Entrainment of free water into hydraulic systems through the rod sealing

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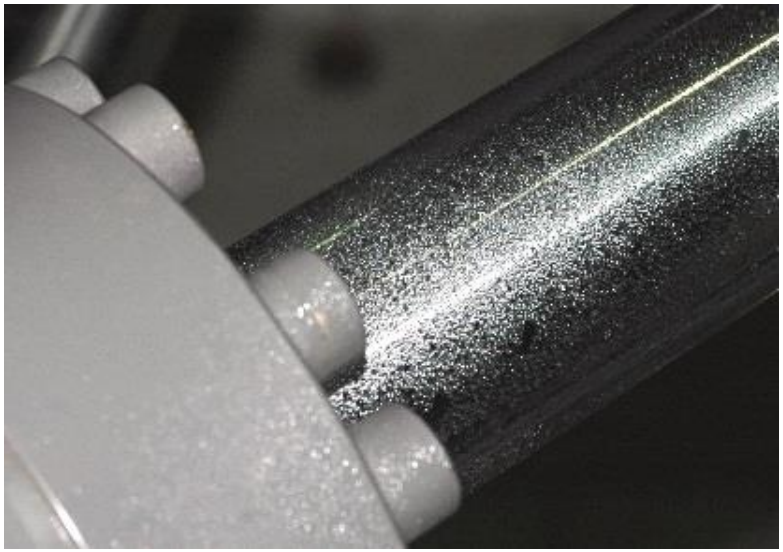


Motivation

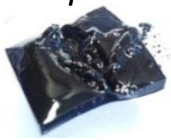
Oil ageing through hydrolysis and oxidation

Ester + H_2O ↔ Alcohol + Acid

Compatibility on seals

Swelling

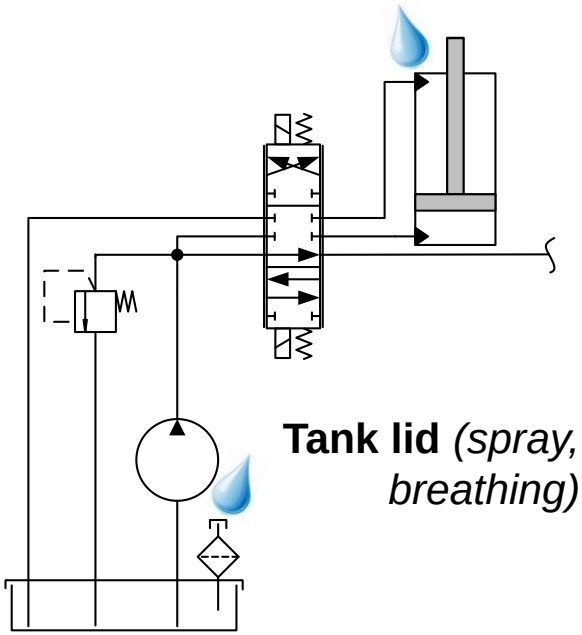
Decomposition



Oxidation of metals

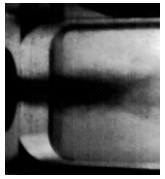
Water entry into hydraulic systems

Dynamic Seals
(relative movement)



