

# Oil compatibility testing of elastomers – challenges and solutions for dynamic and static testing

Dipl. Ing. Timo Richter

## Facts & Figures



- 2 locations
- 40 Employees
- Independent Rubber experts
- Testing
  - Dynamic testing on 60 test heads
  - Static testing
  - Analytical testing
- Training
  - Training courses for oil and additive industry available
- Consulting & Failure Analysis

# Physical rubber / media interactions

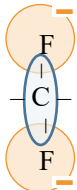
## Electronegativity



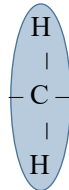
## Physical effects

- Lead to swelling or shrinkage
- No significant temperature dependance

| Periode | I                          | II                           | III                    | Gruppe IV                   | V                             | VI                            | VII                        | VIII                         |
|---------|----------------------------|------------------------------|------------------------|-----------------------------|-------------------------------|-------------------------------|----------------------------|------------------------------|
| 1       | H                          |                              |                        |                             |                               |                               |                            | 2<br>He<br>4,00<br>Helium    |
| 2       | 3<br>Li<br>6,94<br>Lithium | 4<br>Be<br>9,01<br>Beryllium | 5<br>B<br>10,81<br>Bor | C<br>12<br>Kohlenstoff      | 7<br>N<br>14,00<br>Stickstoff | 8<br>O<br>16,00<br>Sauerstoff | 9<br>F<br>19,00<br>Fluor   | 10<br>Ne<br>20,18<br>Neon    |
|         |                            |                              |                        | 14<br>Si<br>28,09<br>Silber | 15<br>P<br>30,97<br>Phosphor  | 16<br>S<br>32,07<br>Schwefel  | 17<br>Cl<br>35,45<br>Chlor | 18<br>Ar<br>39,94<br>Argon   |
|         |                            |                              |                        |                             |                               | 34<br>Se<br>78,96<br>Selen    | 35<br>Br<br>79,90<br>Brom  | 36<br>Kr<br>83,80<br>Krypton |
|         |                            |                              |                        |                             |                               |                               |                            | 54<br>Xe<br>131,29<br>Xenon  |



Polar material  
(e.g. FKM)



Unpolar material  
(e.g. EPDM)

