# Aktifit AM
# in AEM seals and gaskets

**Author: Nicole Holzmayr**

HOFFMANN MINERAL®
We supply material for good ideas

# Contents

- Introduction
- Experimental
- Results
- Summary
- Appendix

# Status Quo



AEM rubber is a specialty polymer which is being used for e.g. seals and gaskets in the automotive sector for under the hood applications due to its excellent resistance to heat and oils.

Carbon black has been the traditional filler of choice because it provides a balanced property profile although in some cases the properties are still not satisfying.

Until today, it has not been able to eliminate the weaknesses of carbon black by a mineral filler without deteriorating the strengths of the system.

# Objective



In this study, the Calcined Neuburg Siliceous Earth grade

Aktifit AM

is suggested to replace carbon black N 550 in a common diamine cured AEM rubber formulation.

In order to evaluate the results in an applicable manner, the standard PSA S22 5106 Class 165 is taken as a base reference.

# Fillers and Characteristics



| | Particle Size | | Oil absorption | Specific Surface Area BET | Functionali-zation |
|---|---|---|---|---|---|
| | $d_{50}$ [µm] | $d_{97}$ [µm] | [g/100g] | [m²/g] | |
| Carbon Black N 550 | n.s. | n.s. | 121 | 39 | × |
| Aktifit AM | 2 | 10 | 55 | 7 | amino |

# Formulations
# Target 60 – 65 Shore A



| in phr | Carbon Black N 550 | | | Aktifit AM | | |
|---|---|---|---|---|---|---|
| | 10 phr W 759 | 20 phr W 759 | 10 phr W 759 pol.blend | 25 phr W 759 cur.syst. | 30 phr W 759 | 30 phr T810T |
| Vamac Ultra IP | 100 | 100 | 70 | 100 | 100 | 100 |
| Vamac VMX-3110 | - | - | 30 | - | - | - |
| Luvomaxx CDPA | 2 | 2 | 2 | 2 | 2 | 2 |
| Stearic acid | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Vanfre VAM | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Crodamide ER | 1 | 1 | 1 | 1 | 1 | 1 |
| N 550 | 50 | 50 | 50 | - | - | - |
| Aktifit AM | - | - | - | 137.5 | 137.5 | 137.5 |
| Rhenosin W 759 | 10 | 20 | 10 | 25 | 30 | - |
| Edenol T810T | - | - | - | - | - | 30 |
| Diak No 1 | 1.5 | 1.5 | 1.5 | 1.25 | 1.5 | 1.5 |
| Luv. Safecure CA | 3 | 3 | 3 | 3.5 | 3 | 3 |

# Preparation and Curing of the Compound



- **Mixing**
  Open mill Ø 150 x 300 mm
  Batch volume: approx. 1000 g
  Temperature: 50 °C
  Mixing time: approx. 15 min.
- **Curing**
  Press, 10 min. / 180 °C
- **Post-cure**
  4 h / 185 °C
- **Hot air aging**
  168 h / 165 °C
- **Immersion in oil**
  Engine oil, type OS 206 304,
  168 h / 165 °C

All mechanical properties given in this report are related to the post-cured specimens.

# Initial Properties

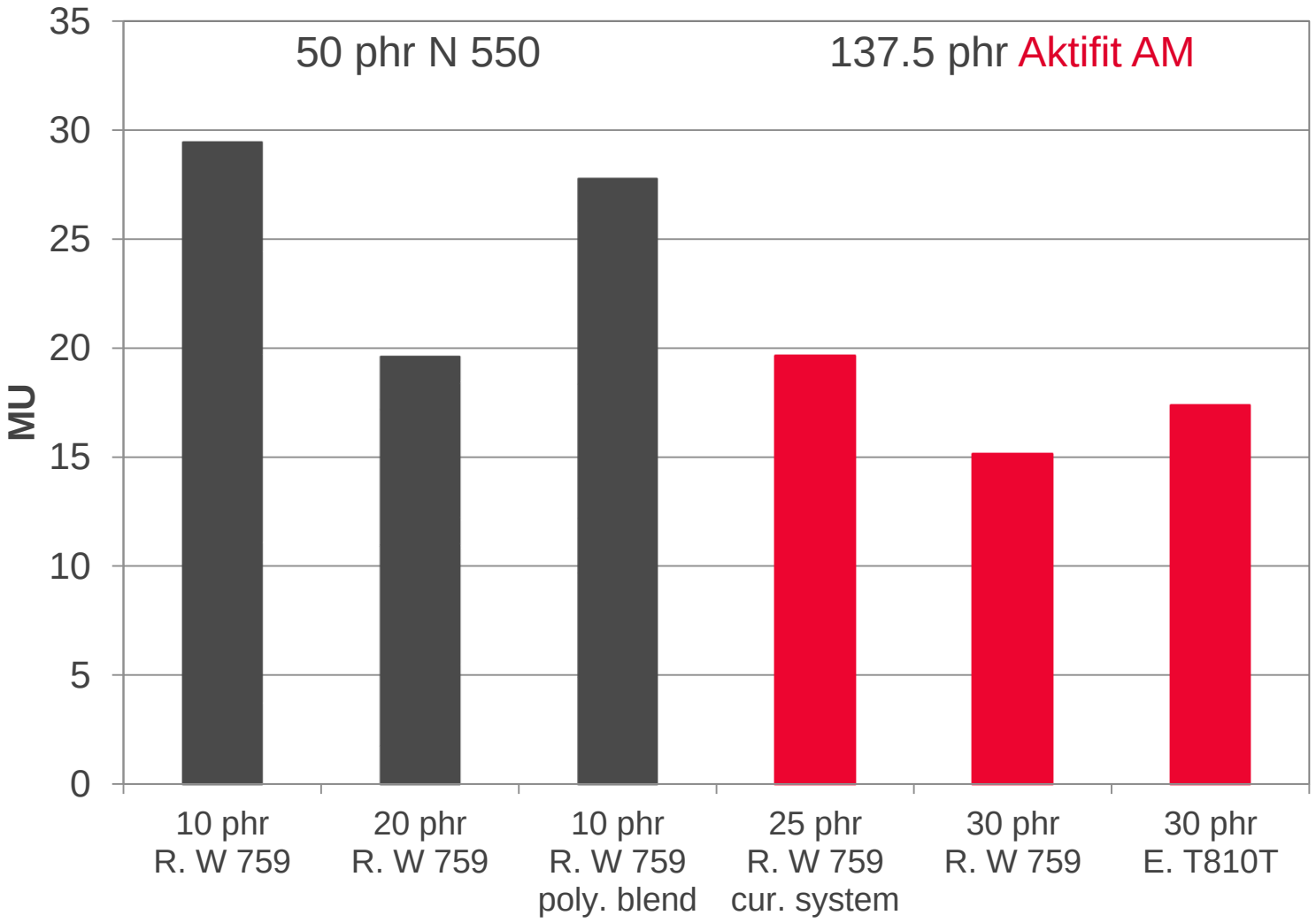
- Rheology
  - Mooney-viscosity

- Mechanical properties (post-cured)
  - Hardness
  - Tensile Strength
  - Elongation at Break
  - Modulus 100 %
  - Compression Set