Tank lid *(spray, breathing)*

Danger of steam cavitation

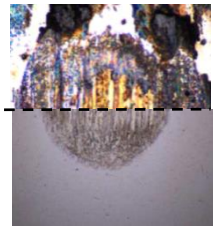


Vapour pressure (50 °C)
Oil: $4.7 \cdot 10^{-8}$ bar
Water: 0.12 bar

Poor lubricity

Hydrodynamic *Wear*

Water
η(40 °C) ≈ 0,65 mPas

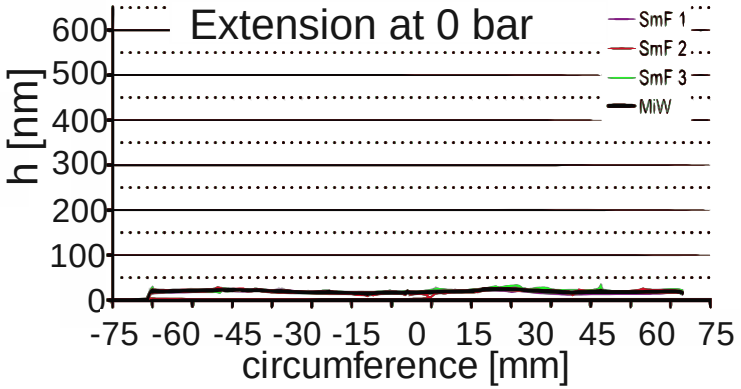


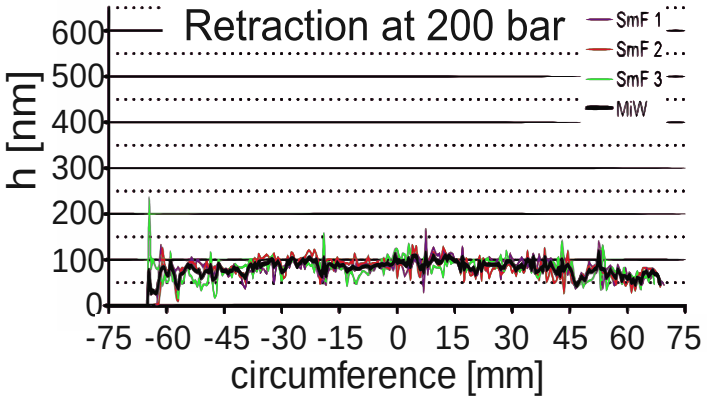
η(40 °C) ≈ 39,1 mPas
Oil

Ice cristals at T < 0 °C

Entrainment potential of rod seals

- Film height greater during retraction than extension (when excessively lubricated)
- Difference can be filled up with water
- → Entrainment potential