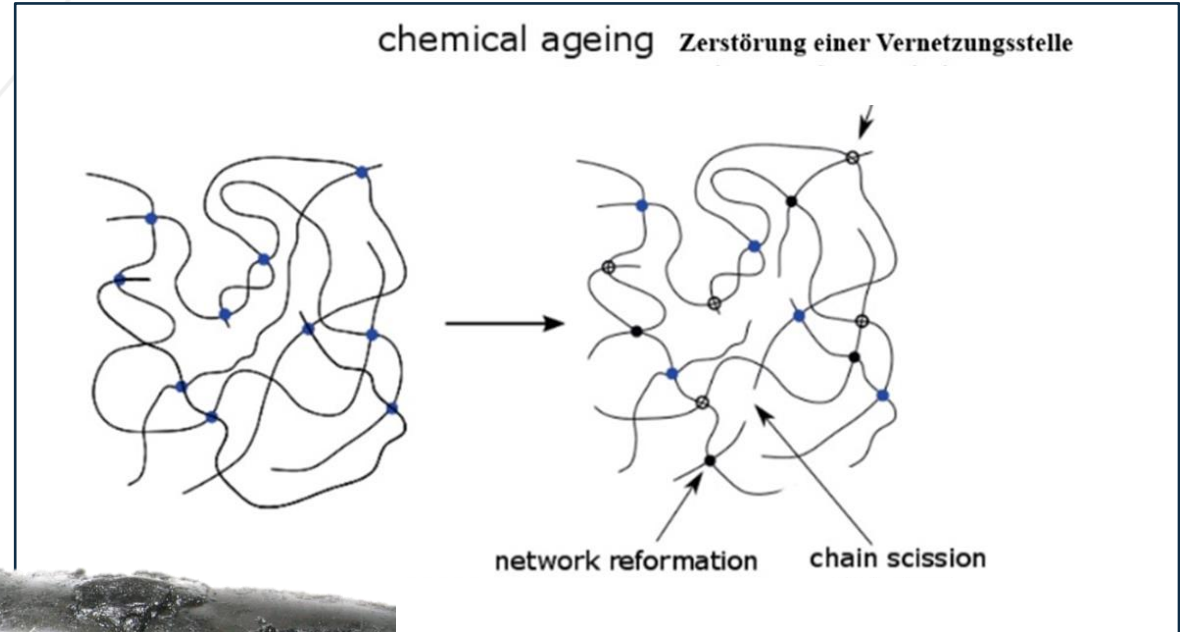
# Physical rubber / media interactions

Polar and Unpolar materials

|                         |  | Polar Elastomers                                                                  |                                                                                   | Unpolar Elastomers                                                                  |                                                                                     |
|-------------------------|--|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                         |  | ACM, AEM<br>FFKM; FKM<br>CO, ECO                                                  | VMQ, FVMQ<br>CR, NBR,HNBR                                                         | EPDM<br>EPM<br>IR                                                                   | NR<br>SBR                                                                           |
| Medium<br><br>Elastomer |  | polar                                                                             | unpolar                                                                           | polar                                                                               | unpolar                                                                             |
|                         |  | polar                                                                             | polar                                                                             | unpolar                                                                             | unpolar                                                                             |
|                         |  |  |  |  |  |
|                         |  | Medium to strong swelling                                                         |                                                                                   |                                                                                     | Strong swelling                                                                     |

# Chemical effects

- Lead to loss of mechanical properties, depolymerization and permanent deformation
- Strong temperature dependance (Arrhenius)
- Irreversible

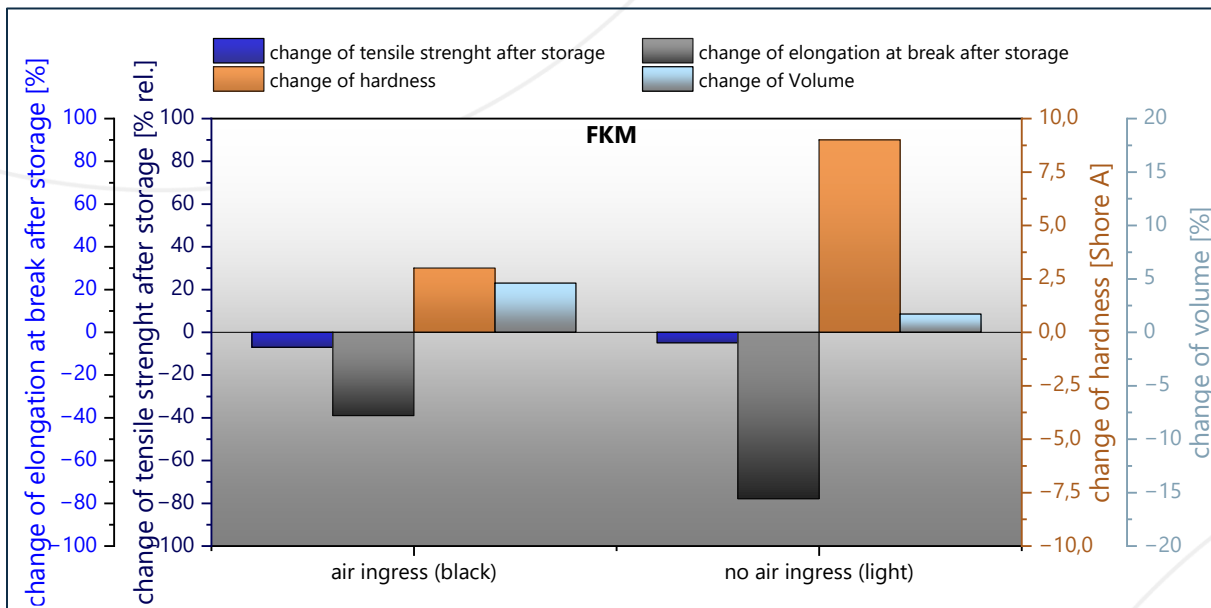


Source: Alexander Kurt Herzig, Thermo-oxidative ageing of elastomers, a contribution to the experimental investigation and modelling, Dissertation 2020, Universität der Bundeswehr