# Mooney-Viscosity



DIN 53 523 Part 3, ML +5, 120 °C



# Hardness

INTRODUCTION

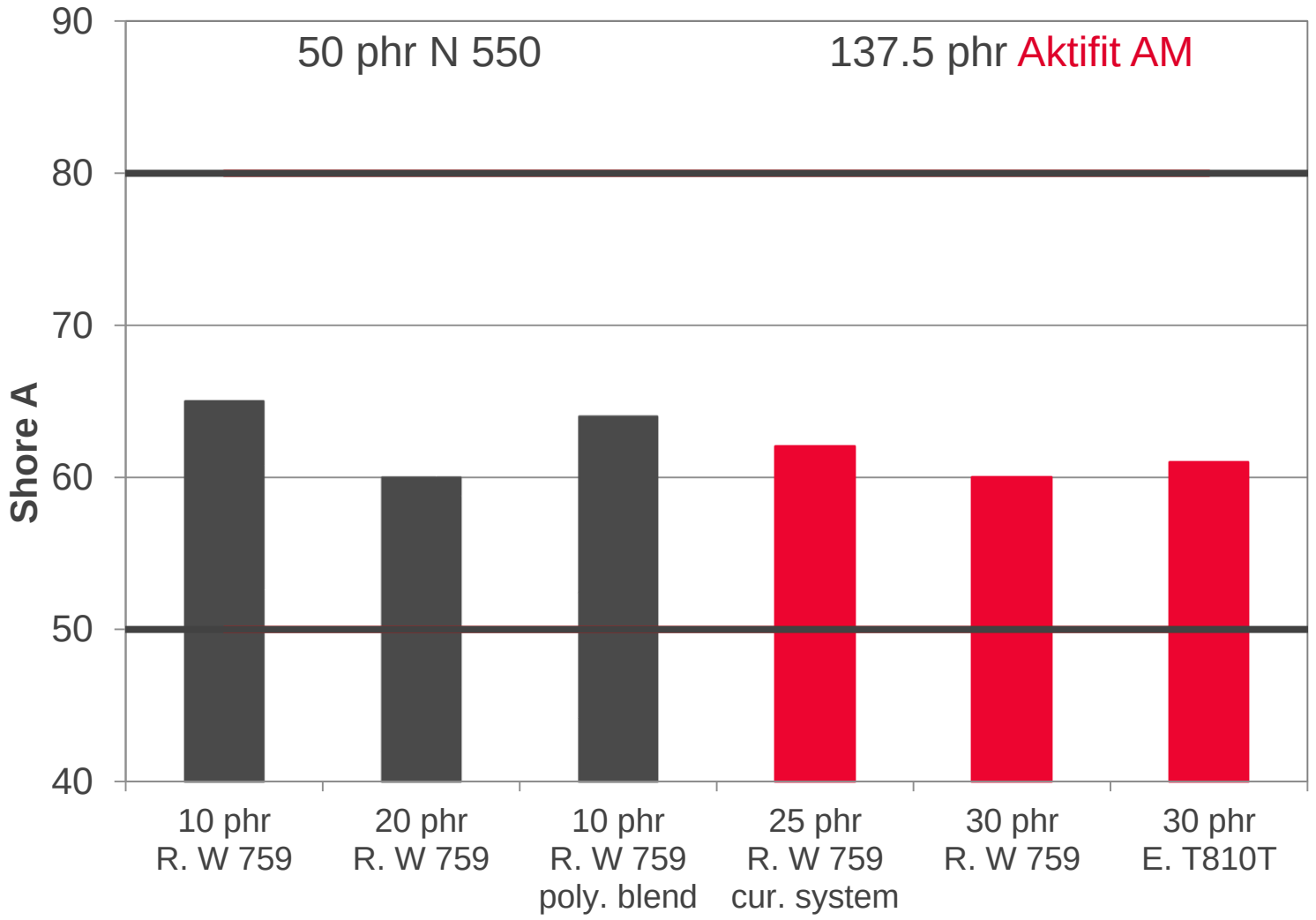
EXPERIMENTAL

RESULTS

- Initial mechanical properties

SUMMARY

DIN ISO 7619-1, piled-up S2-dumbbells



# Tensile Strength

INTRODUCTION

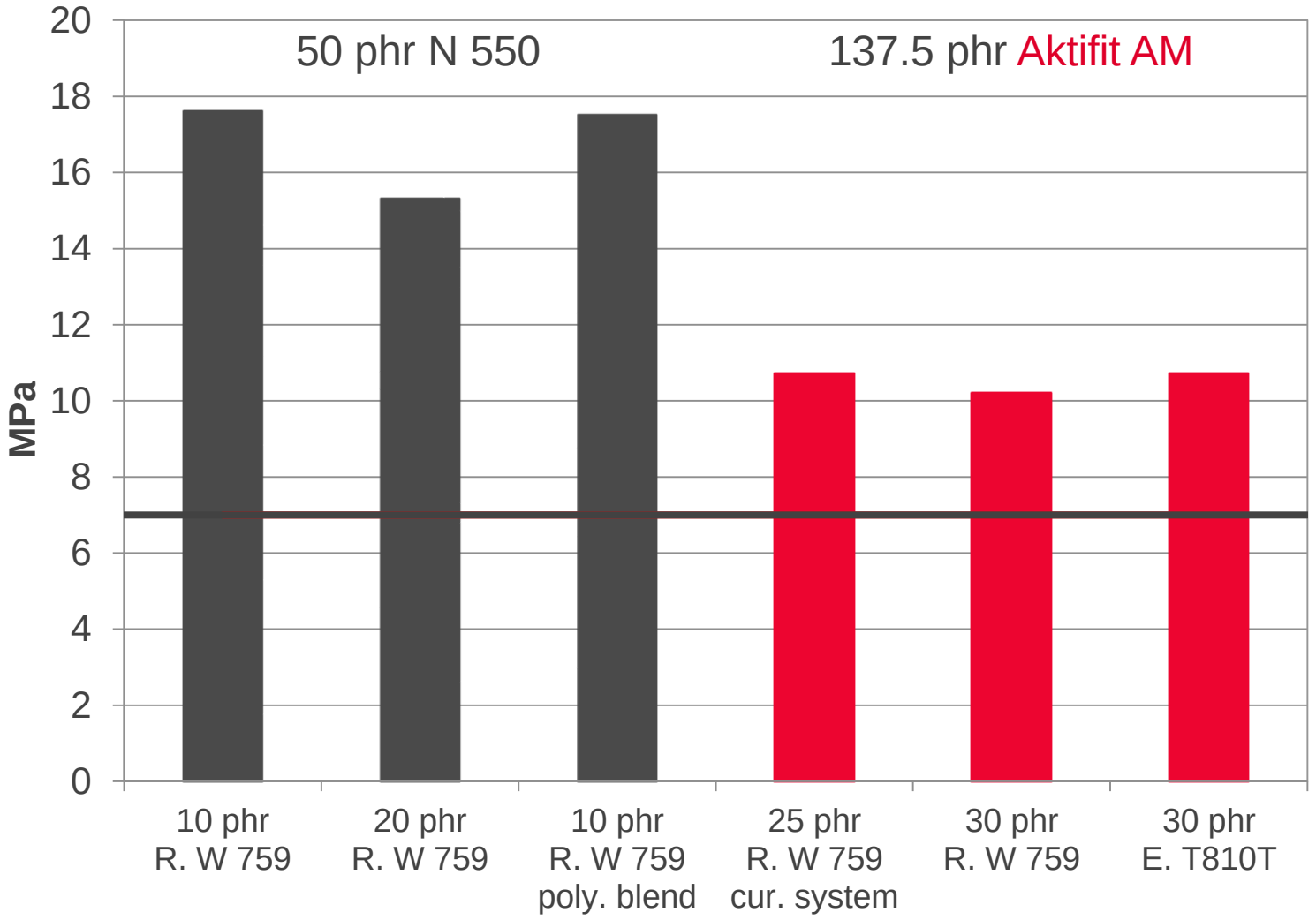
EXPERIMENTAL

RESULTS

- Initial mechanical properties

SUMMARY

DIN 53 504, S2



# Elongation at Break

INTRODUCTION

