layer:  
immersion in cooling fluid

additional properties outer layer:  
hot air aging  
immersion in oil



# Base Formulation

**HOFFMANN**  
**MINERAL®**

EPDM – 65 Shore A

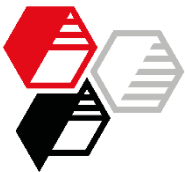
|                        | phr          |
|------------------------|--------------|
| Vistalon 7500          | 70.0         |
| Vistalon 3666          | 52.5         |
| Durex 0                | 55.0         |
| Corax N 550            | 55.0         |
| Sunpar 2280            | 22.5         |
| Flectol TMQ            | 1.0          |
| Rhenofit EDMA/S (70 %) | 0.7          |
| Perkadox 14/40 B       | 7.0          |
| <b>Total</b>           | <b>263.7</b> |

INTRODUCTION

EXPERIMENTAL

RESULTS

SUMMARY



# Compound Variations

**HOFFMANN**  
**MINERAL®**

INTRODUCTION

EXPERIMENTAL

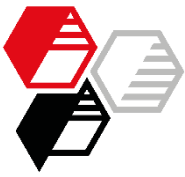
RESULTS

SUMMARY

The loading of Corax N 550, Durex 0 and **AKTISIL VM 56** was varied in the following way:

|                      | phr       |    |    |           |    |    |
|----------------------|-----------|----|----|-----------|----|----|
| <b>Aktisil VM 56</b> | <b>40</b> |    |    | <b>80</b> |    |    |
| Corax N 550          | 45        | 90 | 0  | 35        | 70 | 0  |
| Durex 0              | 45        | 0  | 90 | 35        | 0  | 70 |

As a rough guideline, it was confirmed that for equal hardness 1 part of carbon black can be replaced by 2 parts Aktisil VM 56.



# Fillers, Characteristics

**HOFFMANN  
MINERAL®**

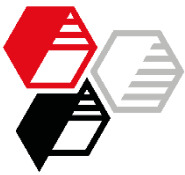
INTRODUCTION

EXPERIMENTAL

RESULTS

SUMMARY

|                                       |                      | Corax<br>N 550 | Durex 0   | Aktisil<br>VM 56 |
|---------------------------------------|----------------------|----------------|-----------|------------------|
| Density                               | [g/cm <sup>3</sup> ] | 1.8            | 1.8       | 2.6              |
| Particle size d <sub>50</sub>         | [μm]                 |                |           | 2.0              |
| Particle size d <sub>97</sub>         | [μm]                 |                |           | 9                |
| Sieve residue >40 μm                  | [mg/kg]              |                |           | 4                |
| Sieve residue<br>45 μm (Siev No. 325) | ppm                  | ≤ 300<br>10    | ≤ 50<br>2 |                  |
| Specific surface area<br>BET          | [m <sup>2</sup> /g]  | 39             | 18        | 11               |
| DBP absorption                        | [ml/100 g]           | 121            | 64        |                  |
| Functionalization                     |                      | none           | none      | Vinyl            |



# Preparation of Compounds

**HOFFMANN**  
**MINERAL®**

INTRODUCTION

EXPERIMENTAL

RESULTS

SUMMARY

- **Mixing**

Open mill Ø 150 x 300 mm

Batch weight: approx. 800 g

Temperature: 70 °C

Mixing time: approx. 20 min.

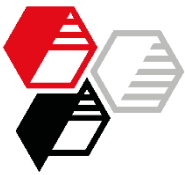
- **Mixing for hose extrusion**

Laboratory mixer (Francis Shaw MK4): 1.5 l

Fill factor: 70 – 75 %

Dump temperature: approx. 118 °C

Mixing time: 6.5 min.



# Curing and Testing of Compounds

**HOFFMANN**  
**MINERAL®**

INTRODUCTION

EXPERIMENTAL

RESULTS

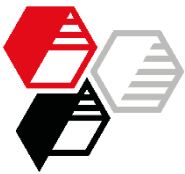
SUMMARY

- **Curing**

Press, 180 °C, 5 min.

- **Testing**

According to DIN methods while respecting the test conditions of the VW specification TL 523 61.



# Hose Extrusion

**HOFFMANN**  
**MINERAL®**

INTRODUCTION

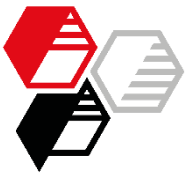
EXPERIMENTAL

RESULTS

SUMMARY

|                                                 |       |                            |
|-------------------------------------------------|-------|----------------------------|
| Extruder                                        |       | Schwabenthan Polytest 30 R |
| Screw diameter                                  | [mm]  | 30                         |
| Working length                                  | [mm]  | 450                        |
| Temperature set point<br>head / zone 1 / zone 2 | [°C]  | 110 / 70 / 70              |
| Screw speed                                     | [rpm] | 100                        |
| Profile                                         |       | see figure                 |
| Feed strips                                     |       | cold, untreated            |
| Objective of extrusion                          |       | max. extrusion output      |



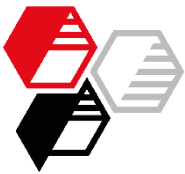


# Volume Resistivity

**HOFFMANN**  
**MINERAL®**

## DIN IEC 93

|                      |                                                                                                                                                                                                                                                                                                                             |                                                       |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| Measuring instrument |                                                                                                                                                                                                                                                                                                                             | Model HM 307 from Fetric                              |
| Modified test method |                                                                                                                                                                                                                                                                                                                             | Measuring instrument<br>Model Mavo 20 from Co. Gossen |
| Dimension of plates  | [cm]                                                                                                                                                                                                                                                                                                                        | 10 x 10                                               |
| Thickness of plates  | [mm]                                                                                                                                                                                                                                                                                                                        | 2                                                     |
| Electrode set-up     |                                                                                                                                                                                                                                                                                                                             | circular plate electrode with protective ring         |
| Test method          |                                                                                                                                                                                                                                                                                                                             | voltage / amperage method                             |
| Test voltage         | [V]                                                                                                                                                                                                                                                                                                                         | 1                                                     |
| Recording time       | [min]                                                                                                                                                                                                                                                                                                                       | 1                                                     |
| Test temperature     | [°C]                                                                                                                                                                                                                                                                                                                        | 23                                                    |
| Evaluation           | $\rho = R_x \cdot A / h$ <p><math>\rho</math> = volume resistivity in <math>\Omega\text{cm}</math><br/><math>R_x</math> = volume resistance in <math>\Omega</math><br/><math>A</math> = effective surface area of the protected electrode (24 cm<sup>2</sup>)<br/><math>h</math> = Median thickness of test plate in cm</p> |                                                       |



# Mooney Viscosity

**HOFFMANN  
MINERAL®**

DIN 53 523 Part 3, ML 1+4 120 °C

ME

110

105

100

95

90

85

80

0  
110

40  
90

80  
70

- ◆ Corax N 550/  
Durex 0 (50/50)
- Durex 0
- ▲ Corax N 550

**Aktisil VM 56 [phr]**  
**Carbon black [phr]**

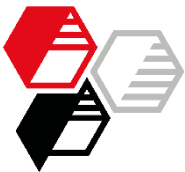
INTRODUCTION

EXPERIMENTAL

RESULTS

- Rheological  
properties

SUMMARY

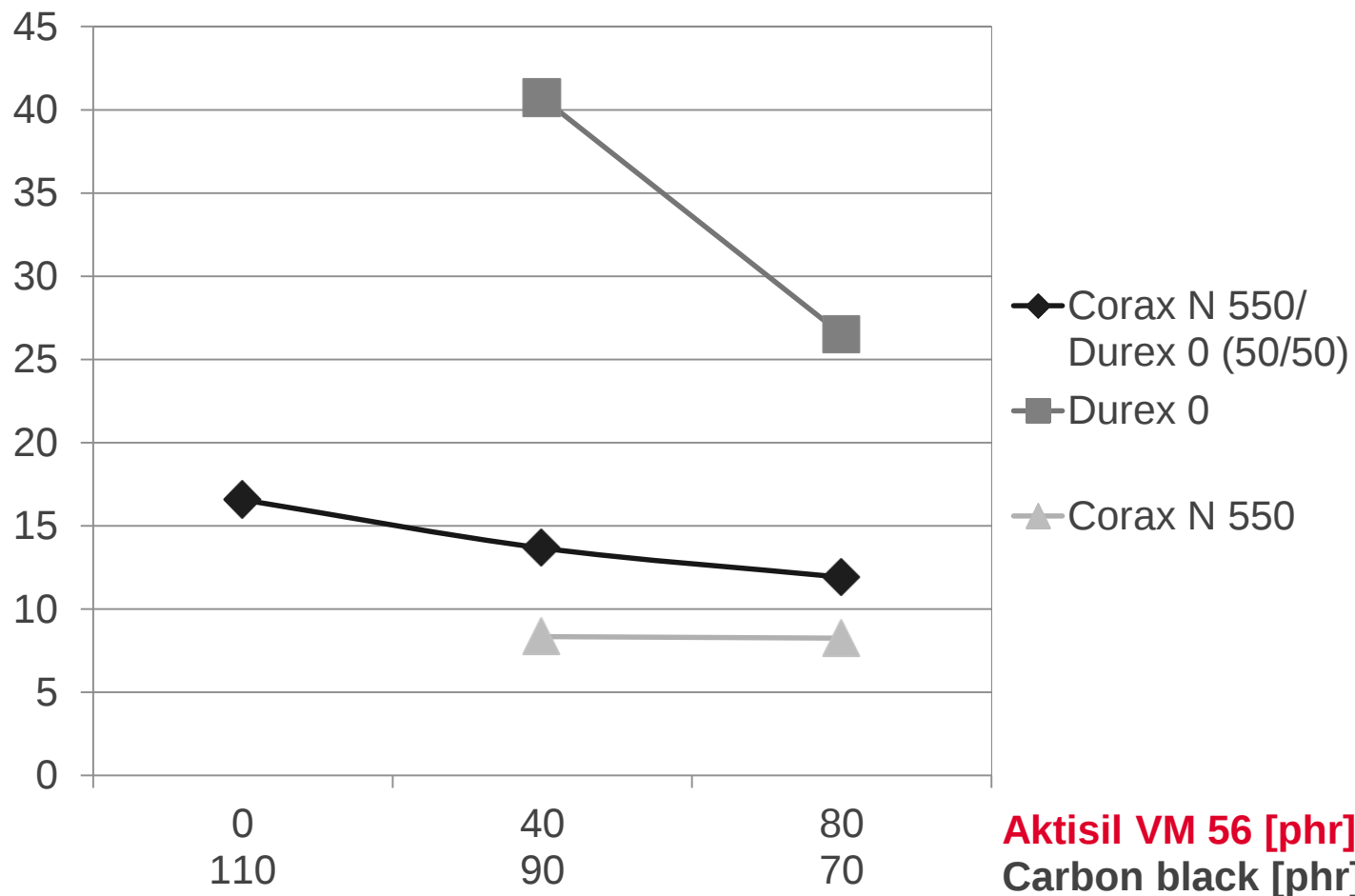


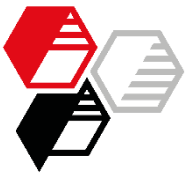
# Mooney Scorch Time

**HOFFMANN**  
**MINERAL®**

DIN 53 523 Part 4, ML +5 120 °C

min.





## Conversion Time $t_5$

DIN 53 529-A3, 180 °C, 0.2° deflection – Göttfert Elastograph

min.

0,52

0,50

0,48

0,46

0,44

0,42

0,40

0  
110

40  
90

80  
70

◆ Corax N 550/  
Durex 0 (50/50)

■ Durex 0

▲ Corax N 550

**Aktisil VM 56 [phr]**  
**Carbon black [phr]**

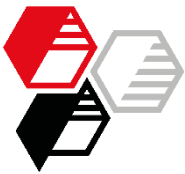
INTRODUCTION

EXPERIMENTAL

RESULTS

- Rheological properties

SUMMARY

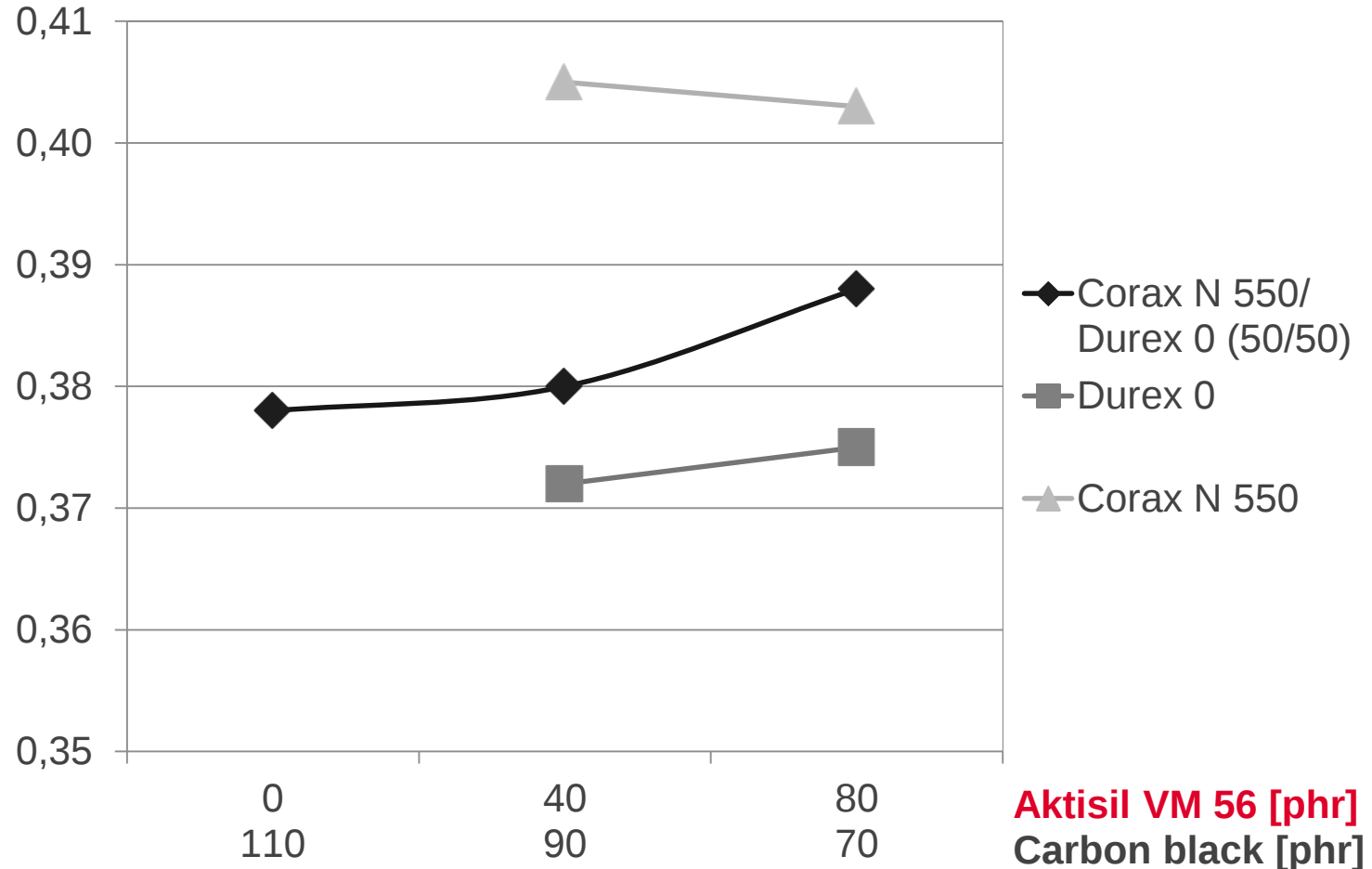


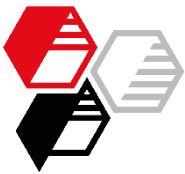
# Torque Maximum

**HOFFMANN**  
**MINERAL®**

DIN 53 529-A3, 180 °C, 0.2° deflection – Göttfert Elastograph

Nm/min.