# Static testing

Impact of air ingress in test vessel (FKM)



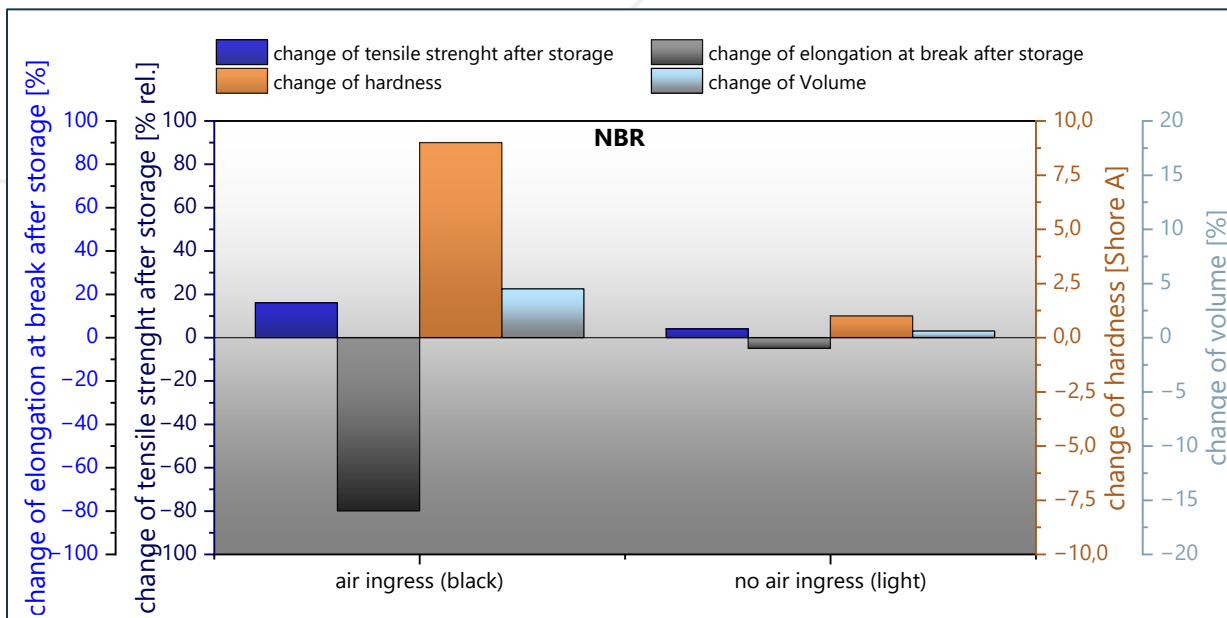
Air ingress for FKM leads to:

- **Higher** swelling (physical effect)
- **Lower** changes in mechanical properties (chemical effect)

Test conditions: 1008h / 130°C

# Static testing

Impact of air ingress in test vessel (NBR)