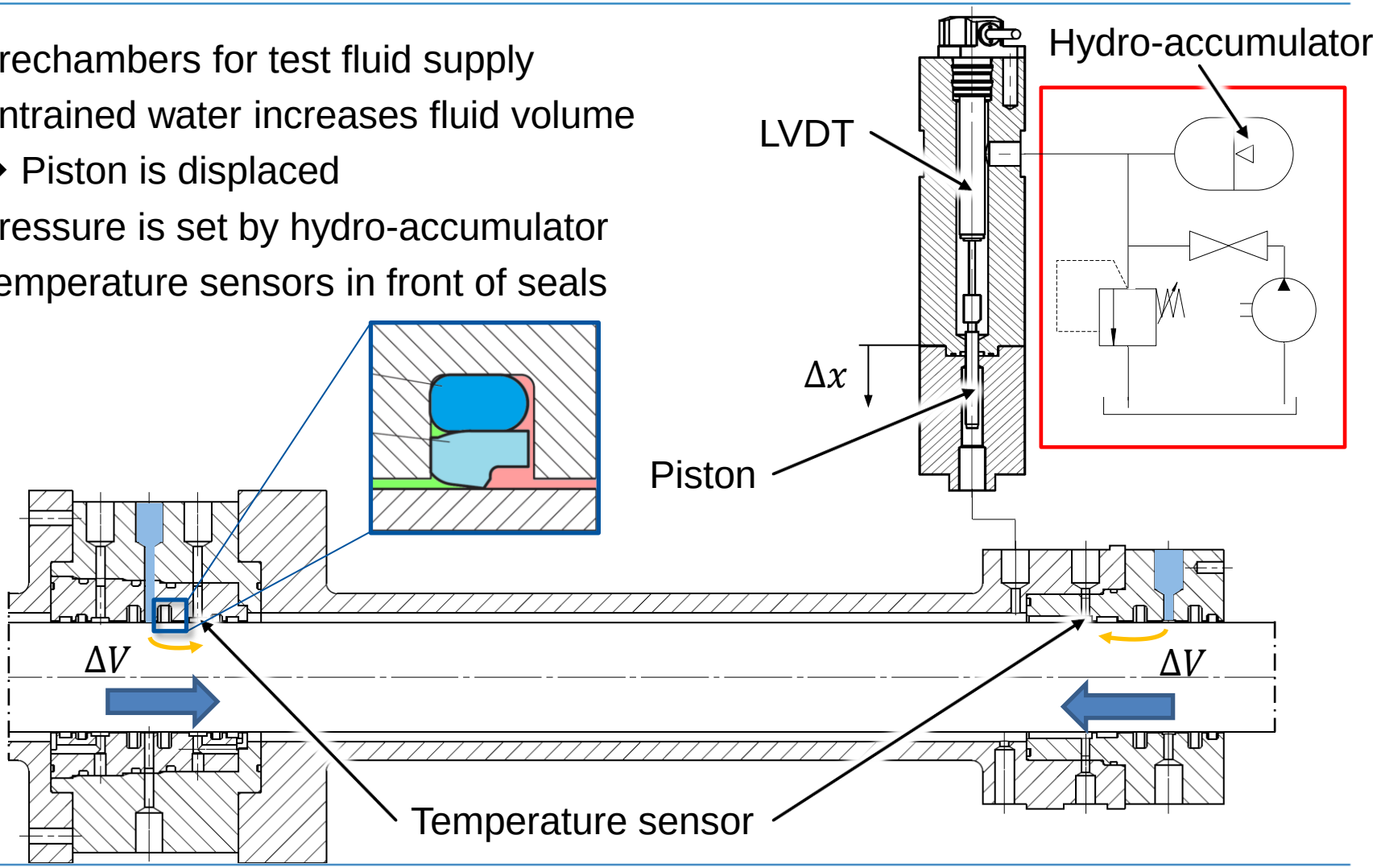




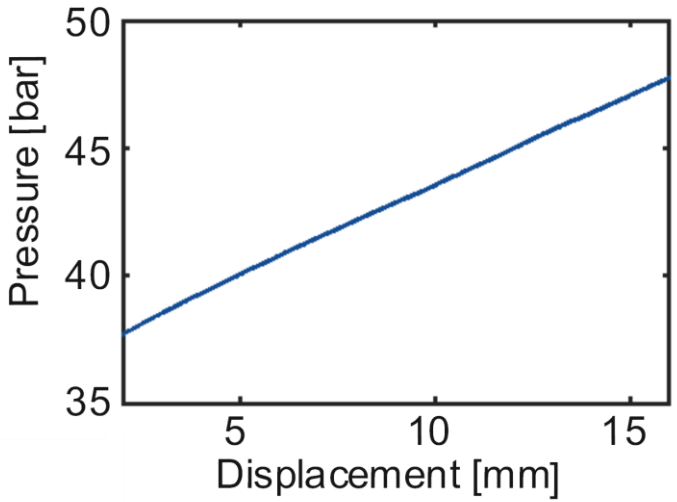
Nißler, U., „Dichtheit von Hydraulikstangendichtringen aus Polyurethan", 2015