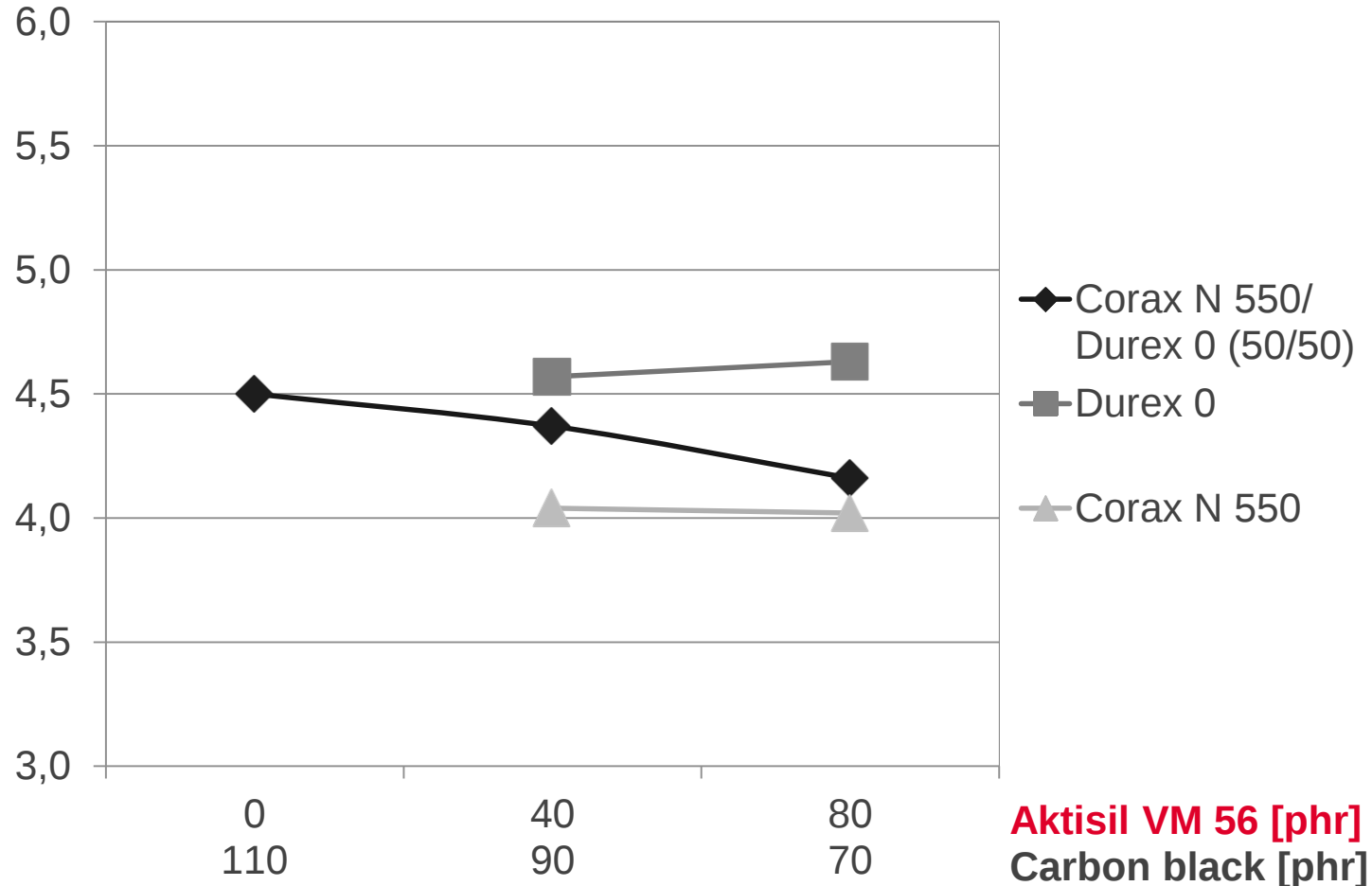


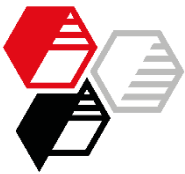


## Conversion Time $t_{90}$

DIN 53 529-A3, 180 °C, 0.2° deflection – Göttfert Elastograph

min.



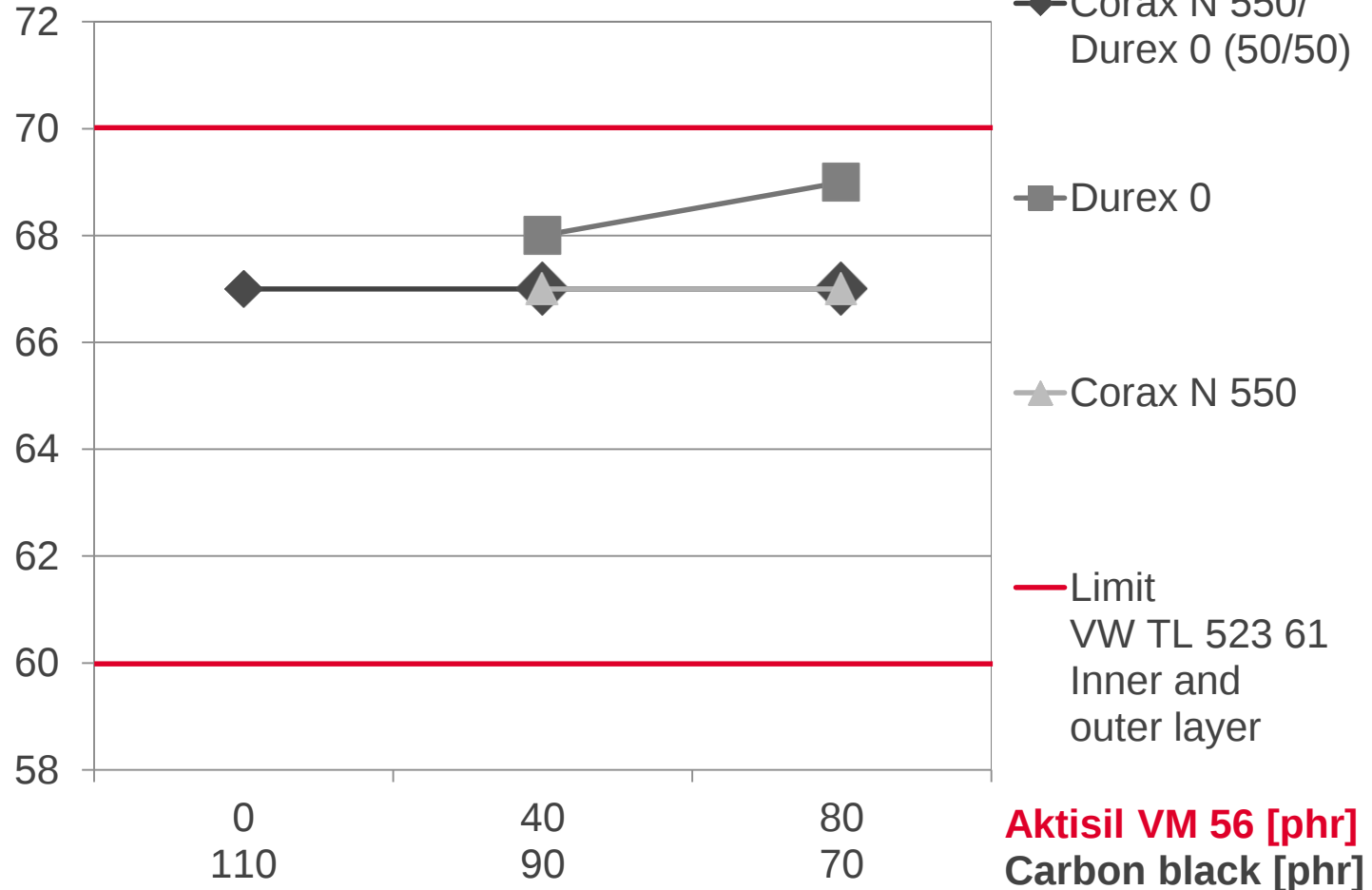


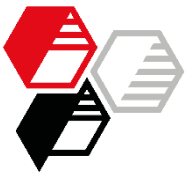
# Hardness

**HOFFMANN  
MINERAL®**

DIN 53 505-A, piled-up S2 dumbbells

## Shore A





# Tensile Strength

**HOFFMANN**  
**MINERAL®**

DIN 53 504, S2

MPa

18

16

14

12

10

8

6

◆ Corax N 550/  
Durex 0 (50/50)

■ Durex 0

▲ Corax N 550

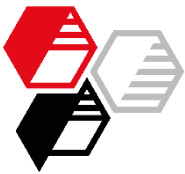
— Limit  
VW TL 523 61  
Inner and  
outer layer

**Aktisil VM 56 [phr]**  
**Carbon black [phr]**

0  
110

40  
90

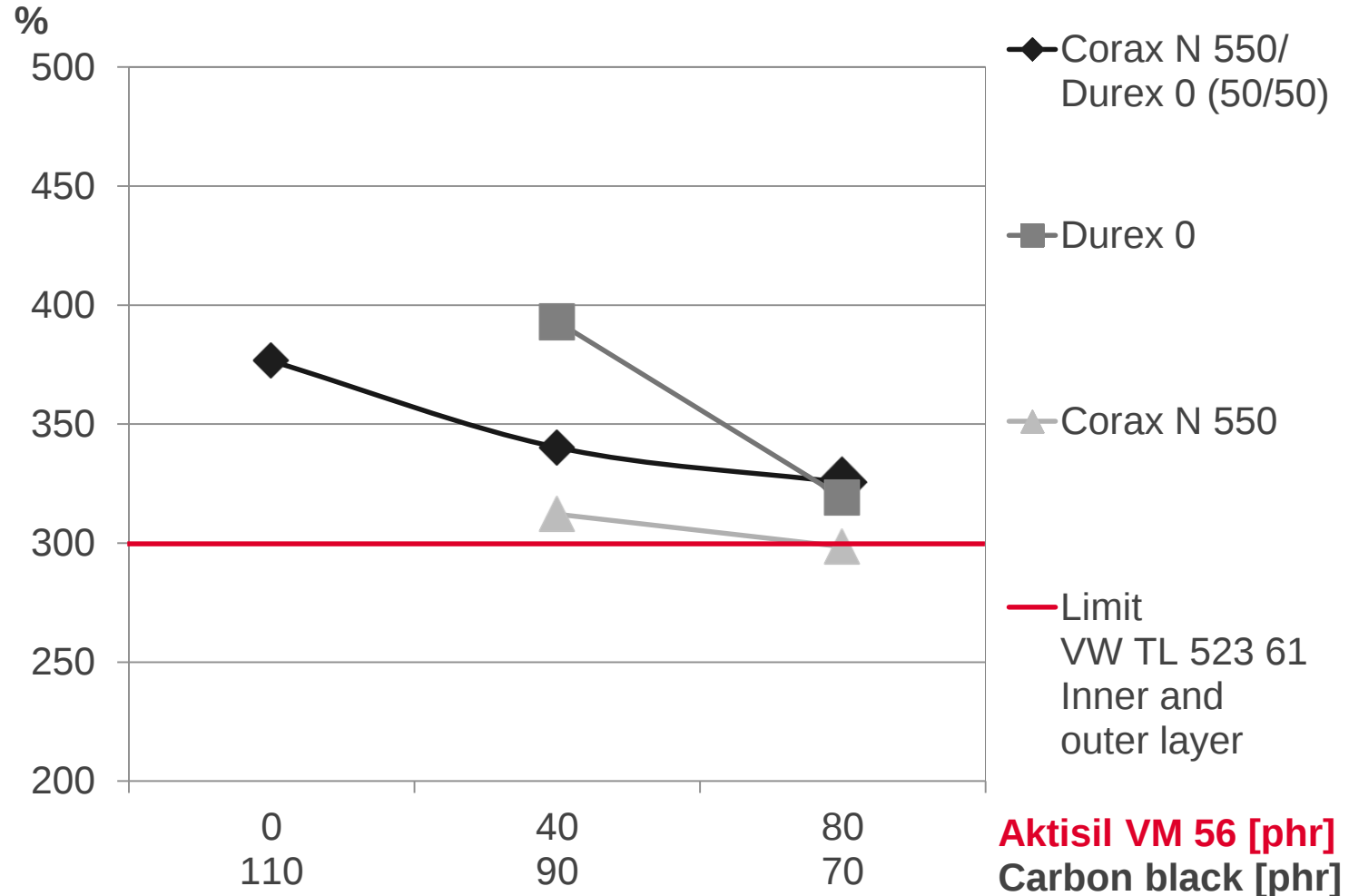
80  
70

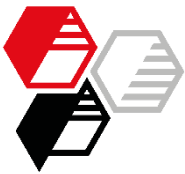


# Elongation at break

**HOFFMANN  
MINERAL®**

DIN 53 504, S2





## Modulus 100 %

**HOFFMANN**  
**MINERAL®**

DIN 53 504, S2

MPa

5,0

4,5

4,0

3,5

3,0

◆ Corax N 550/  
Durex 0 (50/50)