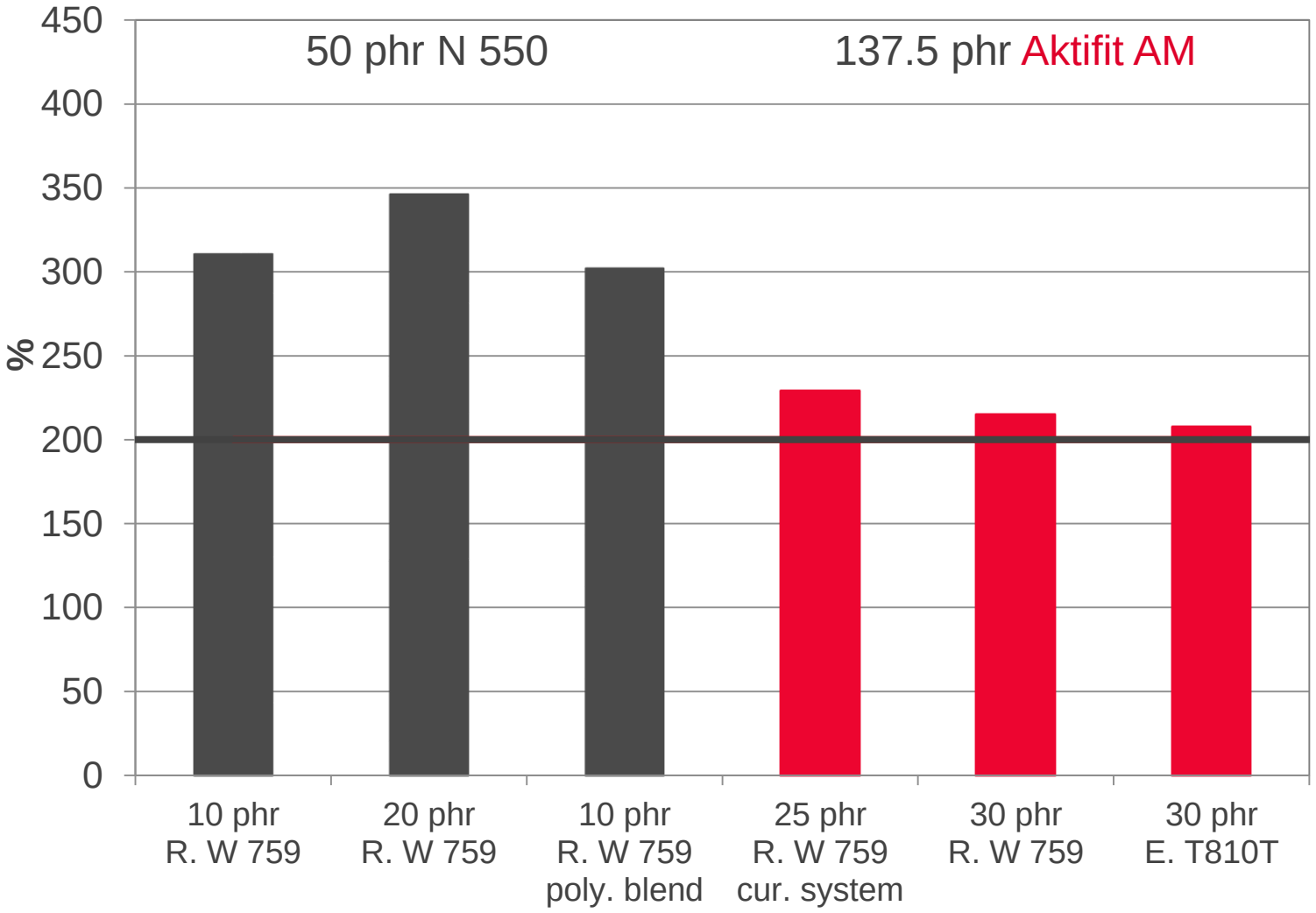
EXPERIMENTAL

RESULTS

- Initial mechanical properties

SUMMARY

DIN 53 504, S2



# Modulus 100 %

INTRODUCTION

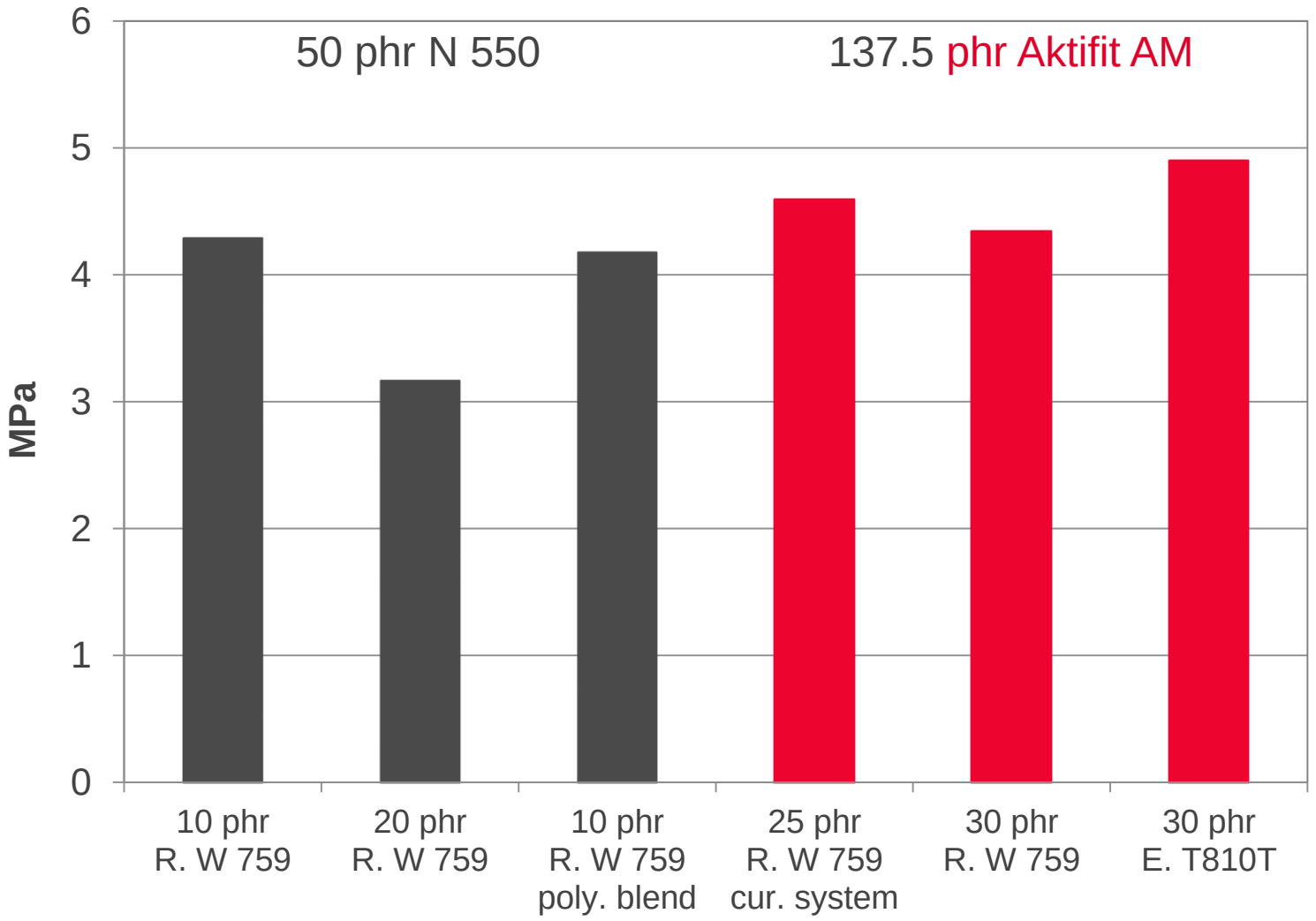
EXPERIMENTAL

RESULTS

- Initial mechanical properties

SUMMARY

DIN 53 504, S2

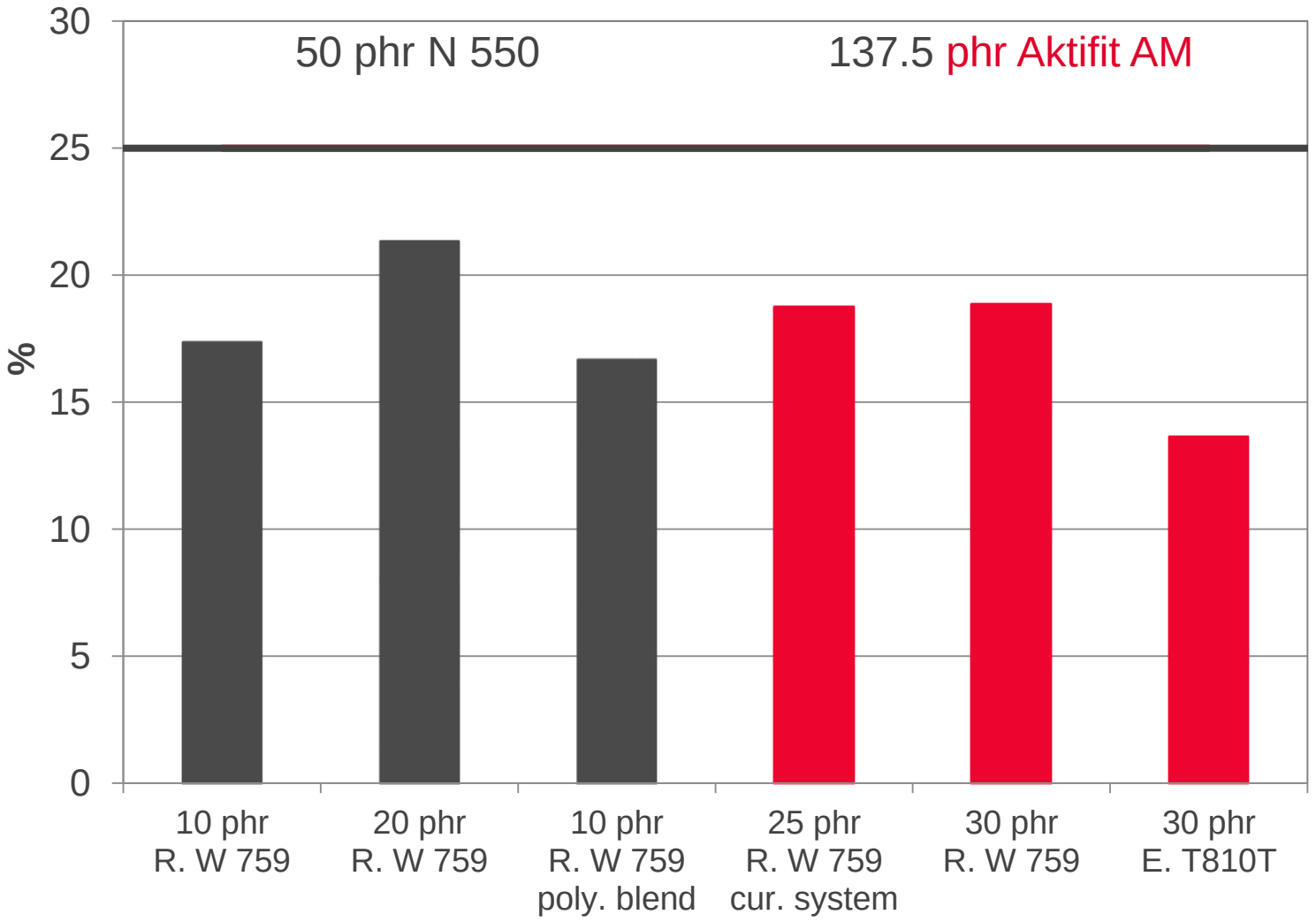


# Compression Set
# 72 h / 165 °C

HOFFMANN MINERAL



DIN ISO 815-1 B, cooling method A, 25 % defl.