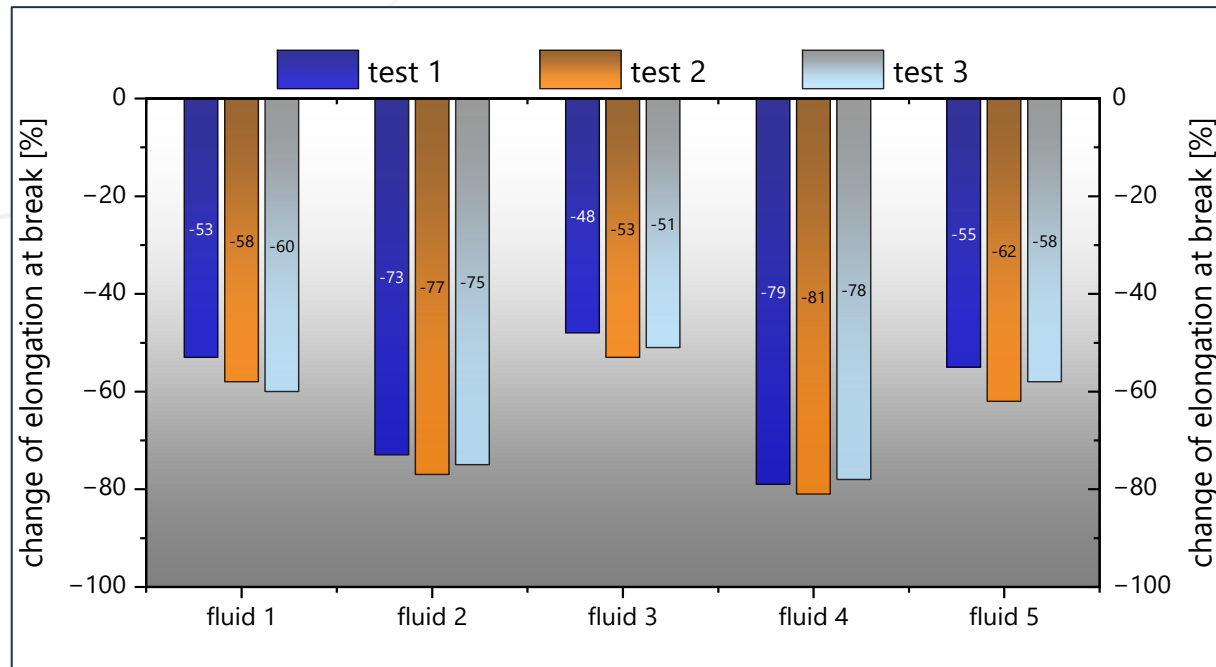
Air ingress for NBR leads to:

- **Higher** swelling (physical effect)
- **Higher** changes in mechanical properties (chemical effect)

Test conditions: 1008h / 100°C

# Static testing

Reproducibility of closed container testing



# Dynamic RSS testing

## Test Set-Up

Potential reasons for reproducibility issues

Eccentricity (static)

Deassembly-  
temperature of RSS

Eccentricity  
(dynamic)

RSS Concentricity

Contamination (oil)