■ Durex 0

▲ Corax N 550

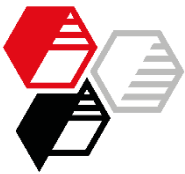
— Limit  
VW TL 523 61  
Inner and  
outer layer

**Aktisil VM 56 [phr]**  
**Carbon black [phr]**

0  
110

40  
90

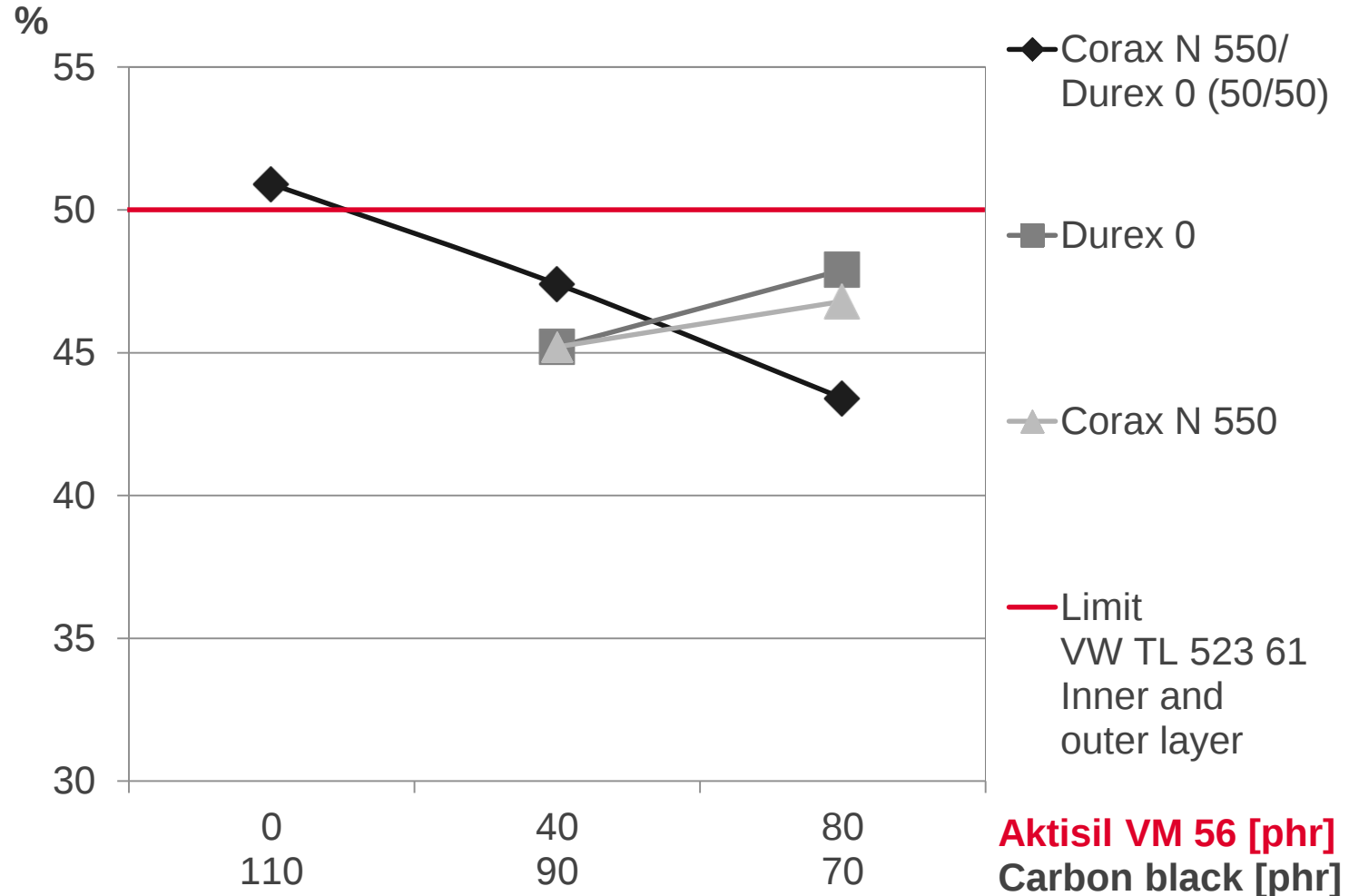
80  
70

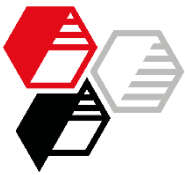


# Compression Set

**HOFFMANN**  
**MINERAL®**

P-VW 3307, 50 % defl., 3 h cooling, 1 min. relaxation, 22 h/160°C



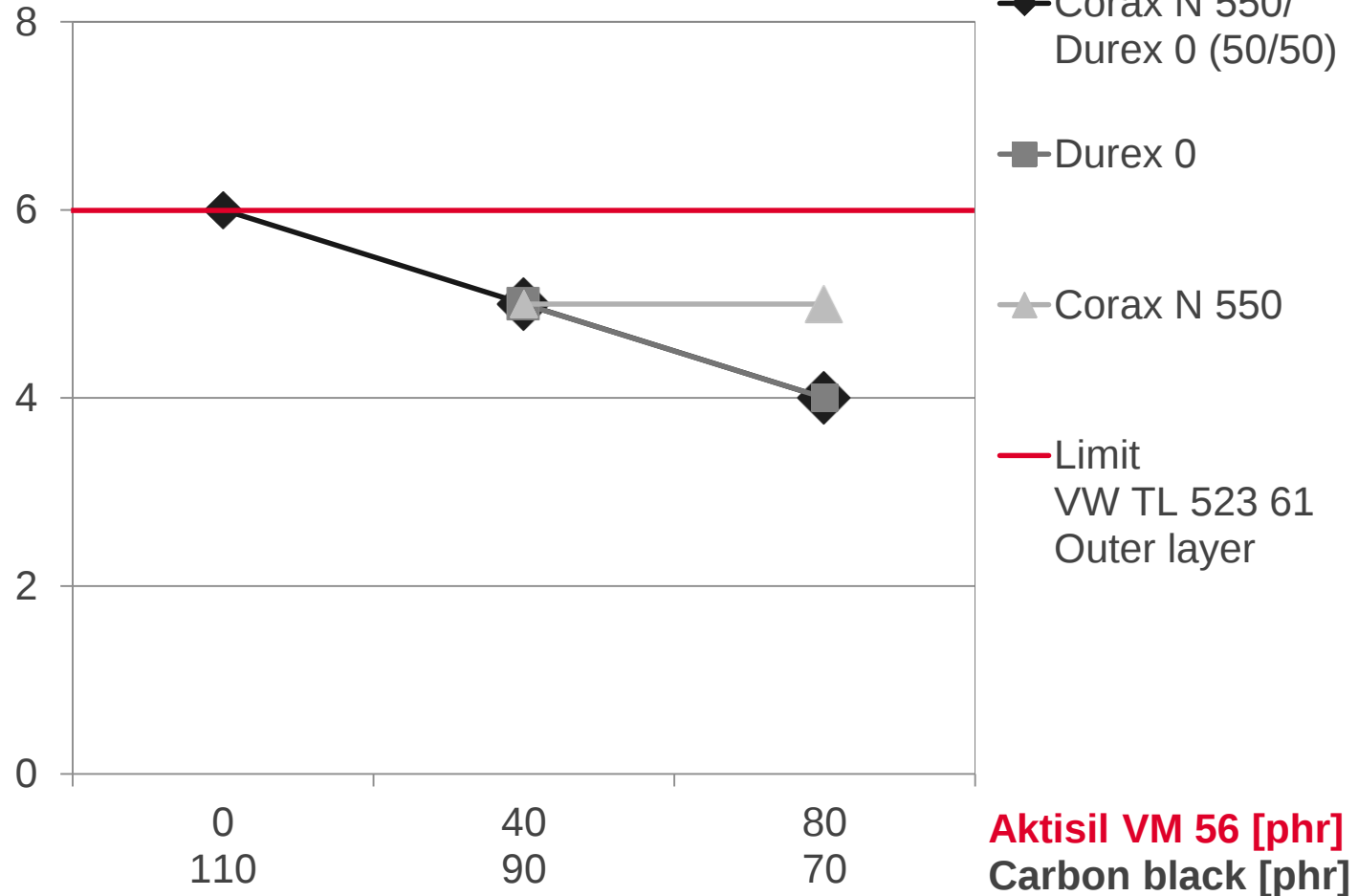


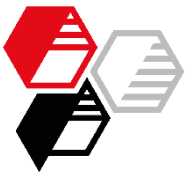
# Hot Air Aging Change of Hardness

**HOFFMANN  
MINERAL®**

DIN 53 508, S2, 94 h / 160 °C

Shore A



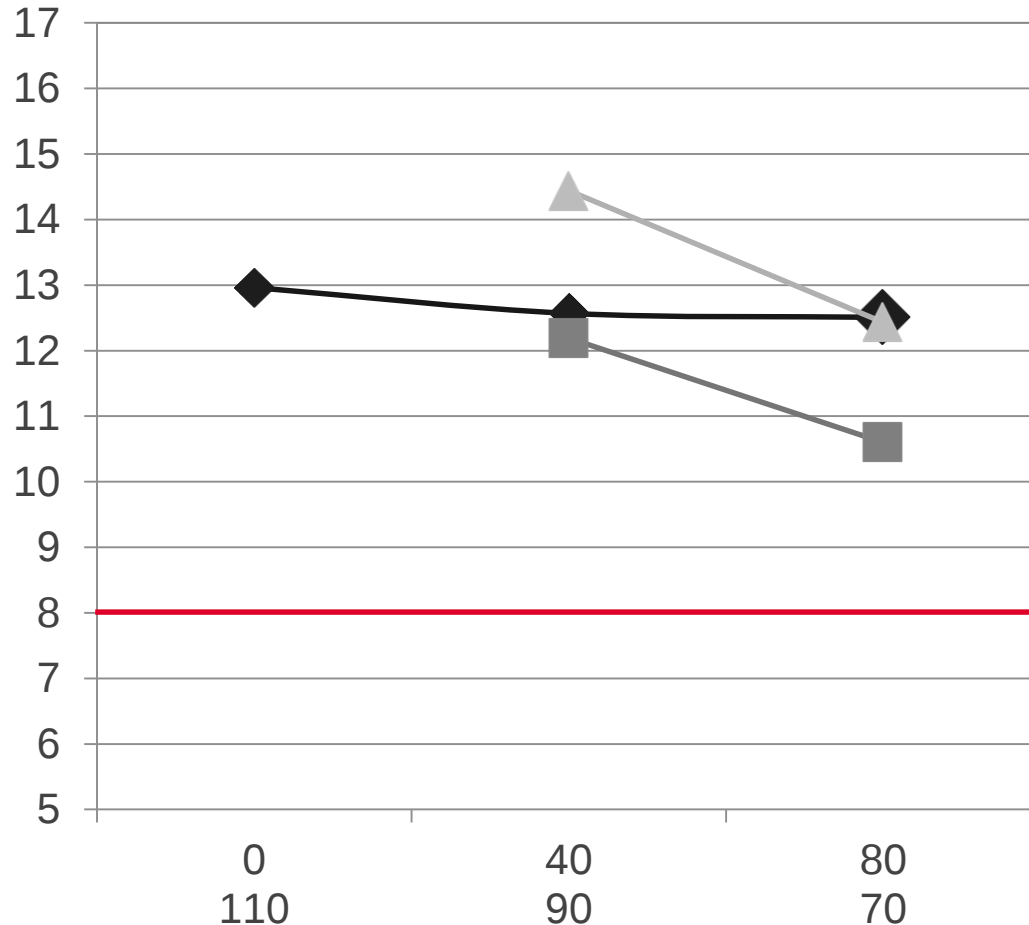


# Hot Air Aging Remaining Tensile Strength

**HOFFMANN  
MINERAL®**

DIN 53 508, S2, 94 h / 160 °C

MPa



◆ Corax N 550/  
Durex 0 (50/50)