# Resistance to Engine Oil

- Immersion in motor oil OS 206 304 (168 h / 165 °C)
  - Change of Volume
  - Change of Hardness
  - Change of Tensile Strength
  - Change of Elongation at Break
  - Elongation at Break, absolute

# Change of Volume

INTRODUCTION

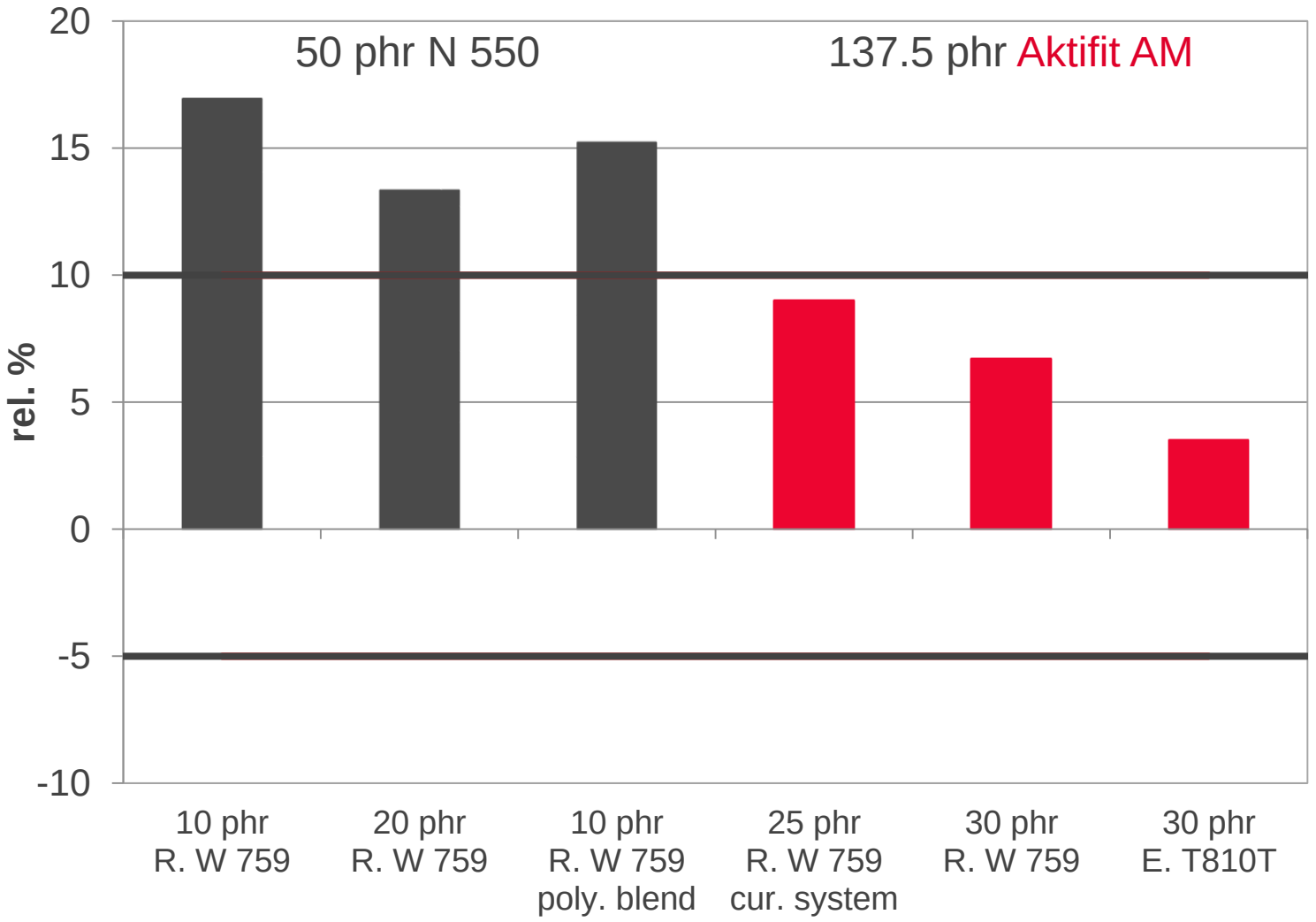
EXPERIMENTAL

RESULTS

- Immersion in engine oil

SUMMARY

DIN ISO 1817, 168 h / 165 °C