Additive distribution

RSS Assembly

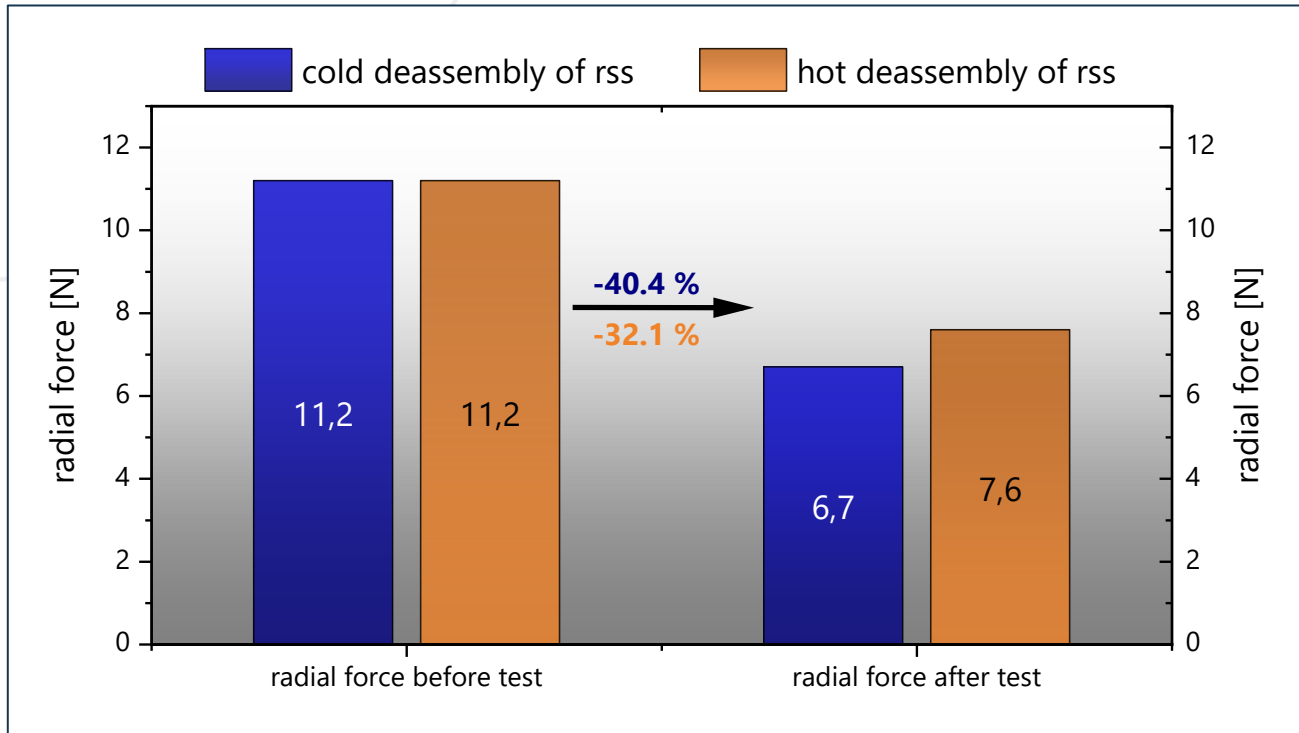
## RSS Evaluation

Microscopic  
Evaluation

Wear Band  
Evaluation

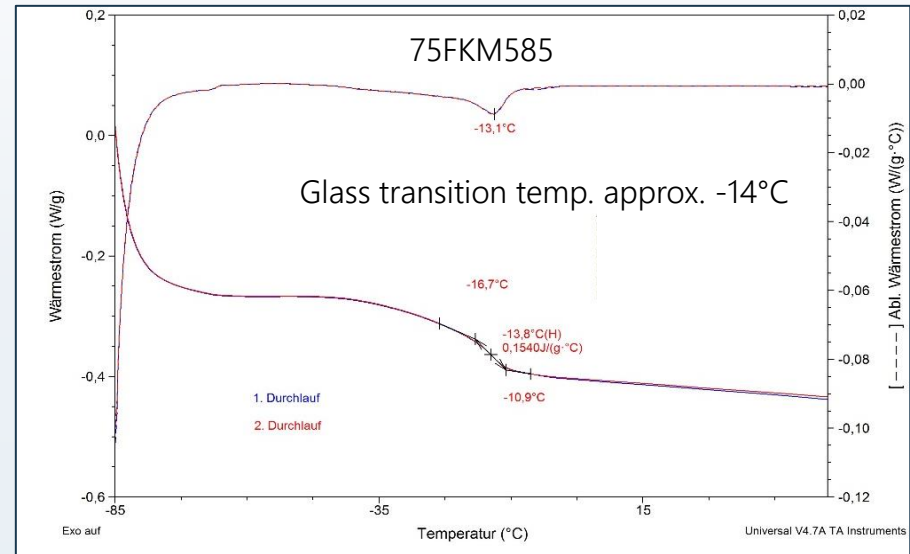
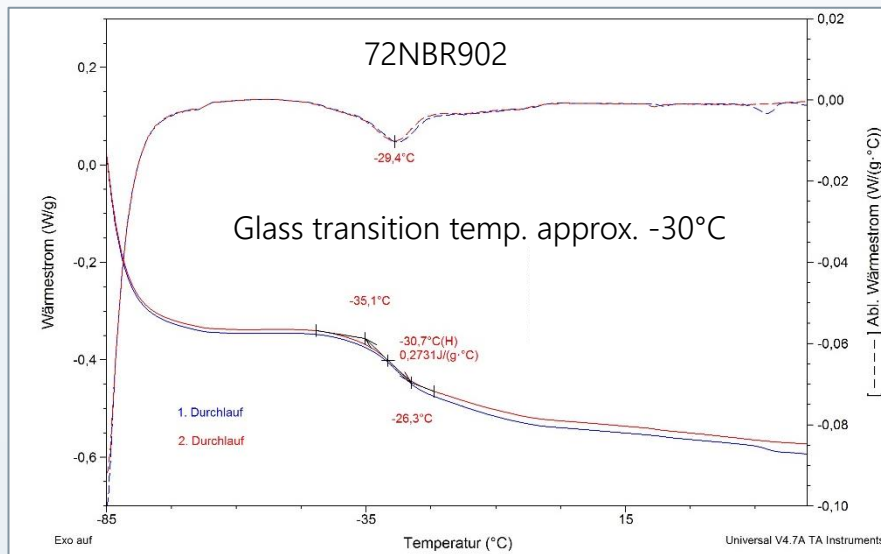
Hardening /  
Softening Evaluation