■ Durex 0

▲ Corax N 550

— Limit  
VW TL 523 61  
Outer layer

**Aktisil VM 56 [phr]  
Carbon black [phr]**

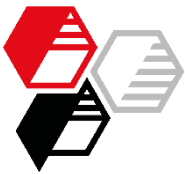
INTRODUCTION

EXPERIMENTAL

RESULTS

• Hot air aging

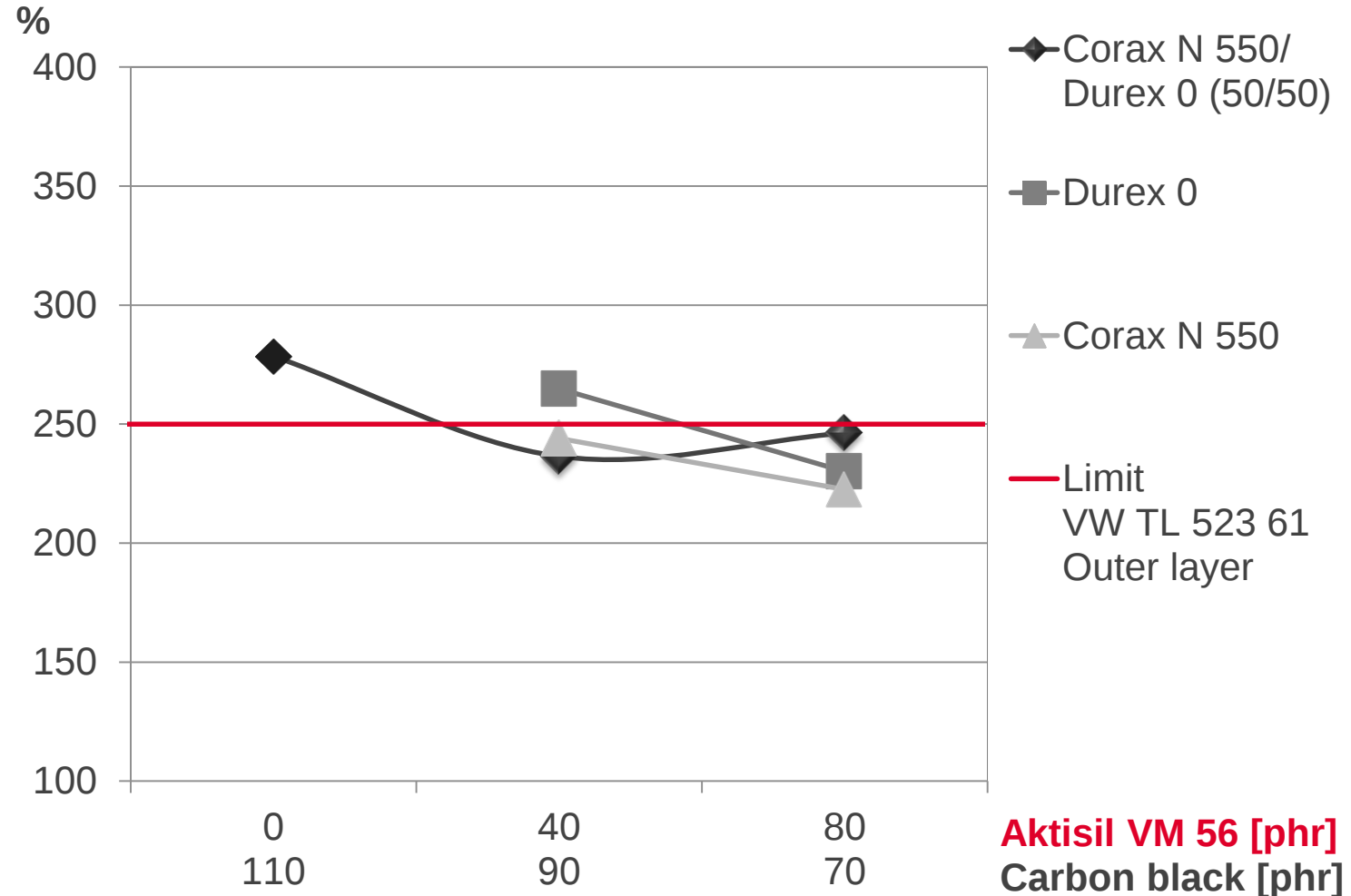
SUMMARY

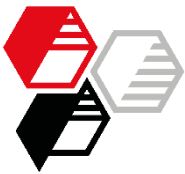


# Hot Air Aging Remaining Elongation at B.

**HOFFMANN**  
**MINERAL®**

DIN 53 508, S2, 94 h / 160 °C



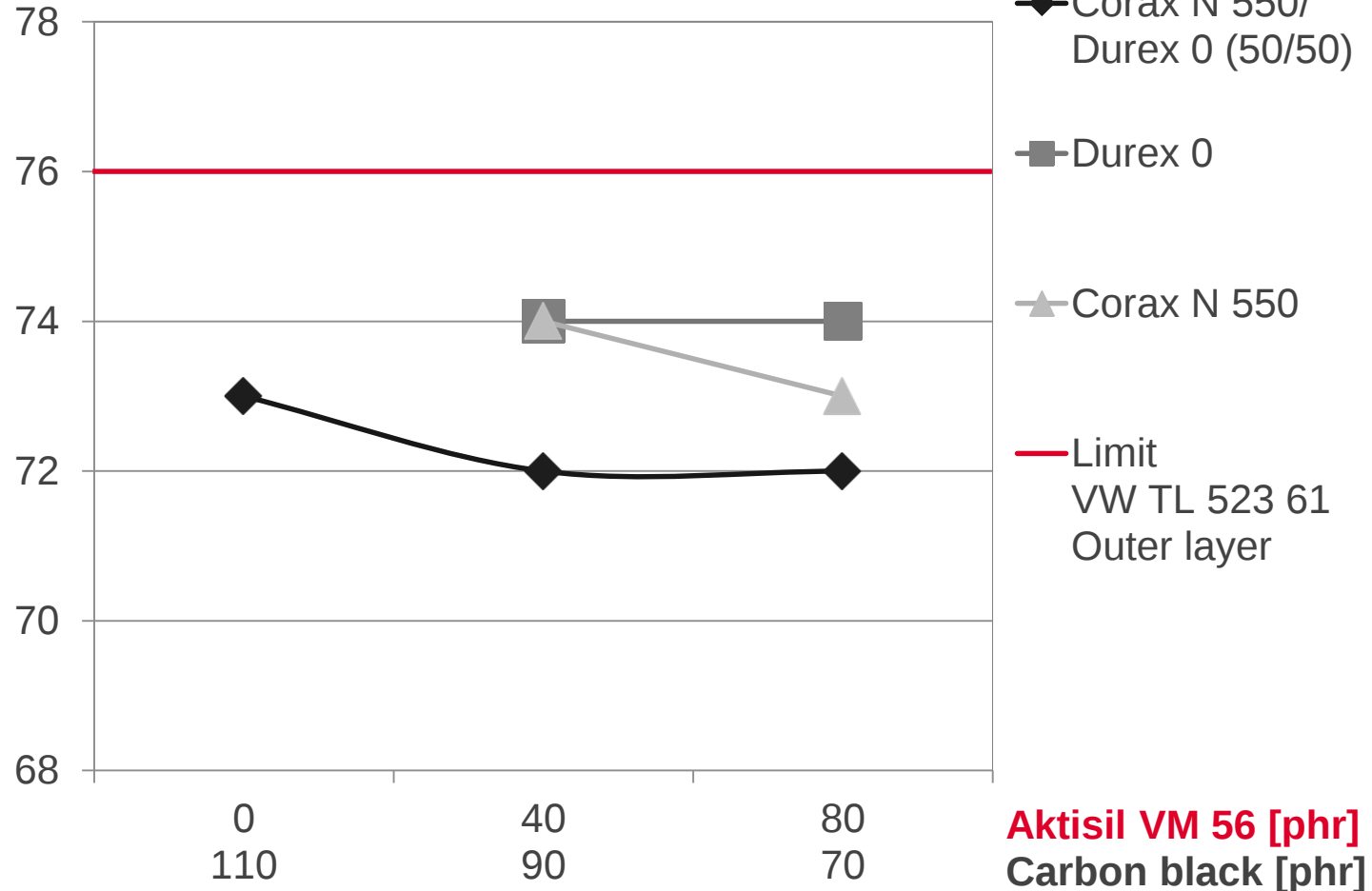


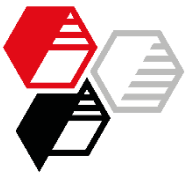
# Hot Air Aging Remaining Hardness

**HOFFMANN  
MINERAL®**

DIN 53 508, S2, 168 h / 150 °C

**Shore A**



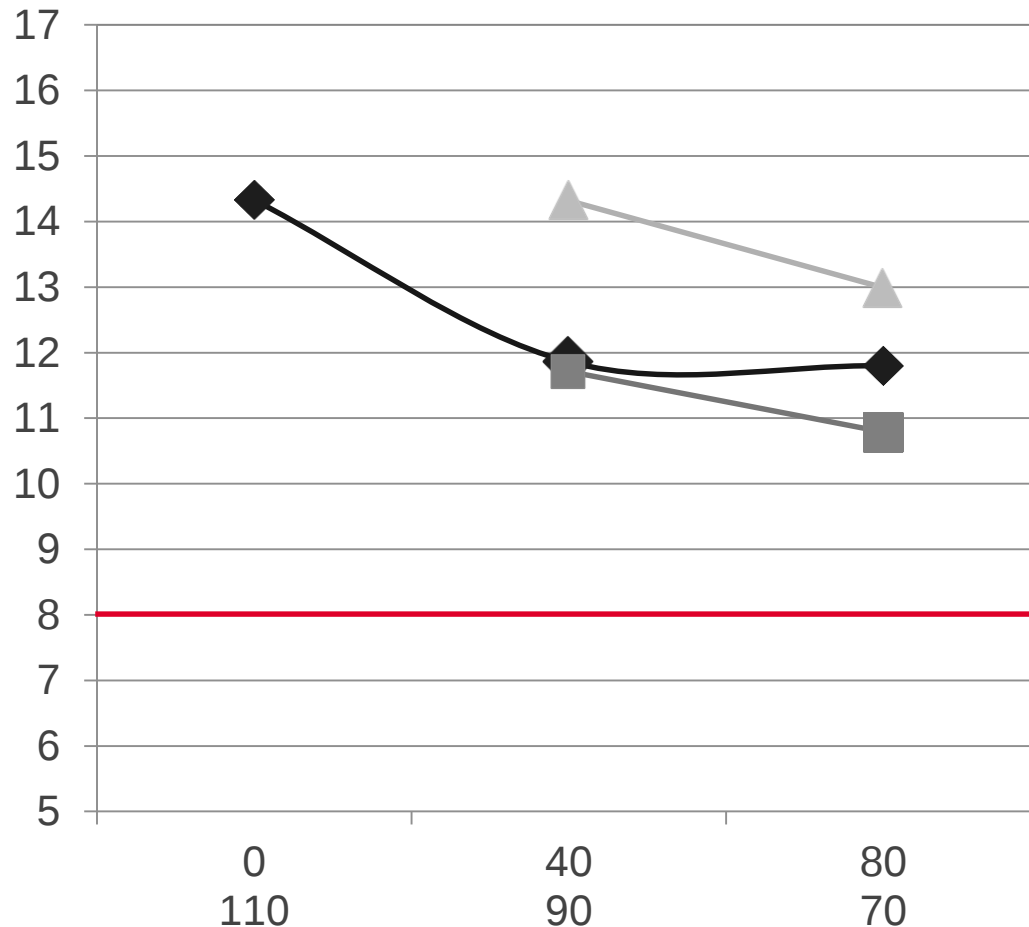


# Hot Air Aging Remaining Tensile Strength

**HOFFMANN  
MINERAL®**

DIN 53 508, S2, 168 h / 150 °C

MPa



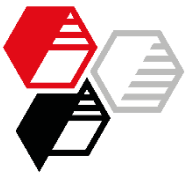
◆ Corax N 550/  
Durex 0 (50/50)

■ Durex 0

▲ Corax N 550

— Limit  
VW TL 523 61  
Outer layer

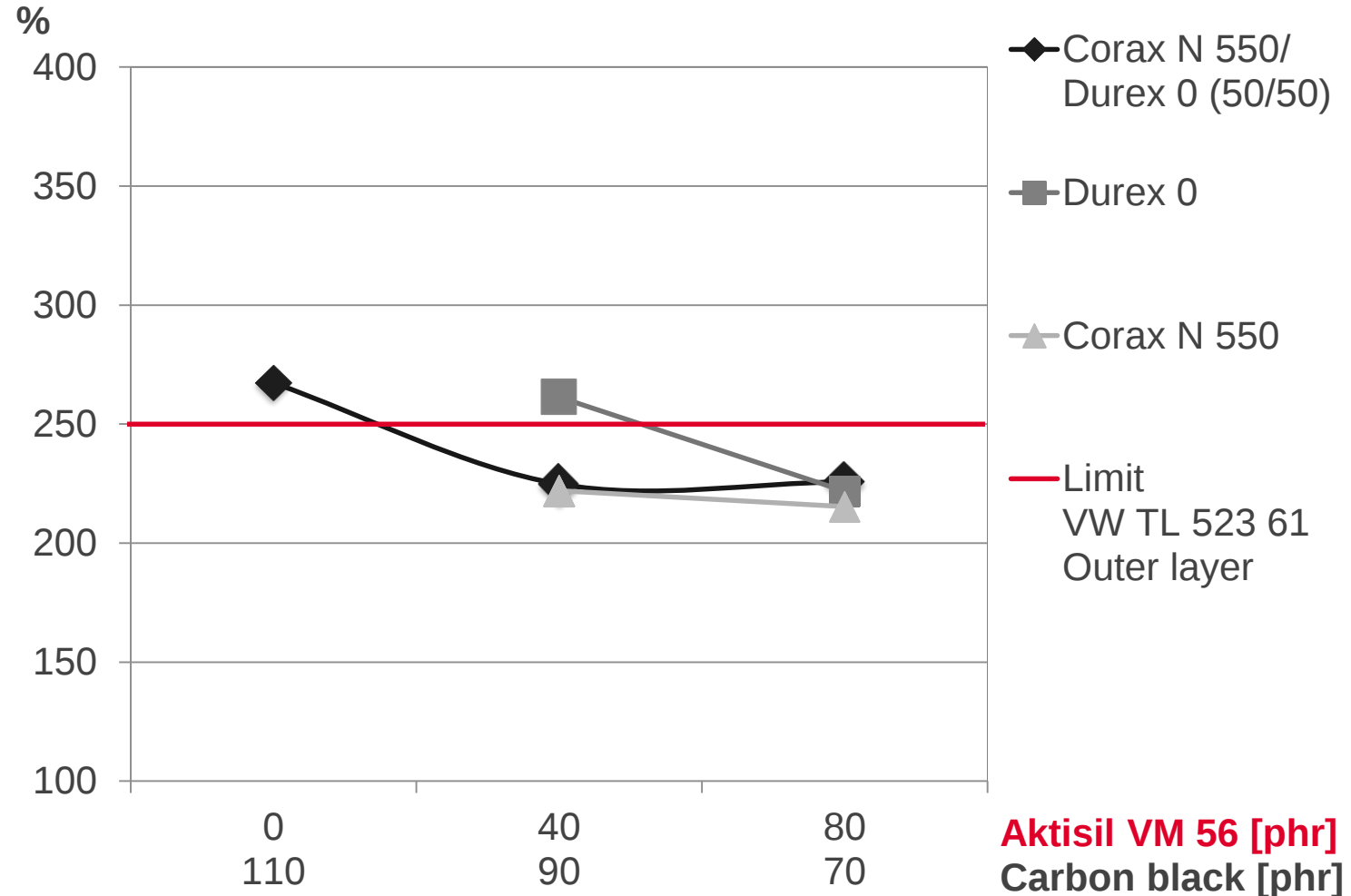
**Aktisil VM 56 [phr]**  
**Carbon black [phr]**