# Change of Hardness

INTRODUCTION

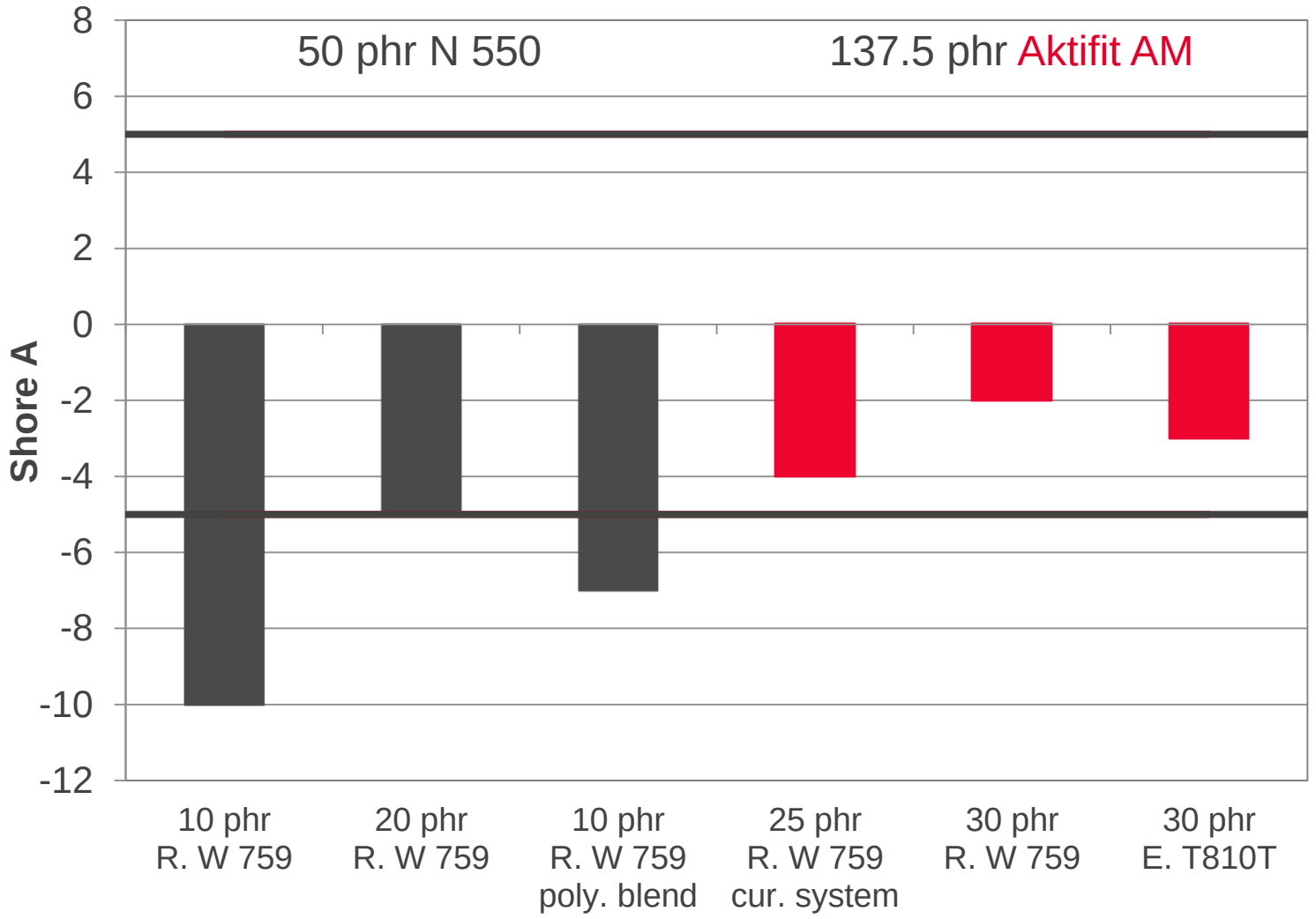
EXPERIMENTAL

RESULTS

- Immersion in engine oil

SUMMARY

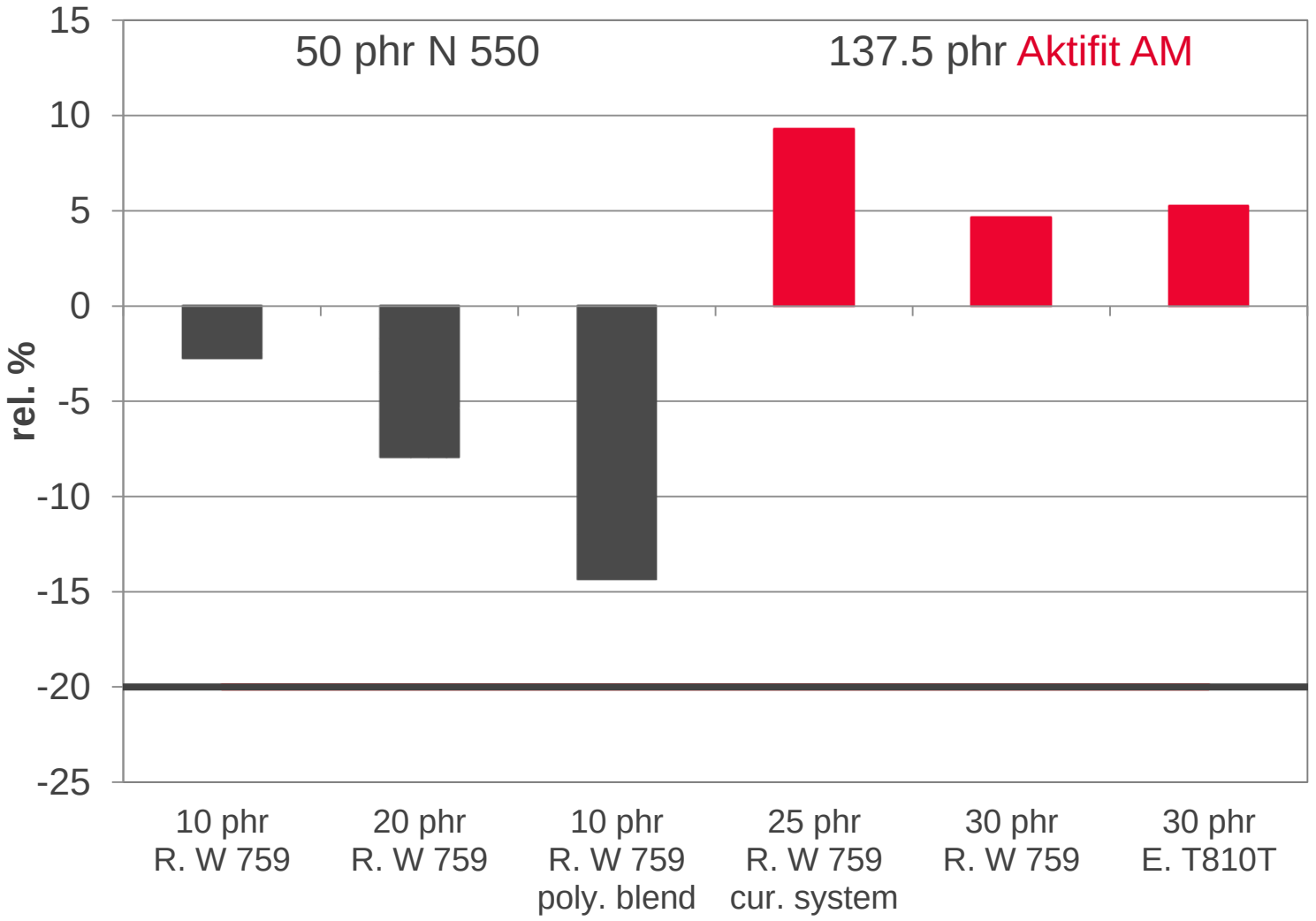
DIN ISO 1817, 168 h / 165 °C



# Change of Tensile Strength

DIN ISO 1817, 168 h / 165 °C



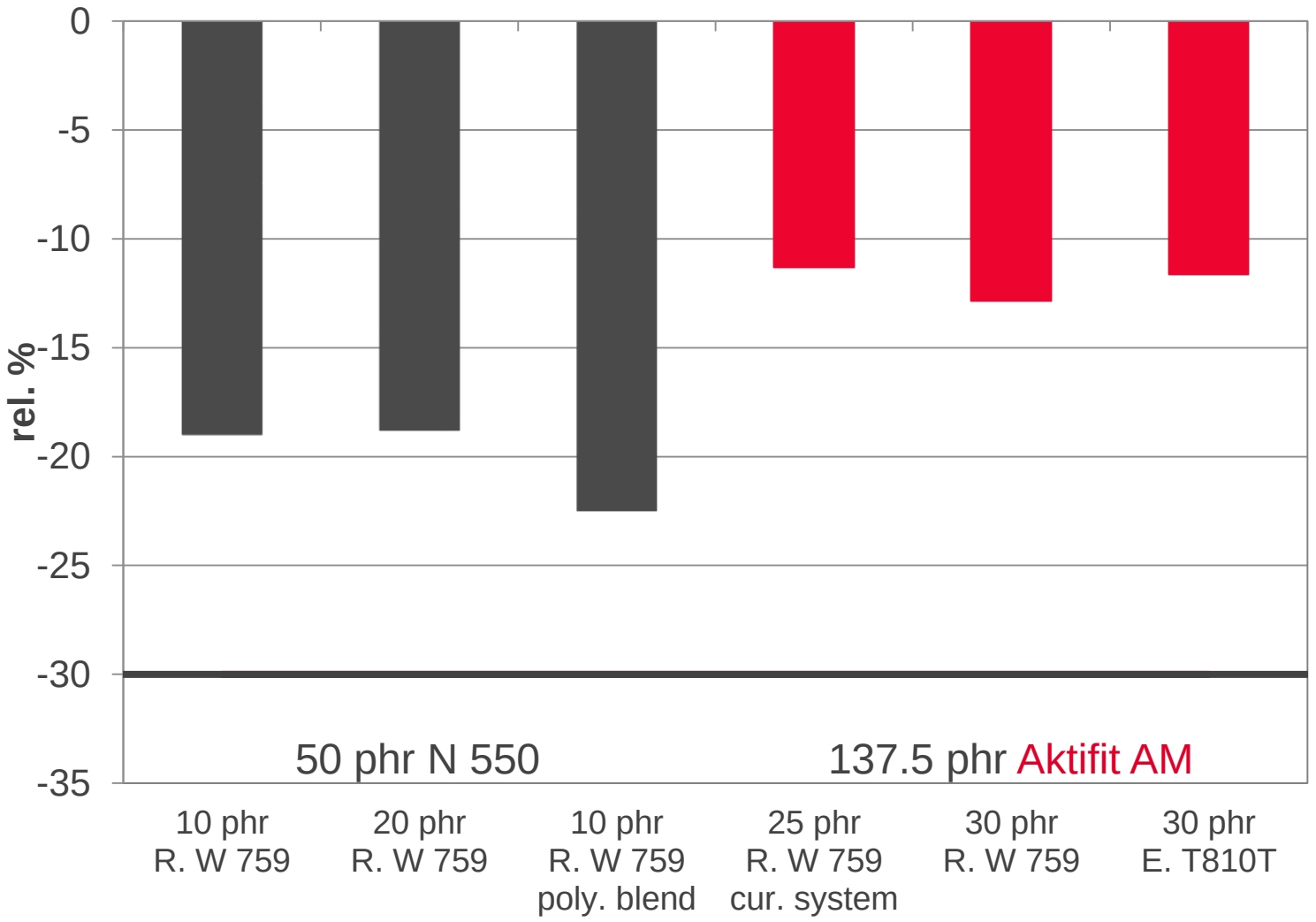


# Change of Elongation at Break

HOFFMANN MINERAL



DIN ISO 1817, 168 h / 165 °C