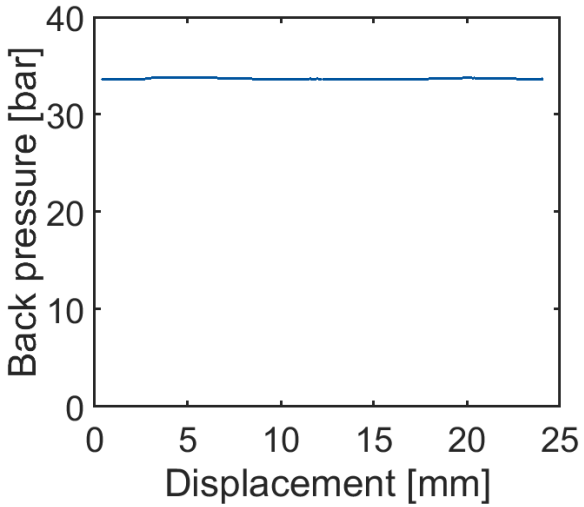
Test bench concept

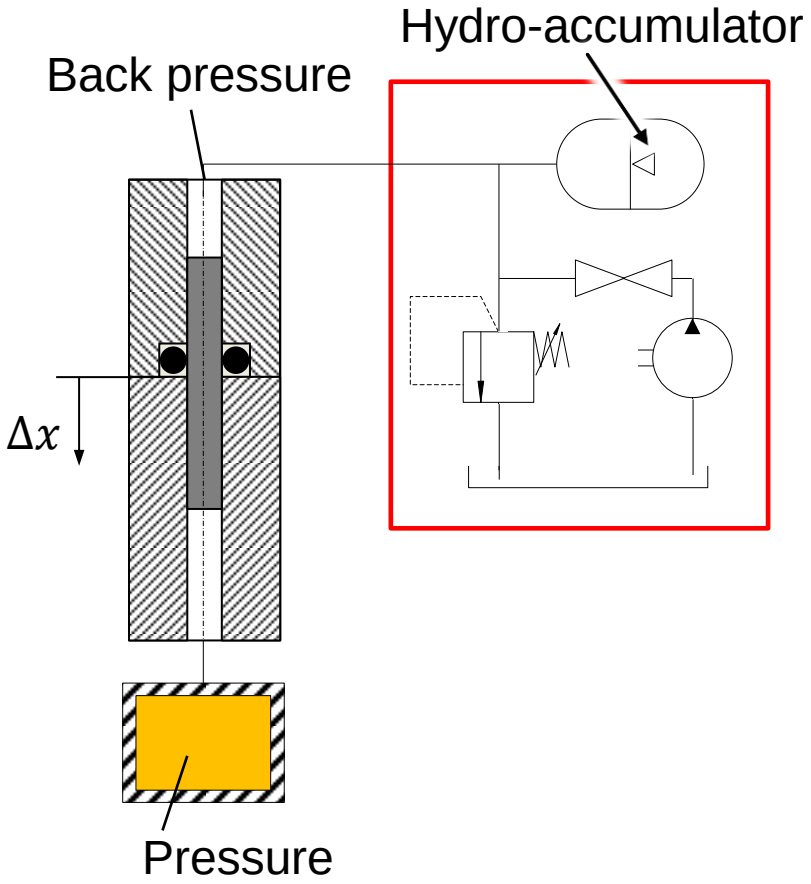
- Prechambers for test fluid supply
- Entrained water increases fluid volume
- → Piston is displaced
- Pressure is set by hydro-accumulator
- Temperature sensors in front of seals



Entrainment sensor





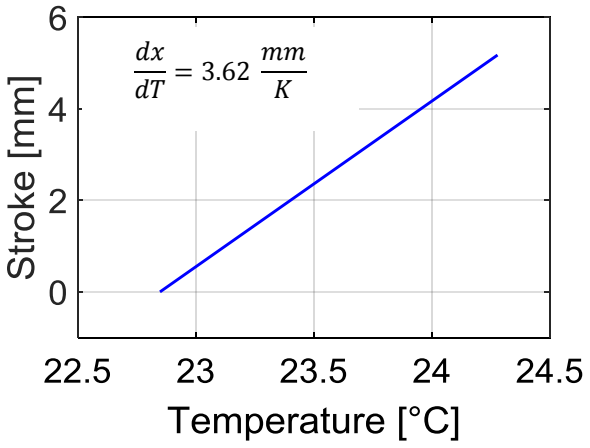


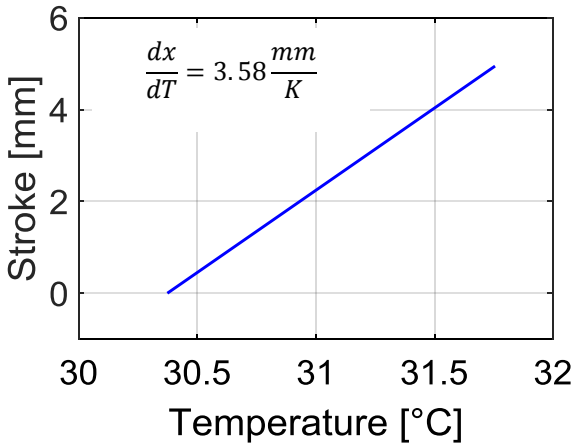
Temperature impact

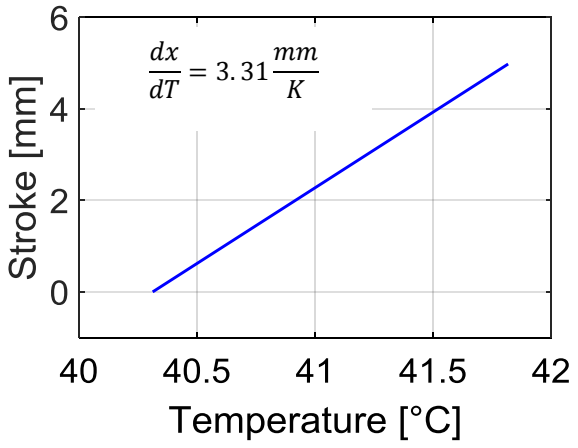
- Temperature rise during operation due to friction in sealing and guide rings
  → Volume expansion of oil leads to thermal induced stroke
- Determine the actual gradient through heating tests
- Used gradient 3.5 $\frac{mm}{K}$ (Standard deviation: 3.9 %)