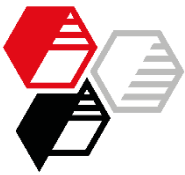


# Hot Air Aging Remaining Elongation at B.

**HOFFMANN**  
**MINERAL®**

DIN 53 508, S2, 168 h / 150 °C



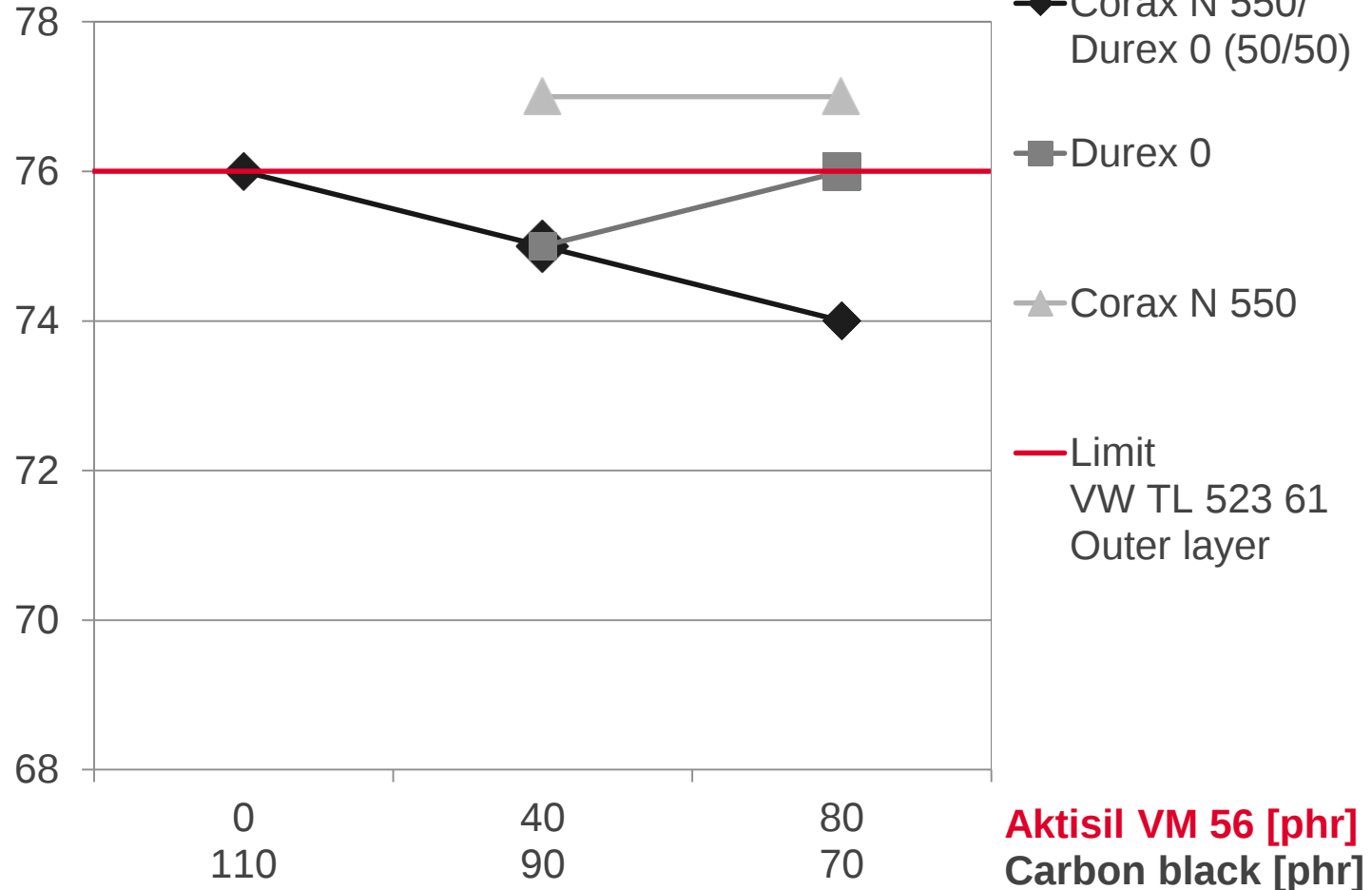


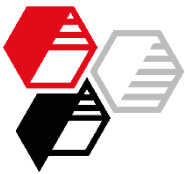
# Hot Air Aging Remaining Hardness

**HOFFMANN  
MINERAL®**

DIN 53 508, S2, 336 h / 150 °C

**Shore A**

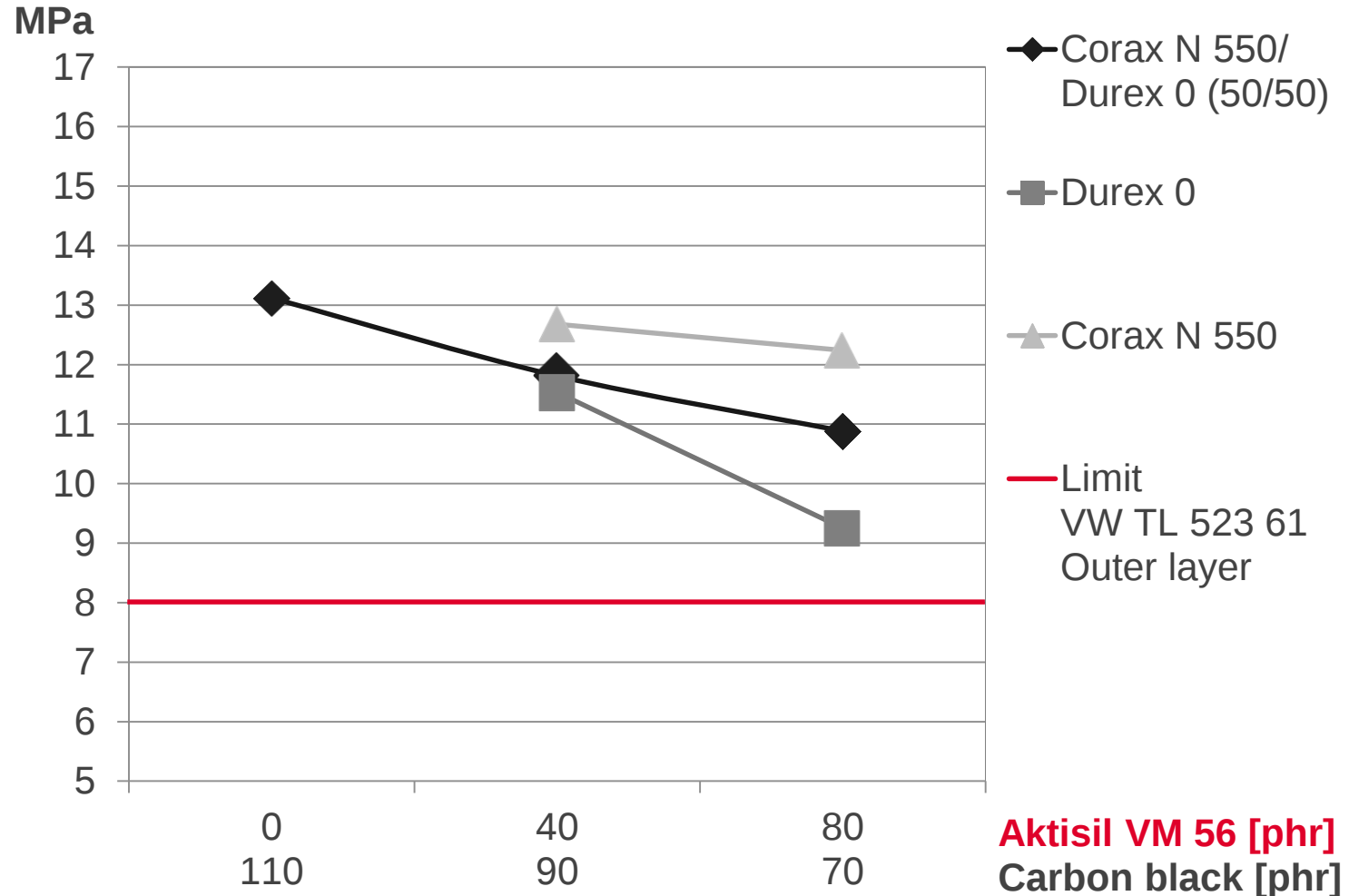


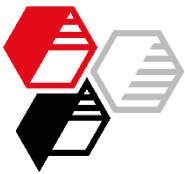


# Hot Air Aging Remaining Tensile Strength

**HOFFMANN  
MINERAL®**

DIN 53 508, S2, 336 h / 150 °C

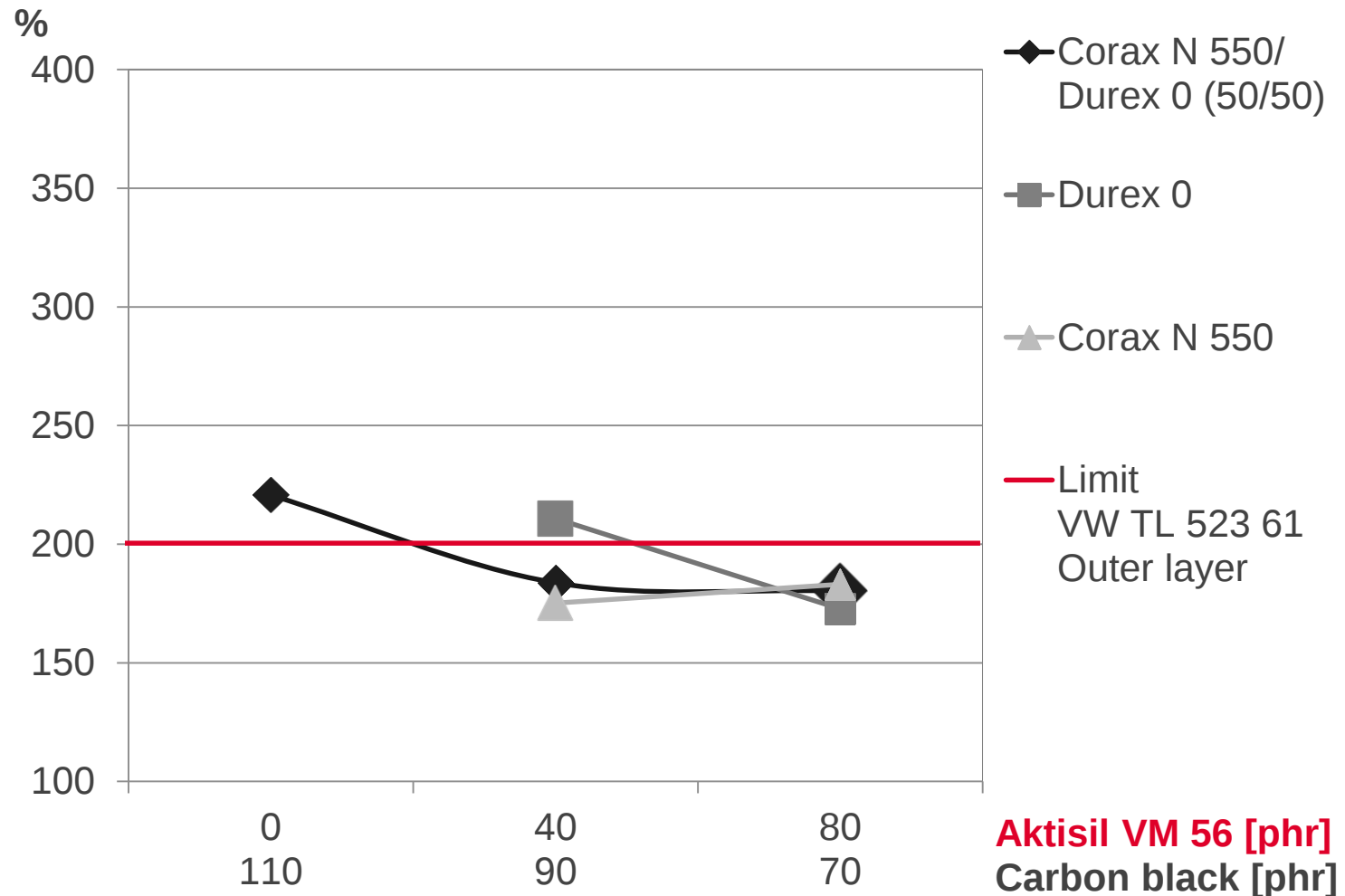


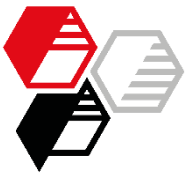


# Hot Air Aging Remaining Elongation at B.

**HOFFMANN  
MINERAL®**

DIN 53 508, S2, 336 h / 150 °C

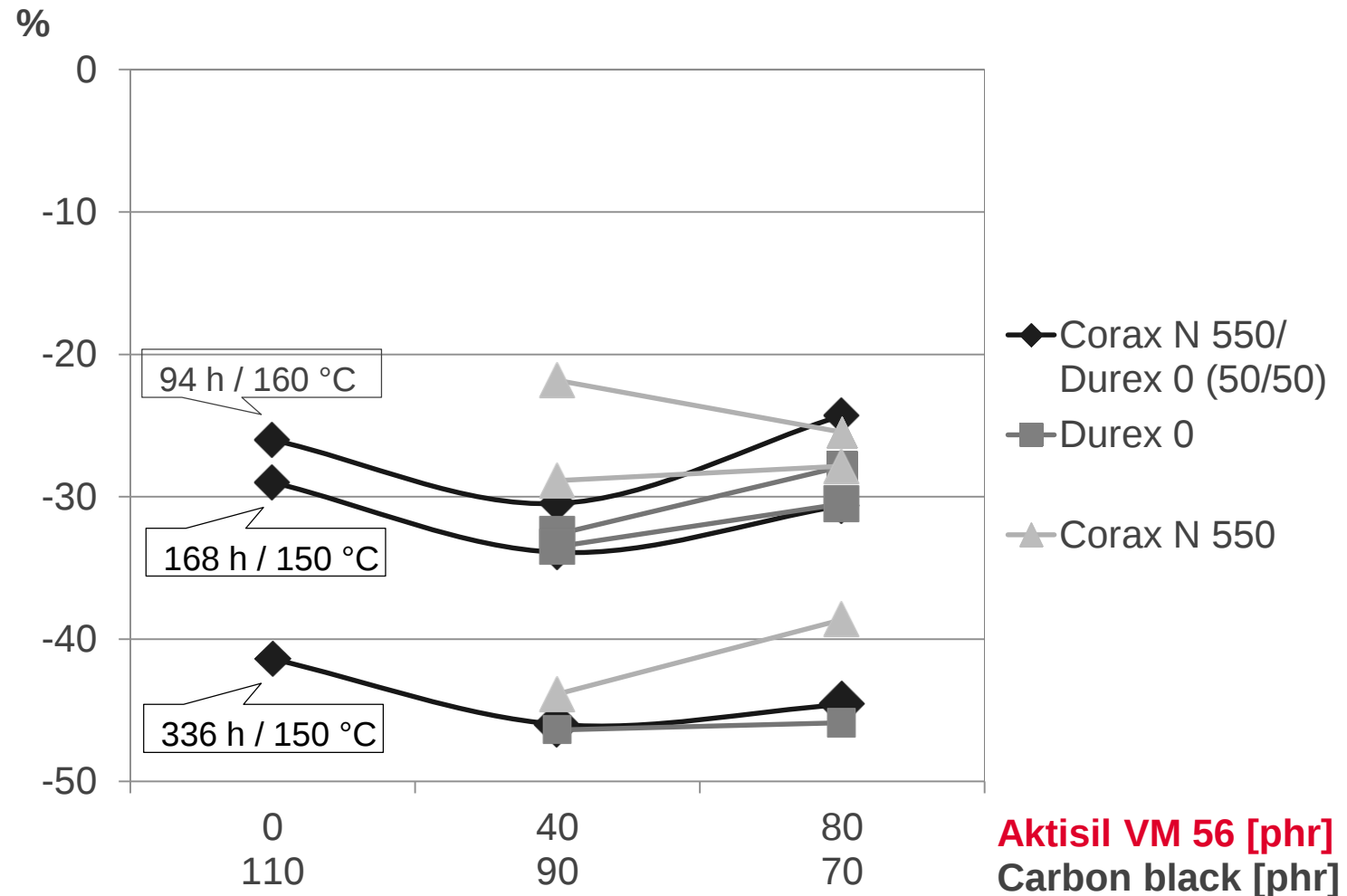


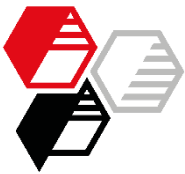


# Hot Air Aging Change of Elongation at B.

**HOFFMANN  
MINERAL®**

DIN 53 508, S2, 150 °C and 160 °C





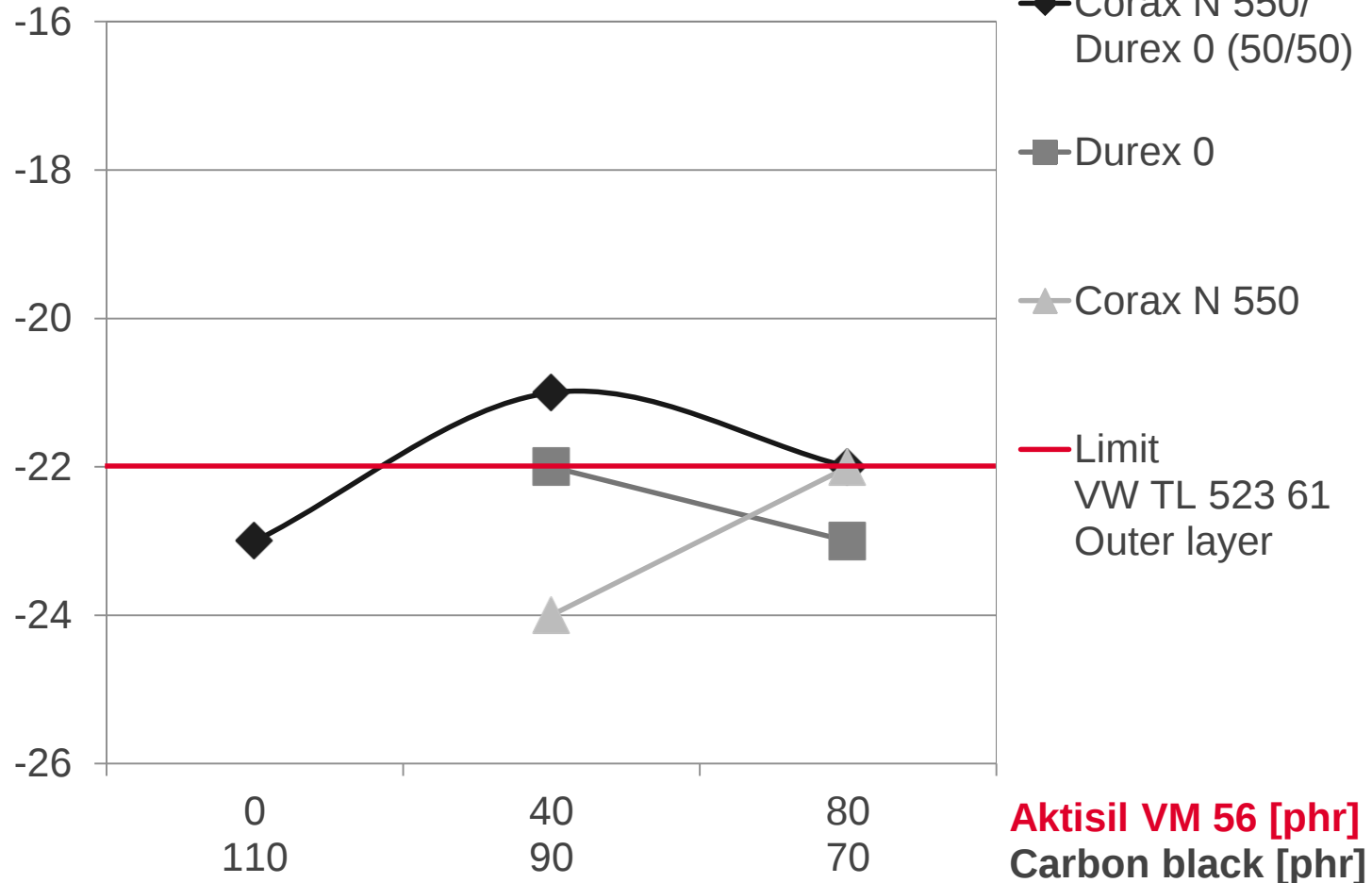
# BP Olex MK 4449

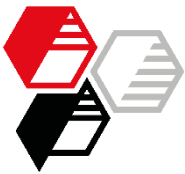
## Change of Hardness

**HOFFMANN**  
**MINERAL®**

DIN 53 521, S2, 22 h / 100 °C

**Shore A**





# BP Olex MK 4449

## Remaining Tensile Strength

**HOFFMANN**  
**MINERAL®**

DIN 53 521, S2, 22 h / 100 °C

MPa

12

11

10

9

8

7

6

5

◆ Corax N 550/  
Durex 0 (50/50)