# Elongation at Break Absolute

HOFFMANN MINERAL

INTRODUCTION

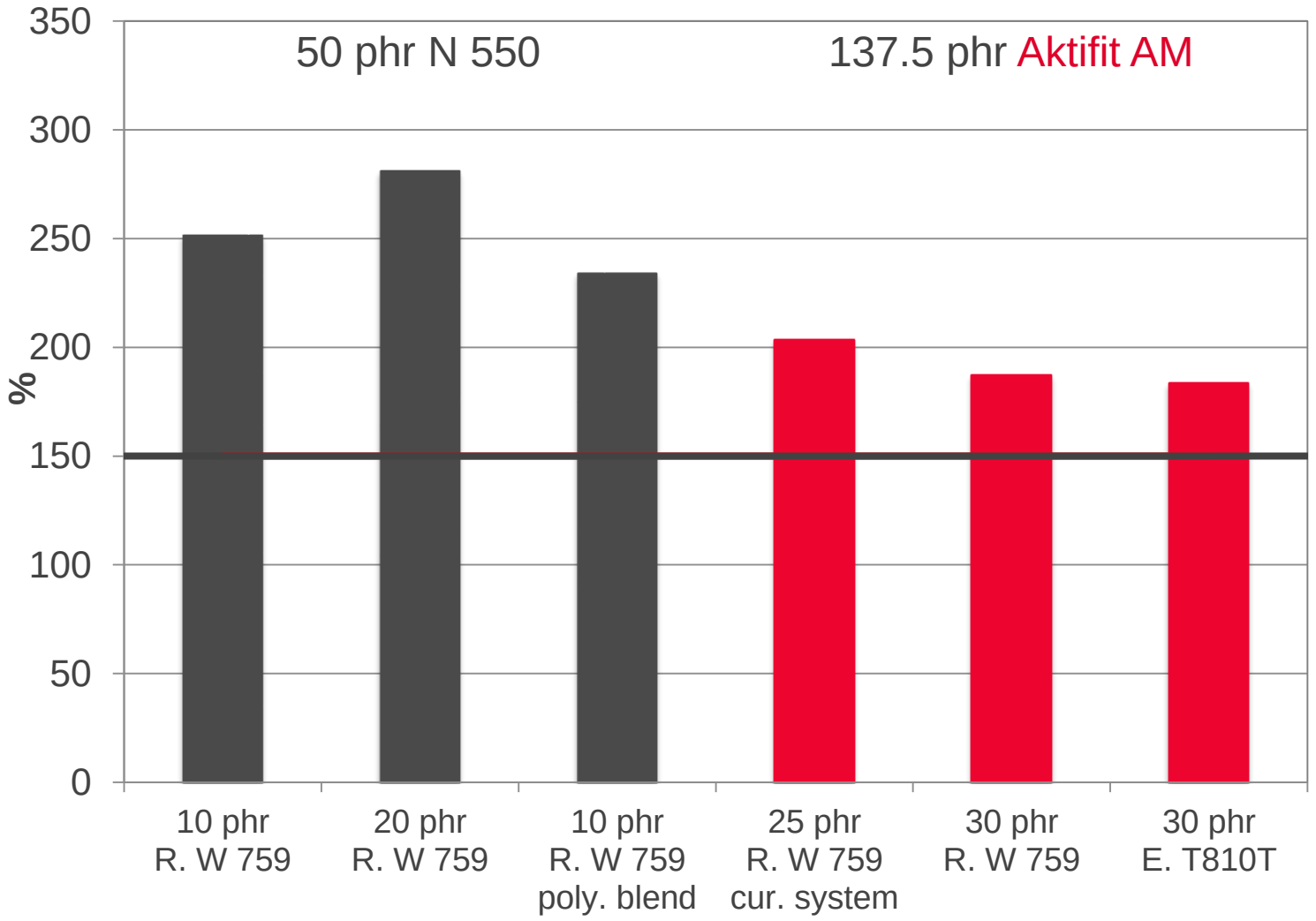
EXPERIMENTAL

RESULTS

- Immersion in engine oil

SUMMARY

DIN ISO 1817, 168 h / 165 °C



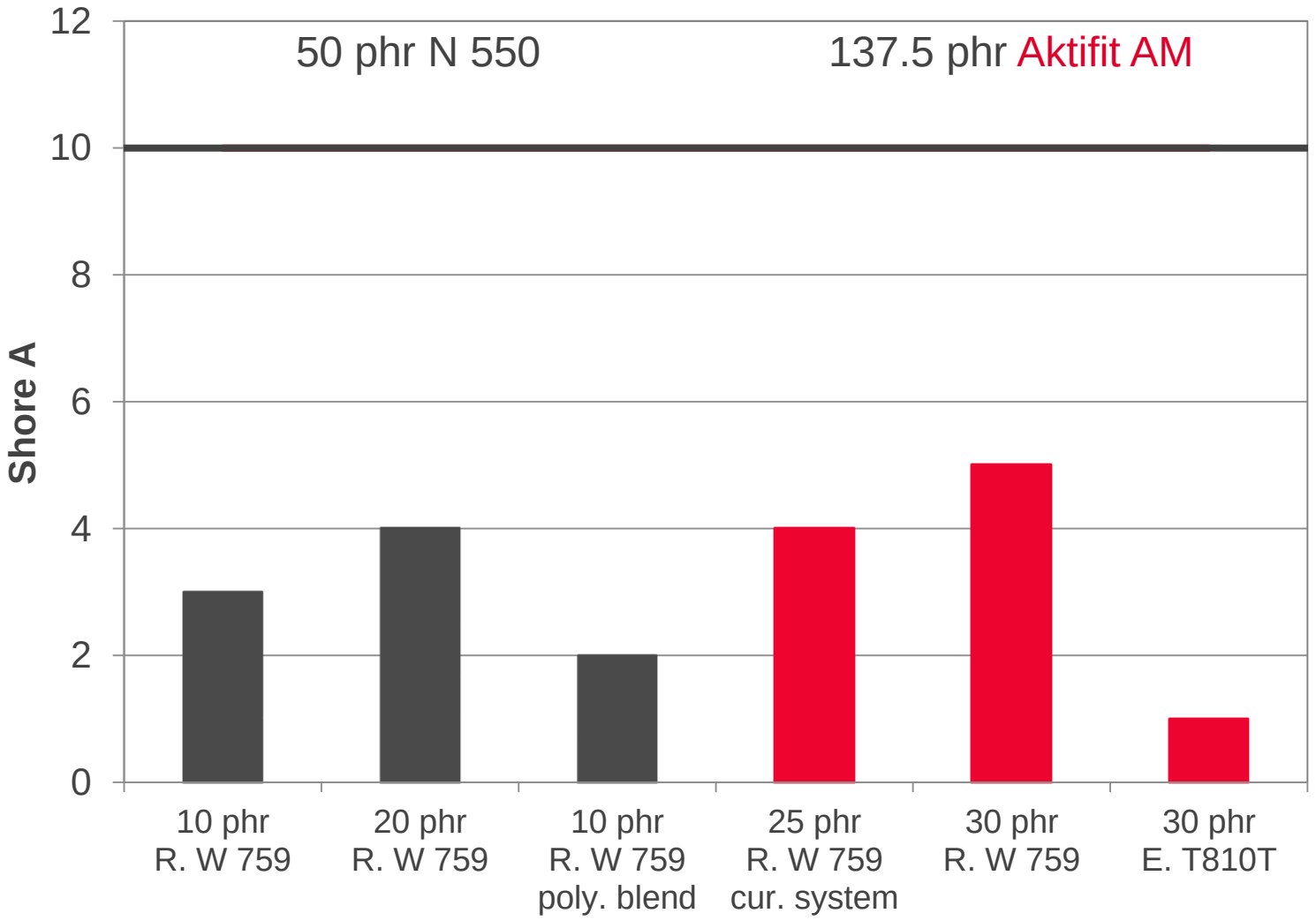
# Heat Resistance

- Storage in Hot Air (168 h / 165 °C)
  - Change of Hardness
  - Change of Tensile Strength
  - Change of Elongation at Break
  - Elongation at Break, absolute