$$\Delta V_{thermal} = V_0 \cdot \gamma \cdot (T - T_{Start}) = A_{piston} \cdot \Delta x_{thermal}$$

$$\Delta x_{thermal} = \left(\frac{dx}{dT}\right)_A \cdot (T - T_{Start}))$$

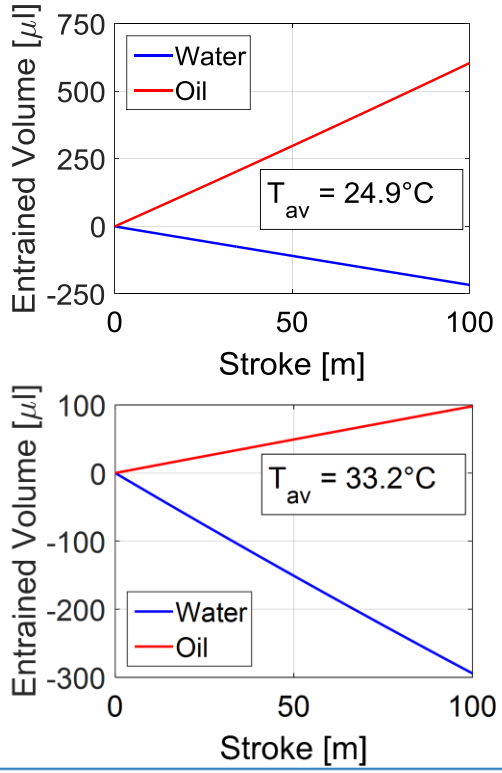


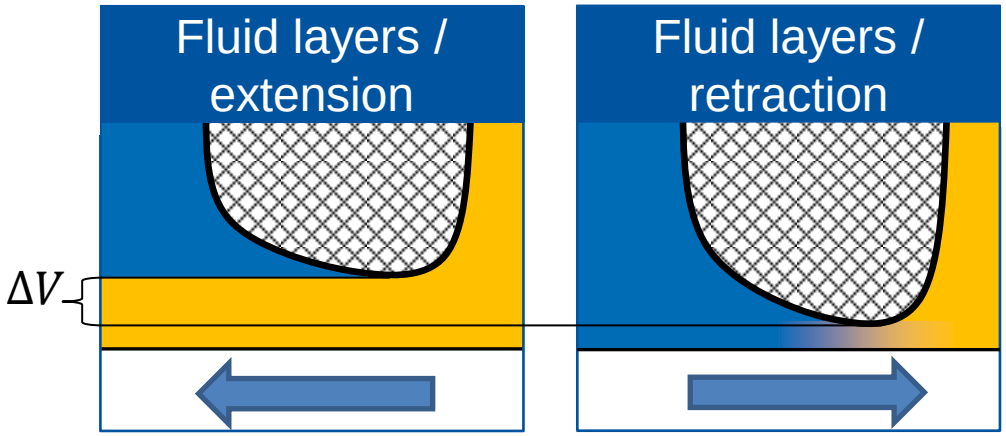




First odd measurement results

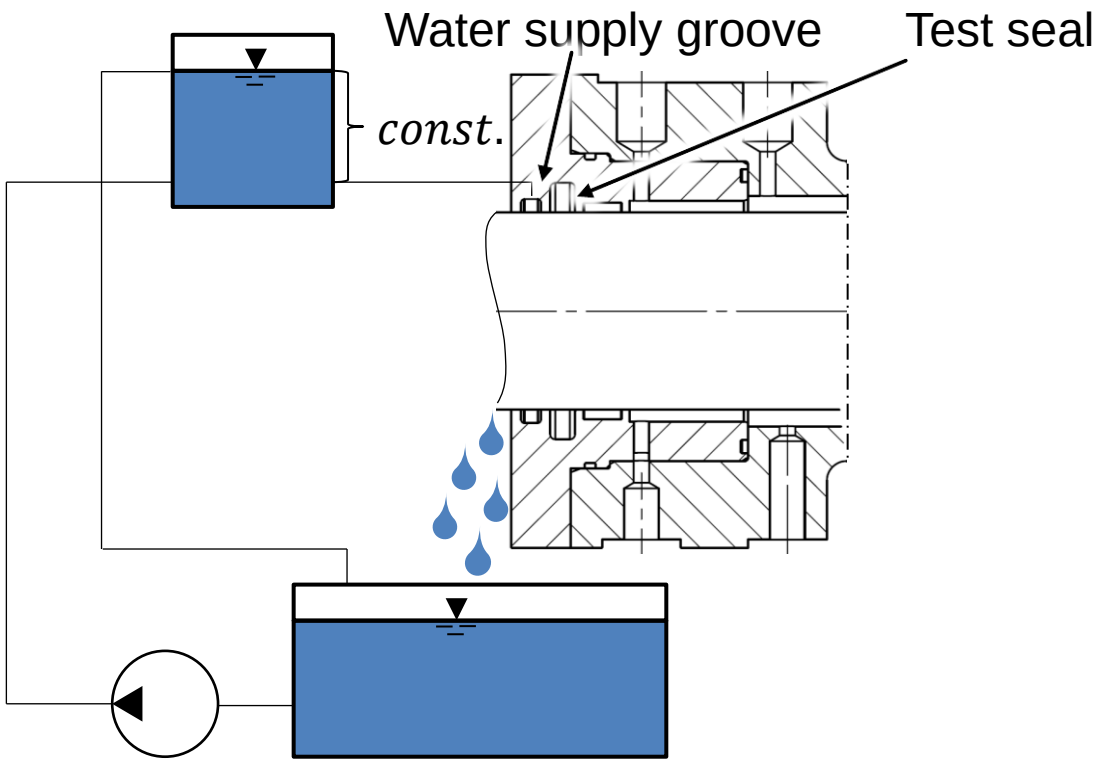
- Measurement carried out for oil and water supplied outside the seals
  - Oil: is entrained into the system through the sealing
  - Water: loss of fluid volume out of the chamber
- Possible explanation: Oil film on rod is detached while water is supplied