## Dynamic testing



# Dynamic testing

Static eccentricity – impact on FKM and NBR



→ Due to higher glass transition temperature, FKM-materials have a higher sensitivity to eccentricity

# Dynamic testing

## Solutions

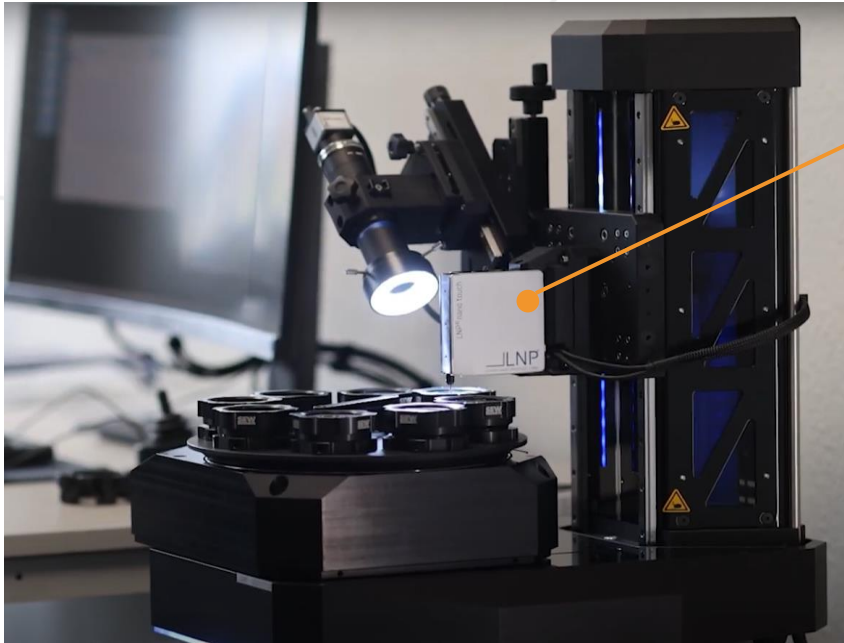


Special groove enables centering of RSS after assembly process of cover plate → Significantly increased precision of centering process and static eccentricity

„Bullseye“ simplifies the cleaning process significantly and reduces risk of cross contamination

# Dynamic testing

## Solutions



Objective evaluation of RSS properties after dynamic test by state of the art test methods with maximum reproducibility.

Rubber and Sealing Know-How and in-depth understanding of rubber-oil-interactions for interpretation of test results

# Summary

Solutions for increased reproducibility



- Hermetically sealed test vessel can significantly increase the reproducibility of static testing but lead to higher loss of mechanical properties for FKM materials.
- High attention to details during assembly and deassembly process and state-of-the-art test equipment are key to achieve high reproducibility for dynamic testing.