■ Durex 0

▲ Corax N 550

— Limit  
VW TL 523 61  
Outer layer

0  
110

40  
90

80  
70

**Aktisil VM 56 [phr]**  
**Carbon black [phr]**

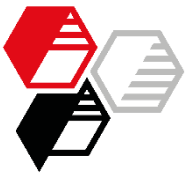
INTRODUCTION

EXPERIMENTAL

RESULTS

• Immersion in oil

SUMMARY

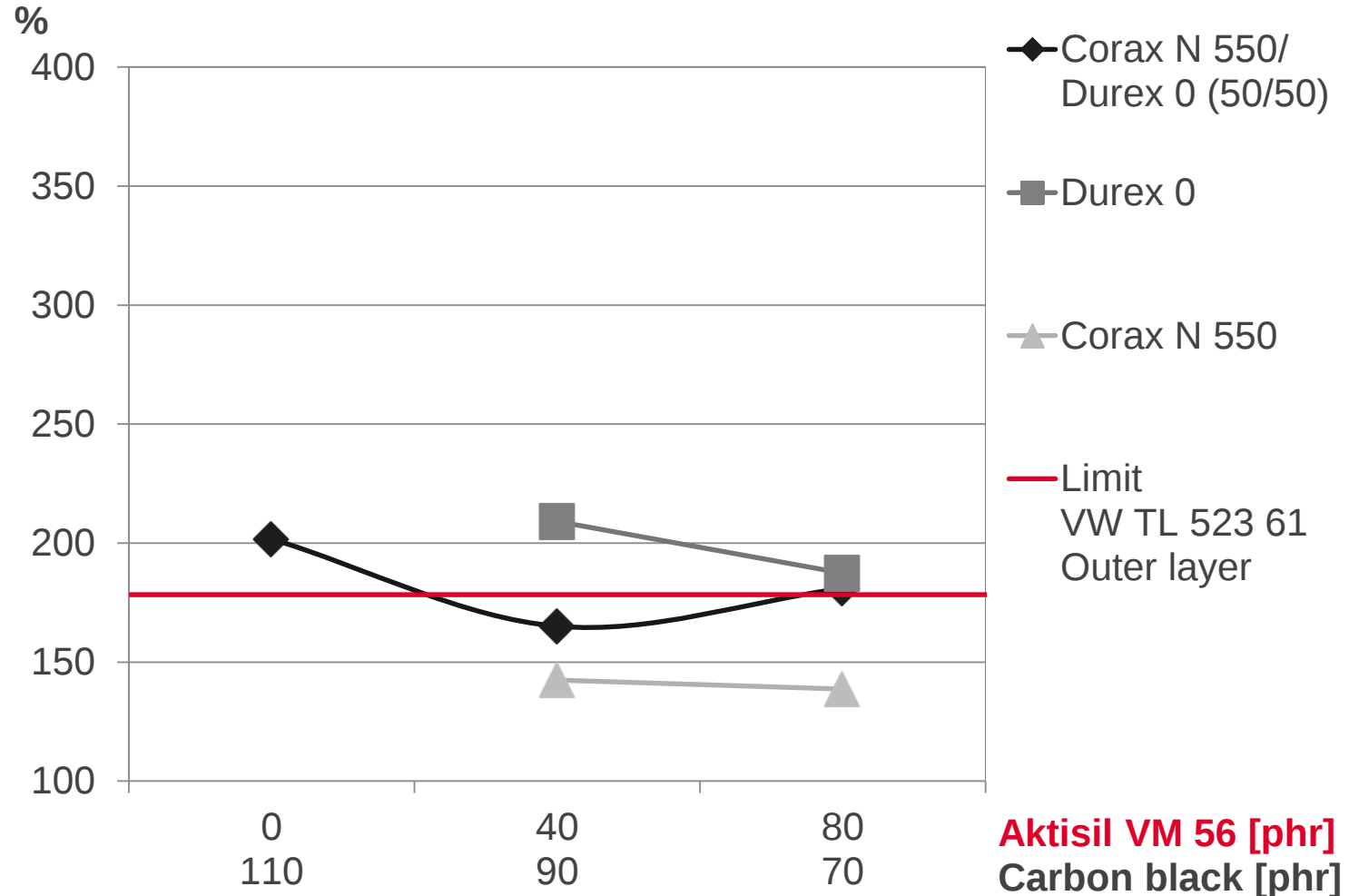


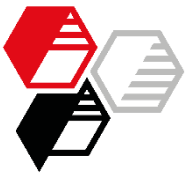
# BP Olex MK 4449

## Remaining Elongation at B.

**HOFFMANN**  
**MINERAL®**

DIN 53 521, S2, 22 h / 100 °C



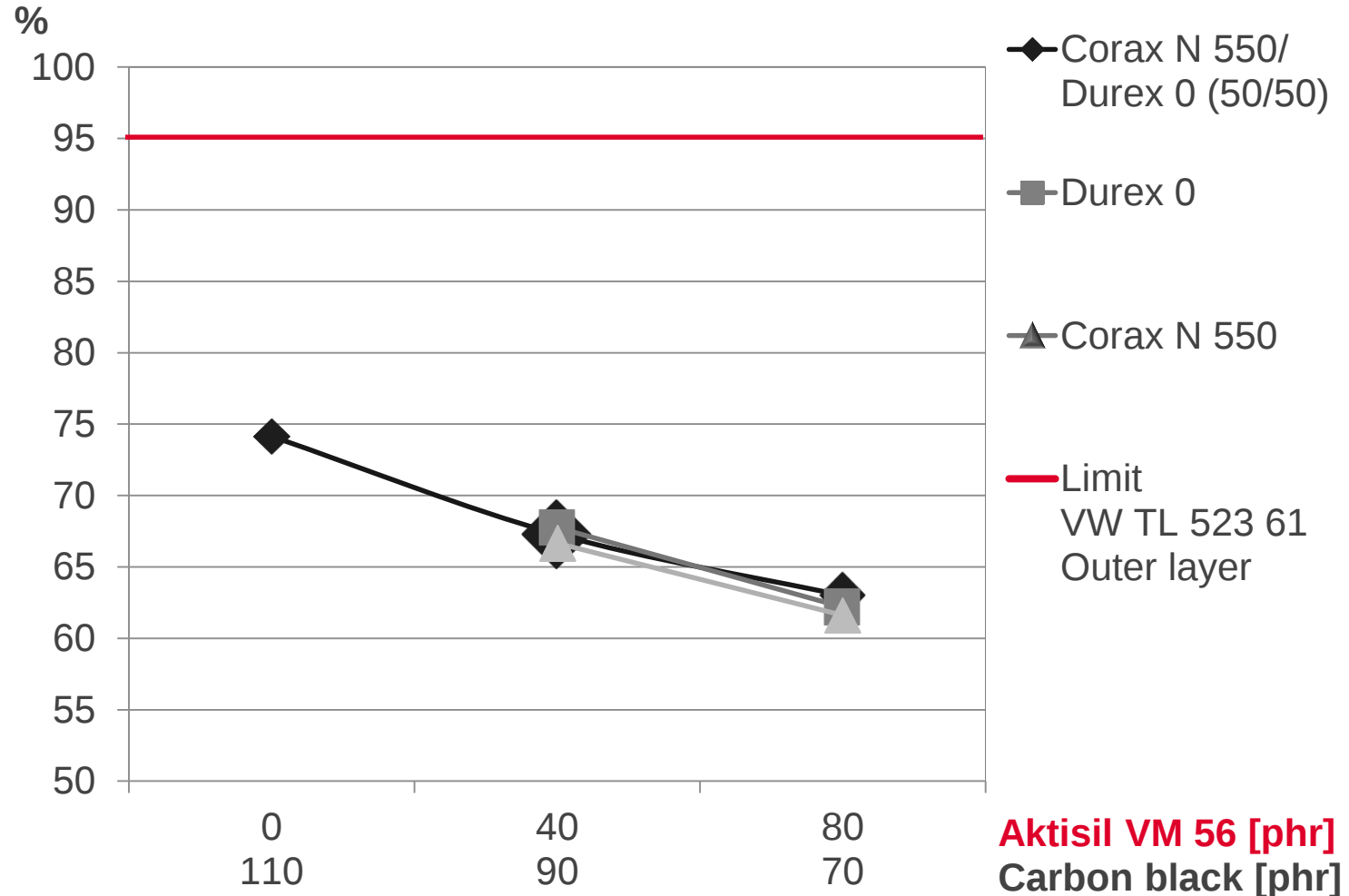


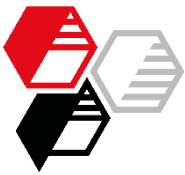
# BP Olex MK 4449

## Change of Weight

**HOFFMANN**  
**MINERAL®**

DIN 53 521, S2, 22 h / 100 °C





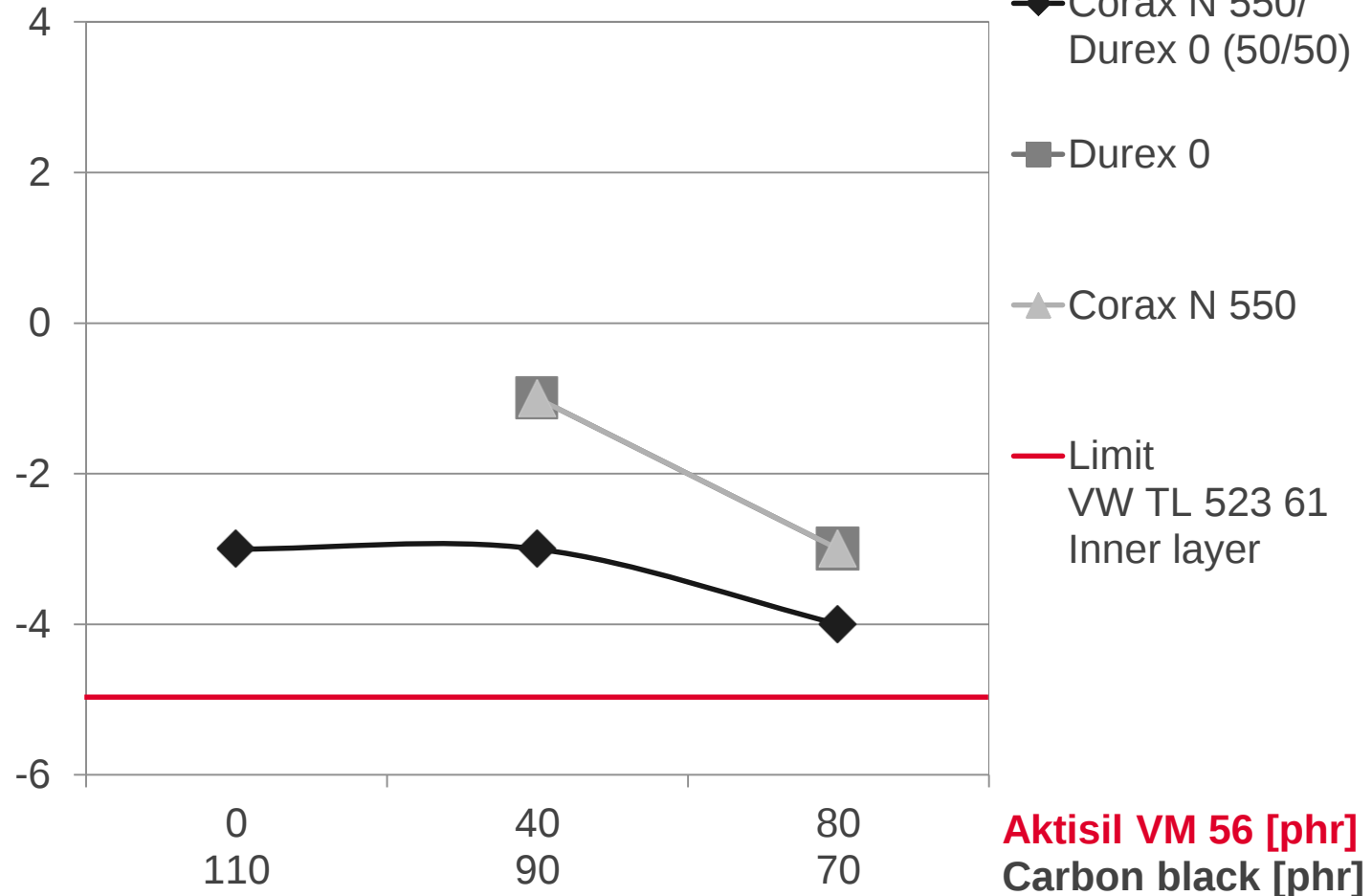
# Cooling Fluid G12

## Change of Hardness

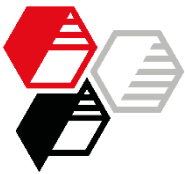
**HOFFMANN**  
**MINERAL®**

VW TL 523 61, S2, dilution 1:1 with H<sub>2</sub>O dist., 94 h / 160 °C

**Shore A**



**Aktisil VM 56 [phr]**  
**Carbon black [phr]**

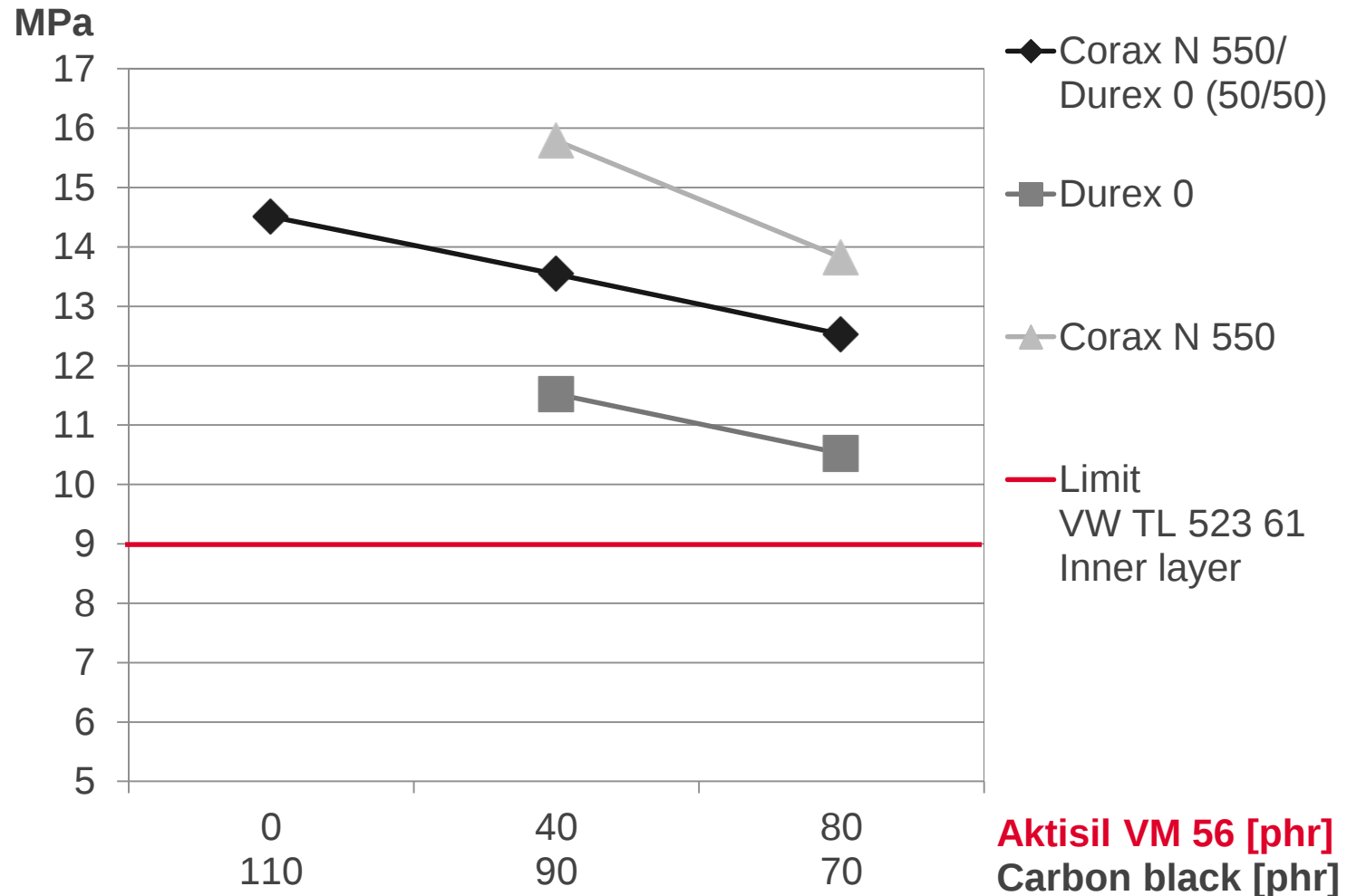


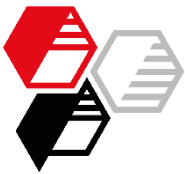
# Cooling Fluid G12

## Remaining Tensile Strength

**HOFFMANN**  
**MINERAL®**

VW TL 523 61, S2, dilution 1:1 with H<sub>2</sub>O dist., 94 h / 160 °C



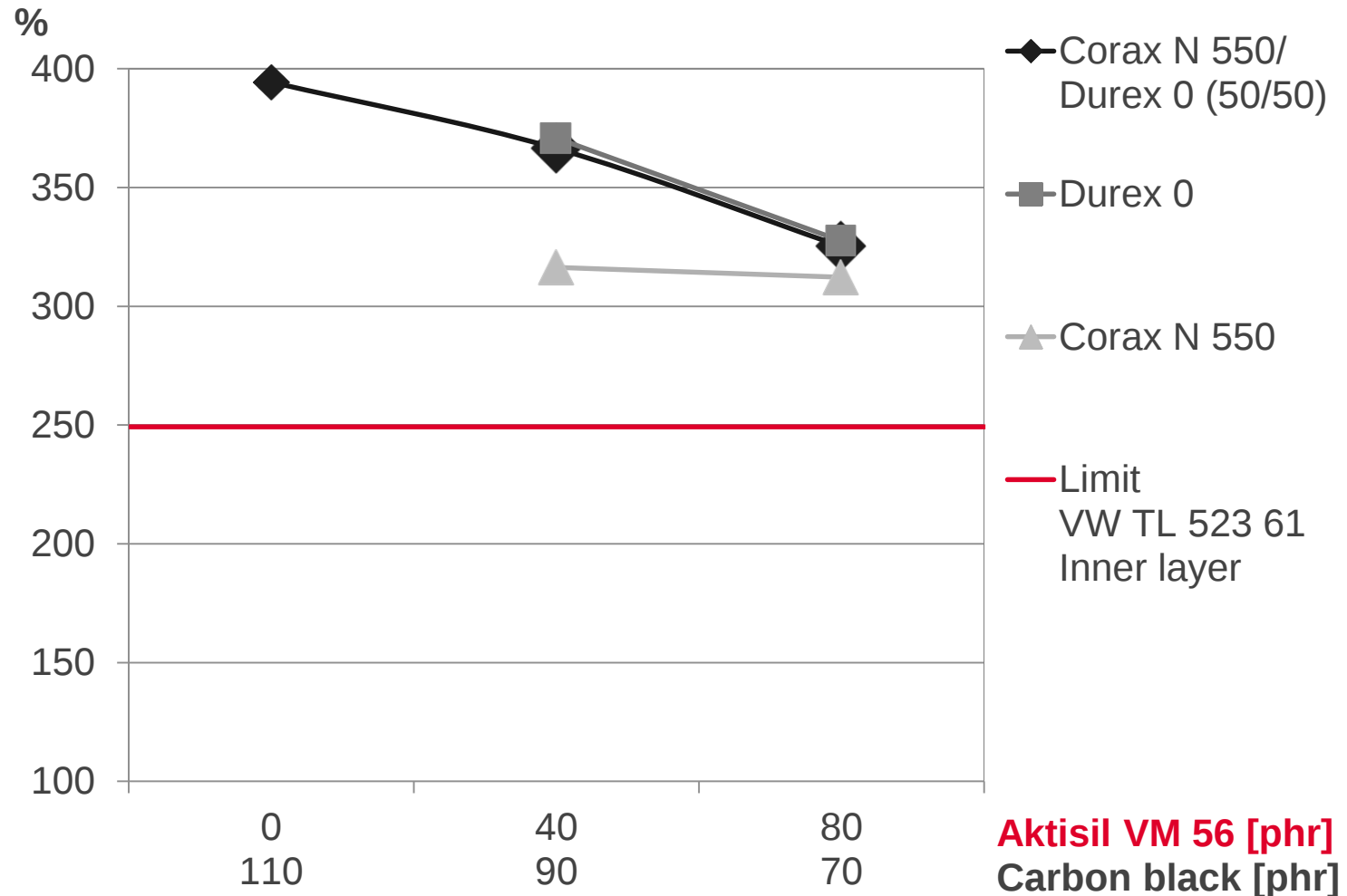


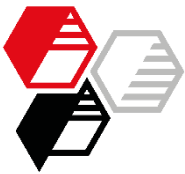
# Cooling Fluid G12

## Remaining Elongation at B.

**HOFFMANN**  
**MINERAL®**

VW TL 523 61, S2, dilution 1:1 with H<sub>2</sub>O dist., 94 h / 160 °C