# Change of Hardness



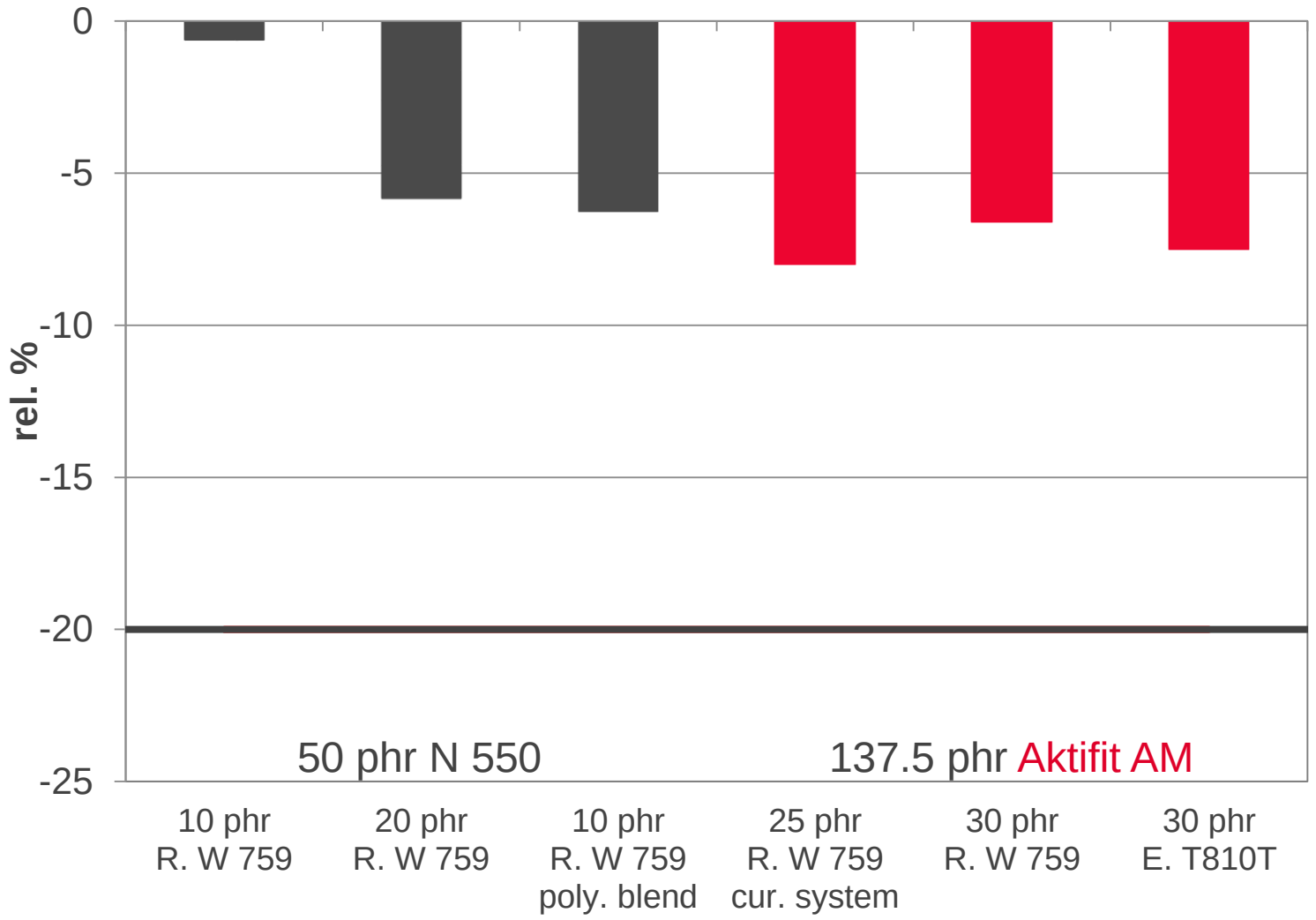
DIN 53 508, 168 h / 165 °C



# Change of Tensile Strength



DIN 53 508, 168 h / 165 °C

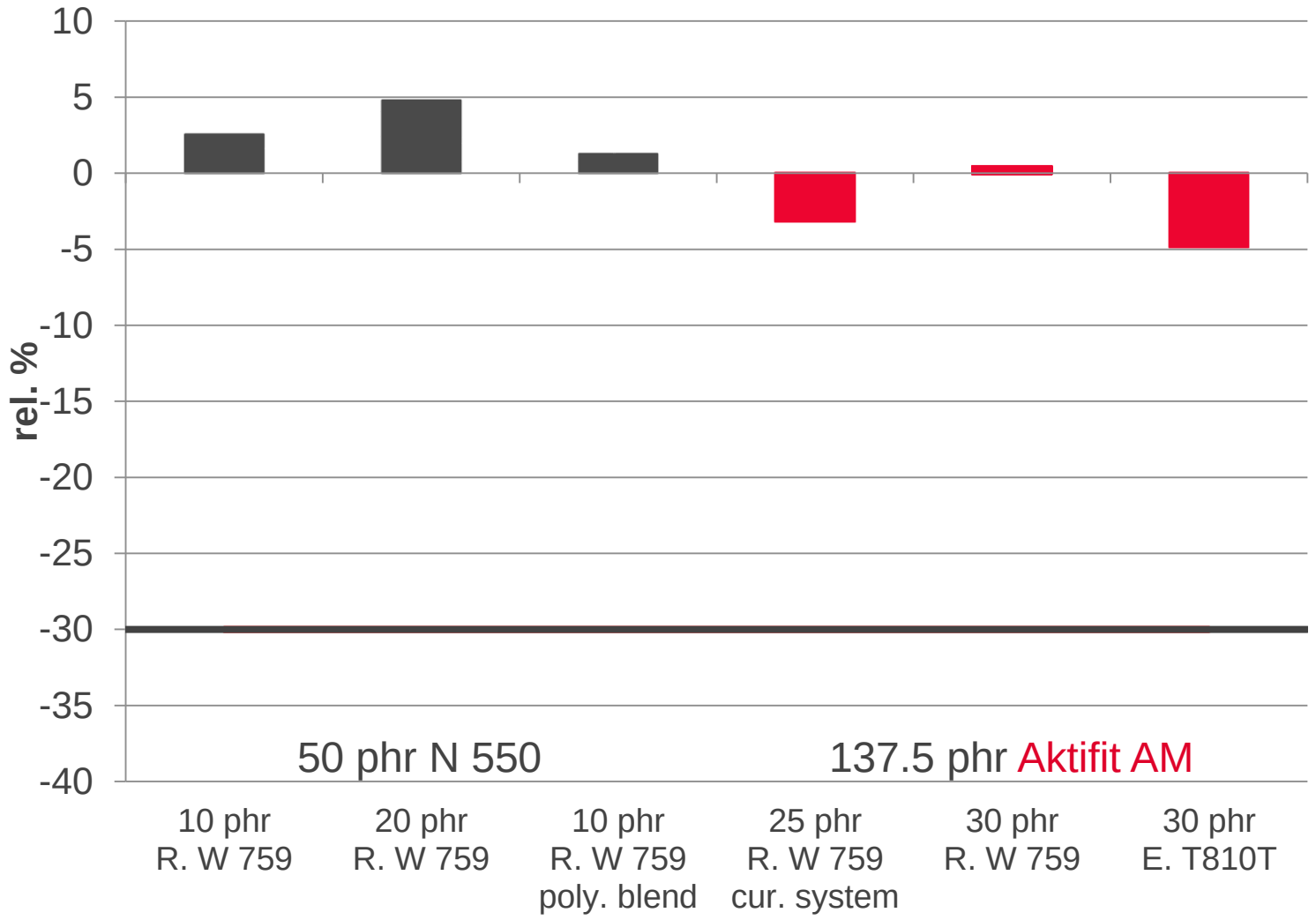


# Change of Elongation at Break

HOFFMANN MINERAL



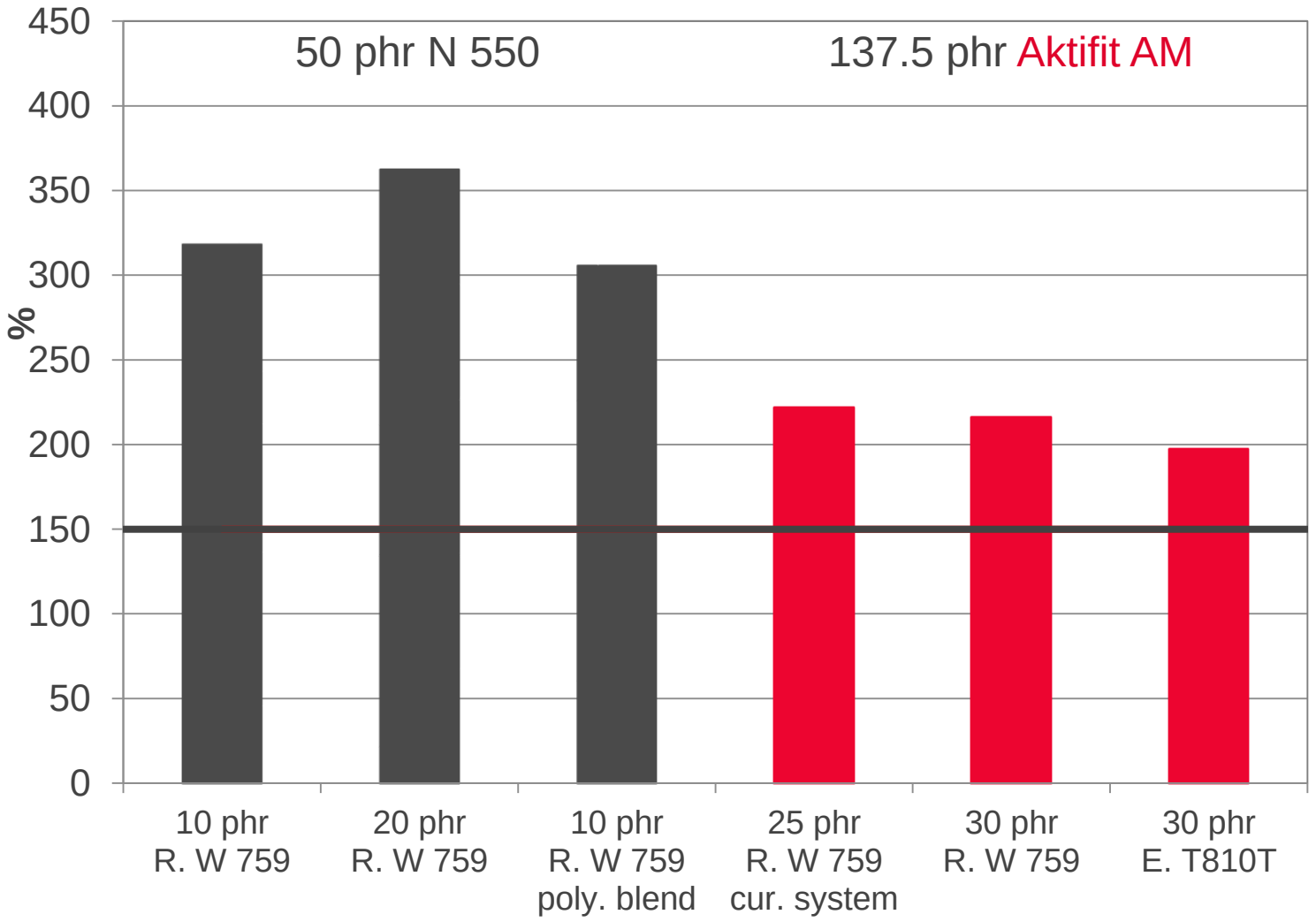
DIN 53 508, 168 h / 165 °C



# Elongation at Break Absolute



DIN 53 508, 168 h / 165 °C



# Rating
# Initial Mech. Properties



| | Carbon Black N 550 | | | Aktifit AM | | |
|---|---|---|---|---|---|---|
| | 10 phr W 759 | 20 phr W 759 | 10 phr W 759 pol.blend | 25 phr W 759 cur.syst. | 30 phr W 759 | 30 phr T810T |
| Hardness | ++ | ++ | ++ | ++ | ++ | ++ |
| Tensile strength | ++ | ++ | ++ | + | + | + |
| Elongation at break | ++ | ++ | ++ | + | + | + |
| Modulus 100 % | ++ | + | ++ | ++ | ++ | ++ |
| Compression set | ++ | + | ++ | ++ | ++ | +++ |
| **Sum of +** | **10** | **8** | **10** | **8** | **8** | **9** |