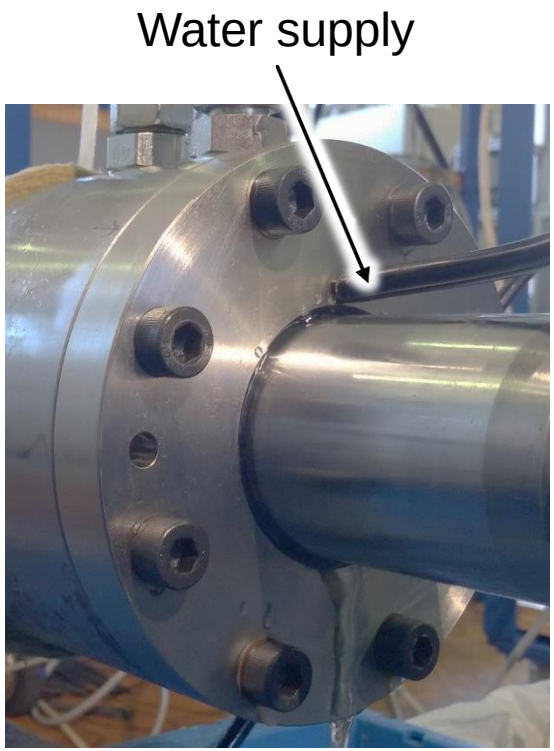




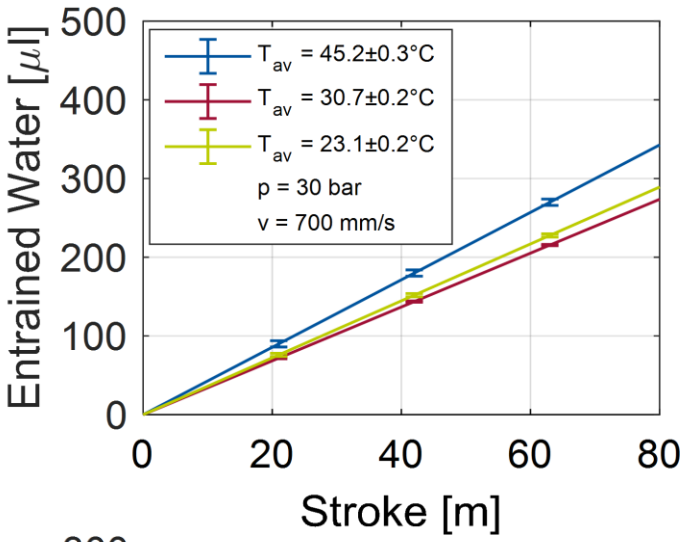
Design change

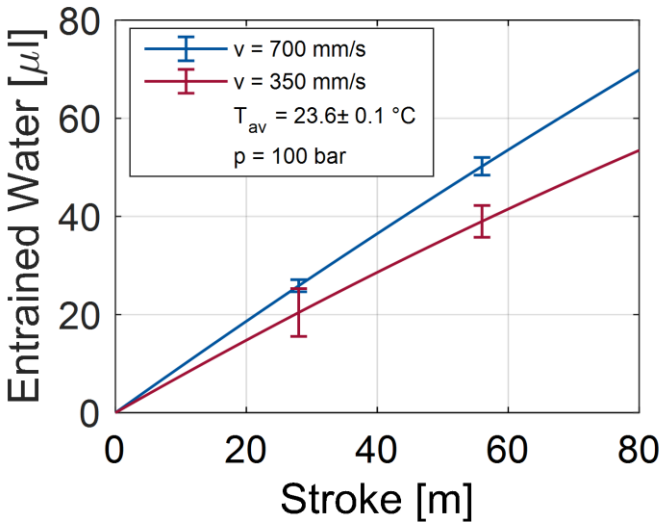
- Modified water supply
  - Water runs pressure free onto the rod in front of seals
  - Water flow is kept constant by maintaining a constant level height

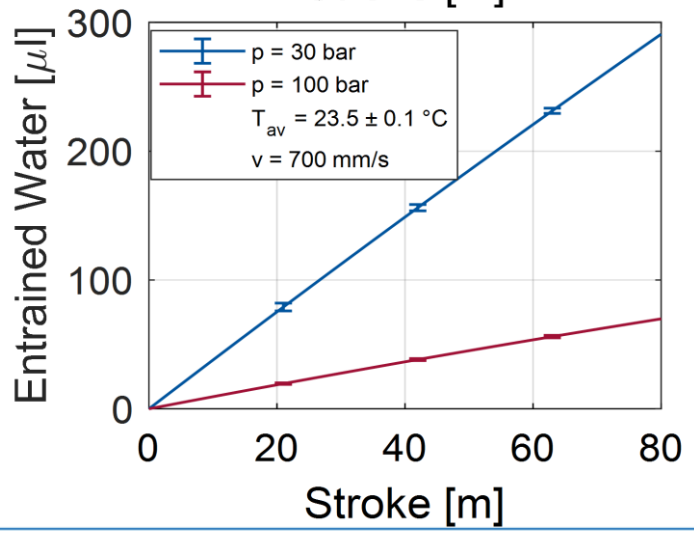




Test results





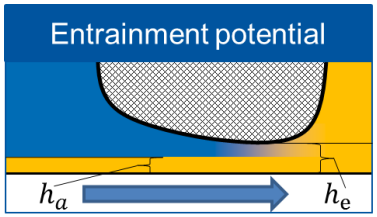