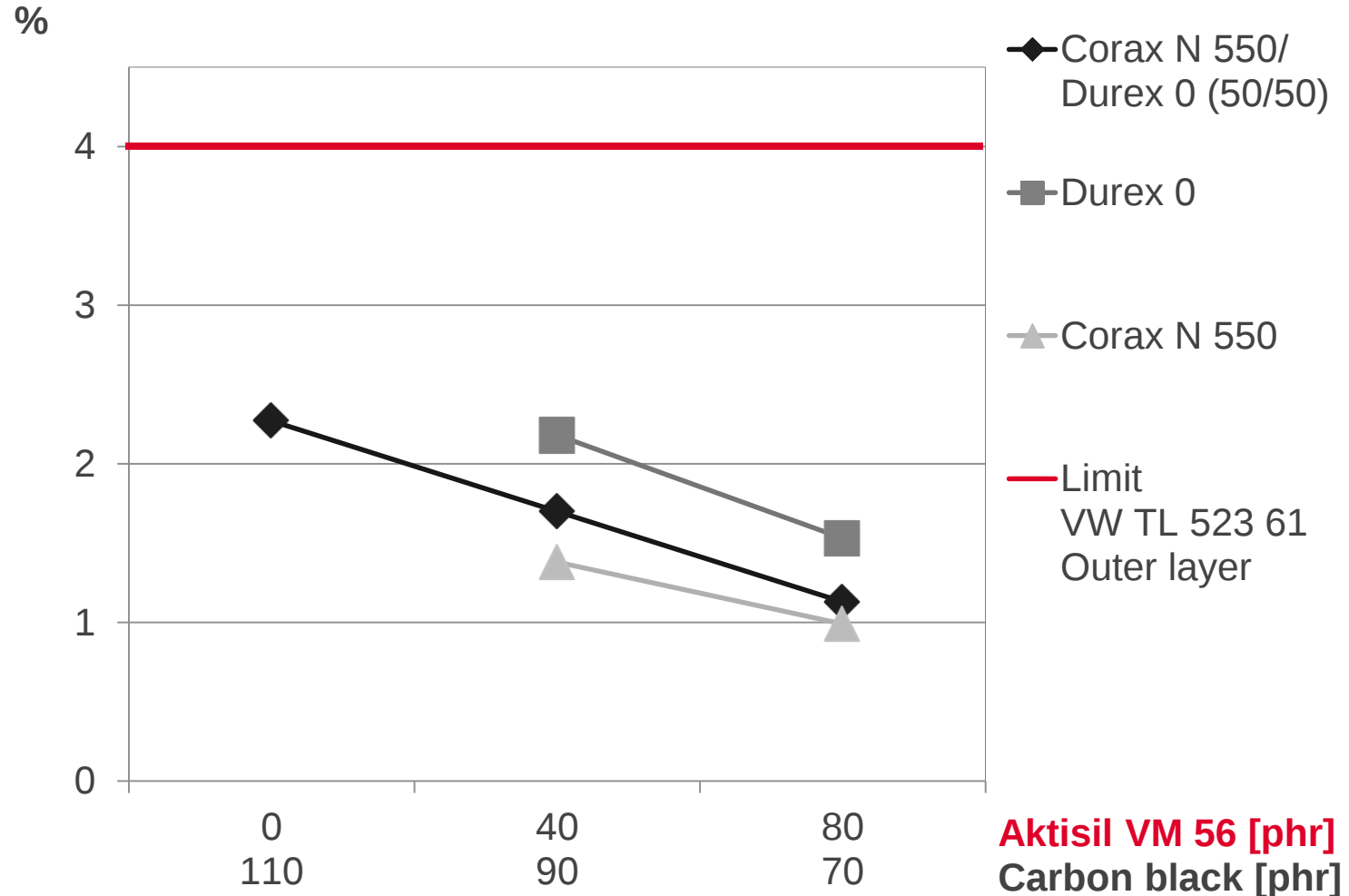


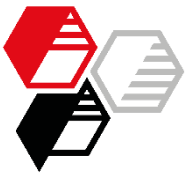
# Cooling Fluid G12

## Change of Weight

**HOFFMANN**  
**MINERAL®**

VW TL 523 61, S2, dilution 1:1 with H<sub>2</sub>O dist., 94 h / 160 °C





# Volume Resistivity

**HOFFMANN**  
**MINERAL®**

DIN IEC 93, 1 Volt, 1 min.

**Ohm\*cm**

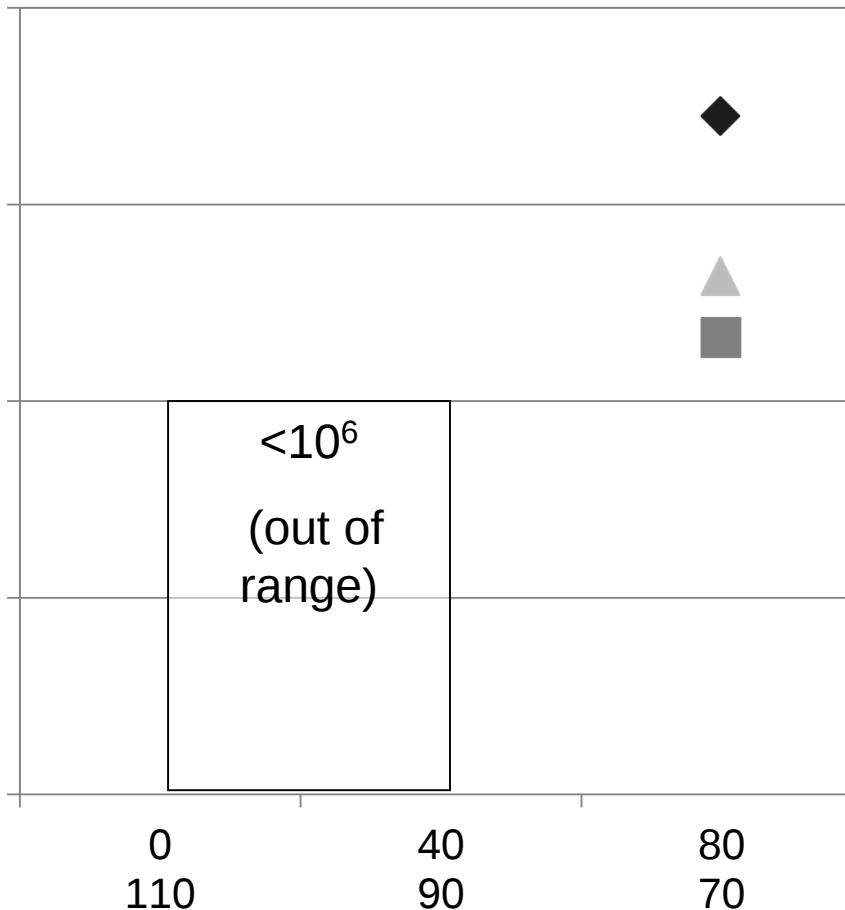
1,00E+08

1,00E+07

1,00E+06

1,00E+05

1,00E+04

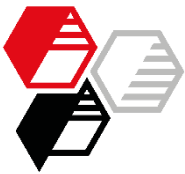


◆ Corax N 550/  
Durex 0 (50/50)

■ Durex 0

▲ Corax N 550

**Aktisil VM 56 [phr]**  
**Carbon black [phr]**



# Volume Resistivity

**HOFFMANN**  
**MINERAL®**

Modified test method, 1 Volt, 1 min.

**Ohm\*cm**

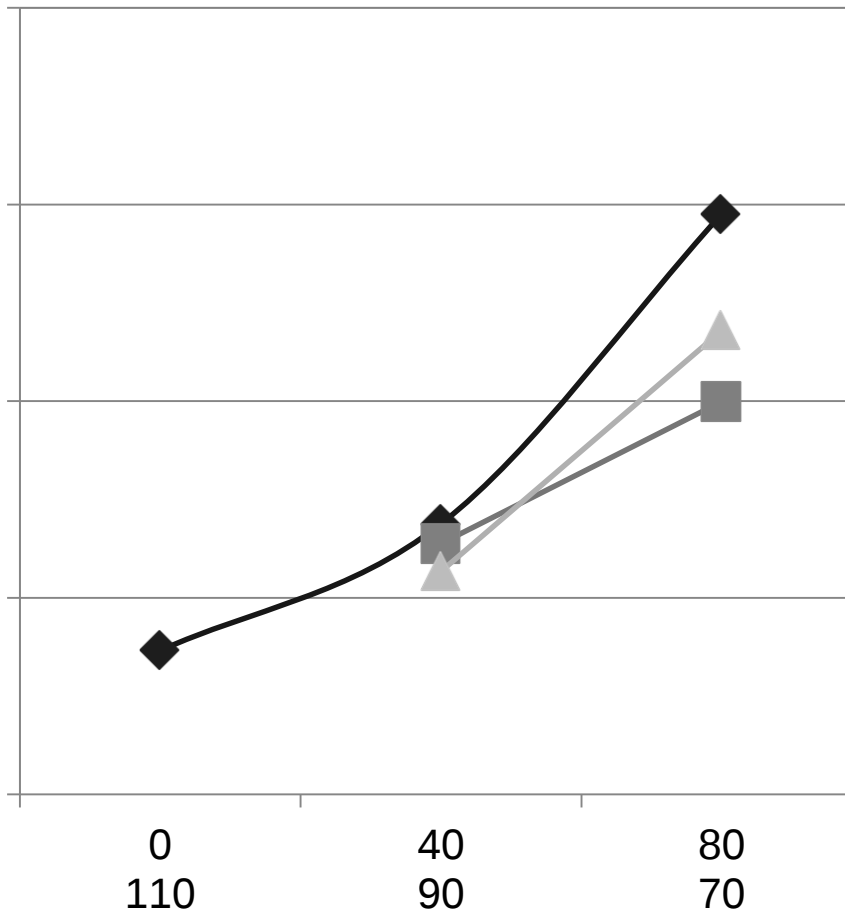
1,00E+08

1,00E+07

1,00E+06

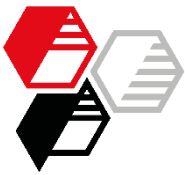
1,00E+05

1,00E+04



◆ Corax N 550/  
Durex 0 (50/50)  
■ Durex 0  
▲ Corax N 550

**Aktisil VM 56 [phr]**  
**Carbon black [phr]**



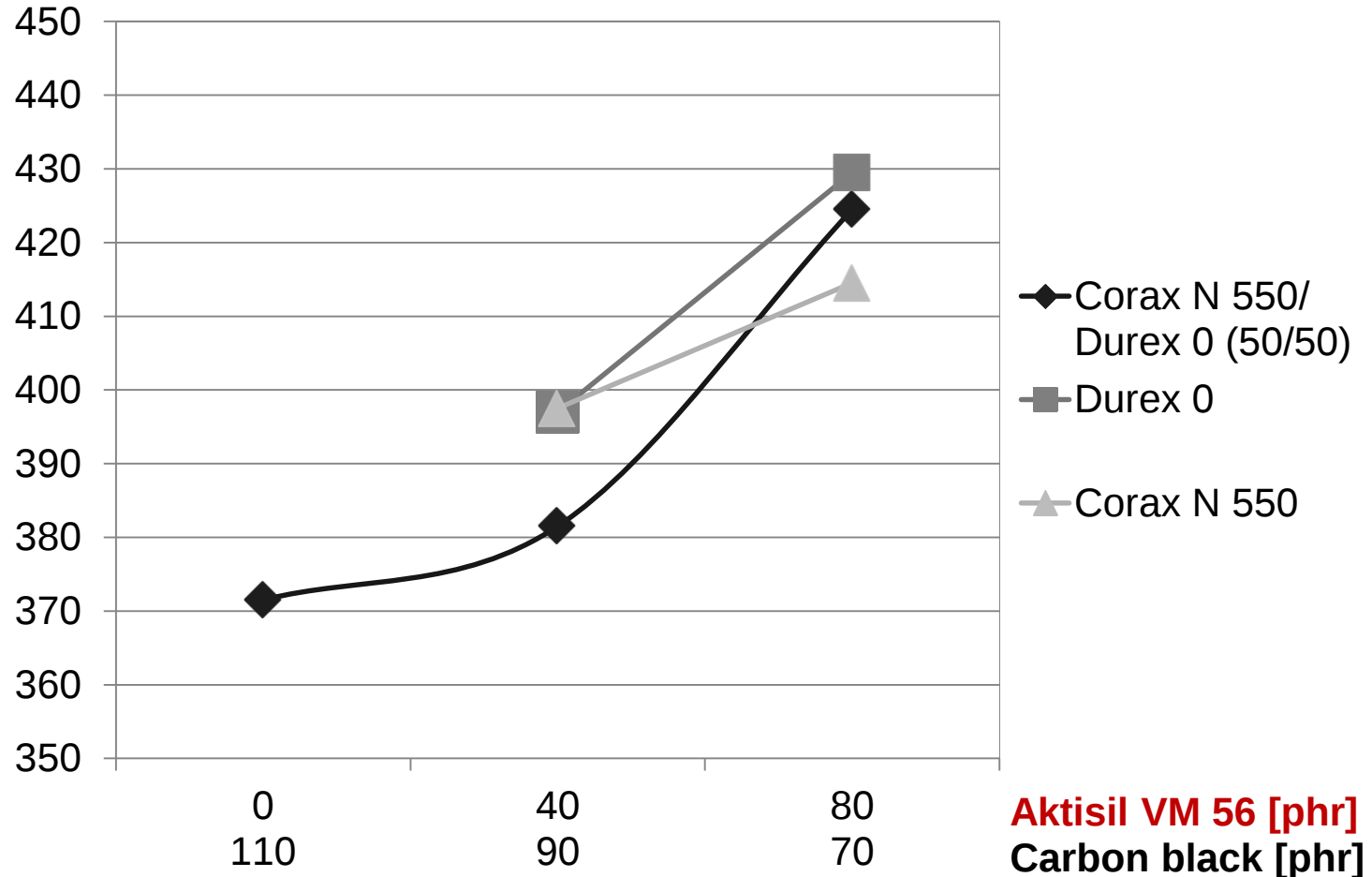
# Hose Extrusion

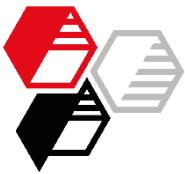
$D_o$ : 20 mm /  $D_i$ : 16.5 mm

**HOFFMANN**  
**MINERAL®**

Extrusion output, 100 rpm

cm/min.





## Conclusion

INTRODUCTION

EXPERIMENTAL

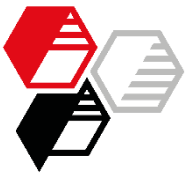
RESULTS

SUMMARY

The use of **AKTISIL VM 56** in combination with reduced carbon black loadings leads to the following results:

- Increased 100 % modulus along with moderate decrease of elongation at break
- Unchanged compression set, unchanged hot air aging properties
- Reduced weight increase upon immersion in oil or cooling fluid
- Increased electrical resistivity (reduced conductivity)
- Improved extrusion properties (increased output with unchanged die swell)

The blend of **AKTISIL VM 56** with Durex 0 allows to meet the requirements Volkswagen TL 523 61 for the inner layer and offers advantages with respect to decreased electrical conductivity.



## We supply material for good ideas!

HOFFMANN MINERAL GmbH  
Muenchener Straße 75  
DE-86633 Neuburg (Donau)

Phone: +49 8431 53-0  
Internet: [www.hoffmann-mineral.de](http://www.hoffmann-mineral.de)  
E-mail: [info@hoffmann-mineral.com](mailto:info@hoffmann-mineral.com)

Our applications engineering advice and the information contained in this memorandum are based on experience and are made to the best of our knowledge and belief, they must be regarded however as non-binding advice without guarantee. Working and employment conditions over which we have no control exclude any damage claim arising from the use of our data and recommendations. Furthermore we cannot assume any responsibility for patent infringements, which might result from the use of our information.