# Rating
# Resistance to Engine Oil



| | Carbon Black N 550 | | | Aktifit AM | | |
|---|---|---|---|---|---|---|
| | 10 phr W 759 | 20 phr W 759 | 10 phr W 759 pol.blend | 25 phr W 759 cur.syst. | 30 phr W 759 | 30 phr T810T |
| Δ Hardness | - - | + | - | ++ | ++ | ++ |
| Δ Tensile strength | + | + | + | ++ | ++ | ++ |
| Δ Elongation at b. | + | + | + | ++ | ++ | ++ |
| Elongation at b. abs. | ++ | ++ | ++ | + | + | + |
| Δ Volume | - - | - - | - - | + | + | ++ |
| **Sum of +** | **0** | **3** | **1** | **8** | **8** | **9** |

# Rating
# Heat Resistance

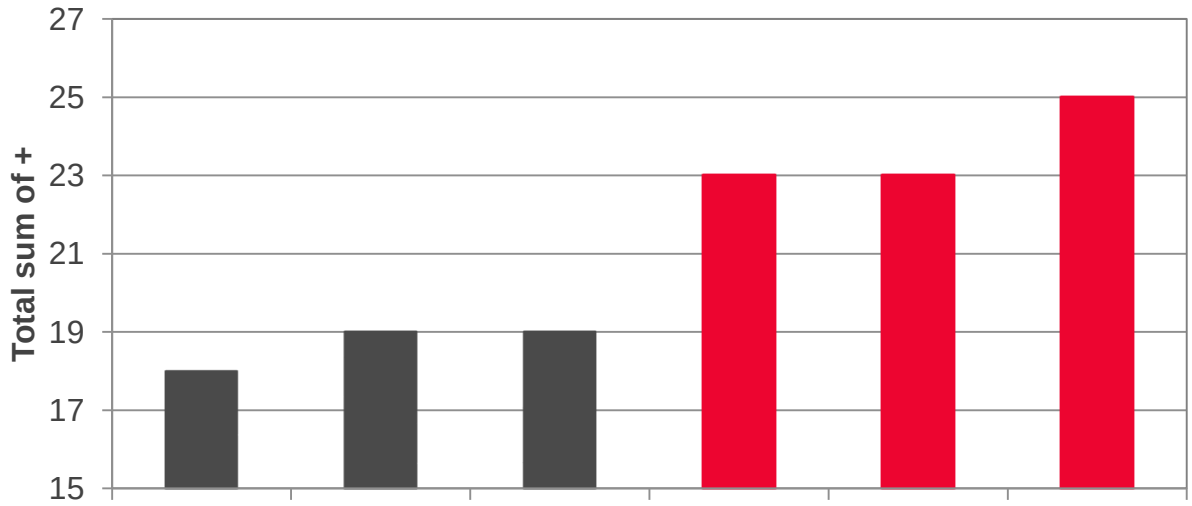


| | Carbon Black N 550 | | | Aktifit AM | | |
|---|---|---|---|---|---|---|
| | 10 phr W 759 | 20 phr W 759 | 10 phr W 759 pol.blend | 25 phr W 759 cur.syst. | 30 phr W 759 | 30 phr T810T |
| Δ Hardness | ++ | ++ | ++ | ++ | ++ | ++ |
| Δ Tensile strength | ++ | ++ | ++ | ++ | ++ | ++ |
| Δ Elongation at b. | ++ | ++ | ++ | ++ | ++ | ++ |
| Elongation at b. abs. | ++ | ++ | ++ | + | + | + |
| **Sum of +** | **8** | **8** | **8** | **7** | **7** | **7** |

# Total Sum of +



| | Carbon Black N 550 | | | Aktifit AM | | |
|---|---|---|---|---|---|---|
| | 10 phr W 759 | 20 phr W 759 | 10 phr W 759 pol.blend | 25 phr W 759 cur.syst. | 30 phr W 759 | 30 phr T810T |
| Initial mech. properties | 10 | 8 | 10 | 8 | 8 | 9 |
| Heat resistance | 8 | 8 | 8 | 7 | 7 | 7 |
| Engine oil resistance | 0 | 3 | 1 | 8 | 8 | 9 |
| **Total sum of +** | **18** | **19** | **19** | **23** | **23** | **25** |



# Conclusion



The use of carbon black N 550 leads to

- ✓ excellent initial mechanical properties
- ✓ very good heat resistance

but also to

- × insufficient engine oil resistance regarding the PSA S22 5106 Class 165, esp.
  - × decrease of hardness
  - × volume increase

The specification of the standard regarding oil resistance cannot be met by

- × an increase of the plasticizer content or
- × blending Vamac Ultra IP with the more oil resistant Vamac VMX-3110

# Conclusion



Along with

- ✓ positive cost aspects

**replacing N 550 by** Aktifit AM in combination with various possibilities of optimation, results in

- ✓ good initial mechanical properties along with a good compression set
- ✓ very good heat resistance
- ✓ markedly improved engine oil resistance, esp.
  - ✓ reduced hardness change
  - ✓ reduced change of elongation at break and
  - ✓ reduced volume increase

# Conclusion



The means to achieve that improvement in oil resistance are various.

**Increased filler loading with** Aktifit AM and additionally

- increased plasticizer content in combination with an adapted curing system (the latter is recommended to improve the initial elongation at break)

or

- increasing the plasticizer content to an even higher level without deteriorating the modulus or compression set to a lower level compared to N 550

or

- using an alternative plasticizer which results in an even better oil resistance in combination with a reduced compression set and lower hardness increase after hot air aging

Outlook:

- The higher plasticizer content should lead to an additional improvement of low temperature properties.

# Conclusion



With the Calcined Neuburg Siliceous Earth grade

Aktifit AM

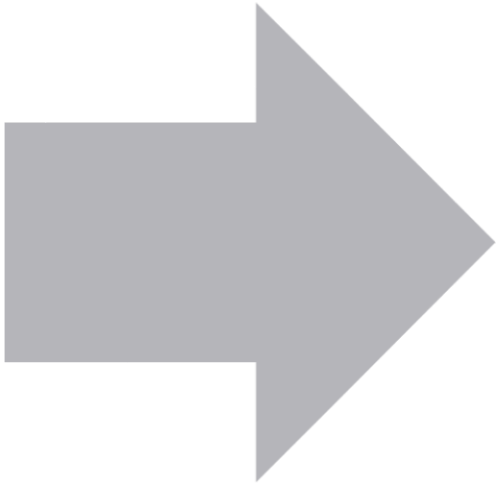
a mineral filler is found that is able to replace carbon black N 550 in AEM rubber based seals and gaskets for under the hood applications in the automotive sector.

Calcined Neuburg Siliceous Earth:

Material for good ideas

# Supplement
# September 2016

Luvomaxx Safecure CA
no longer available.

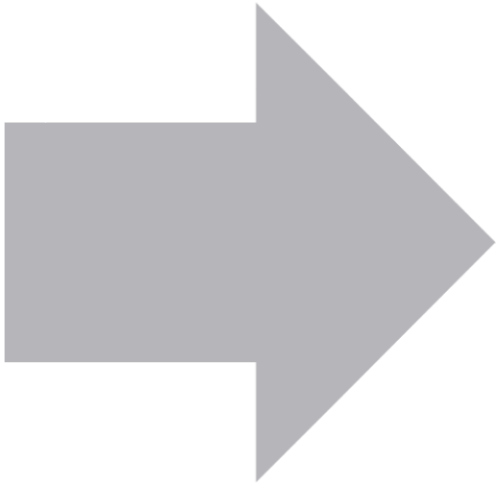


recommended replacement:
Luvomaxx DBU DL 70
(2,57 phr ≙ 3 phr Luvomaxx Safecure CA)

# Supplement September 2016

**Problem**

Strong decrease of elongation at break of compounds filled with Aktifit AM.



**Solution**

partial replacement of Aktifit AM by Silfit Z 91 in a ratio of 75:25.

# Supplement
# September 2016

Benefits of

Calcined Neuburg Siliceous Earth

over carbon black remain.

Injection molding tests did not show any significant differences between carbon black filled compounds and those filled with Calcined Neuburg Siliceous Earth.

# 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
E-mail: info@hoffmann-mineral.com

# Compound Costs



Cost index, volume price related, Germany 2014