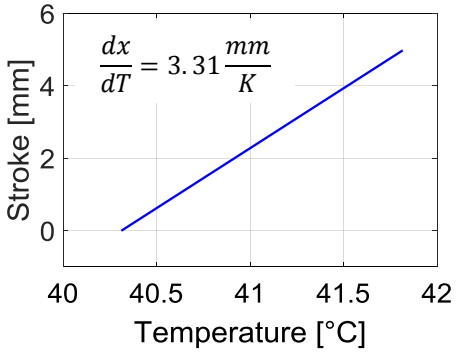
- Velocity and Temperatur have only minor impact
- Main impact is pressure
- Higher pressure → seal is harder pressed against rod → water is better wiped off

Conclusion and outlook

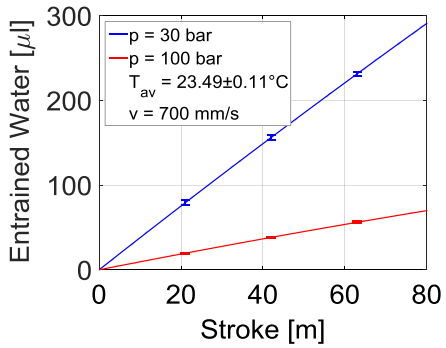
- Water entrainment potential of rod seals
- Test bench concept
- Thermal induced stroke
- Measurement results

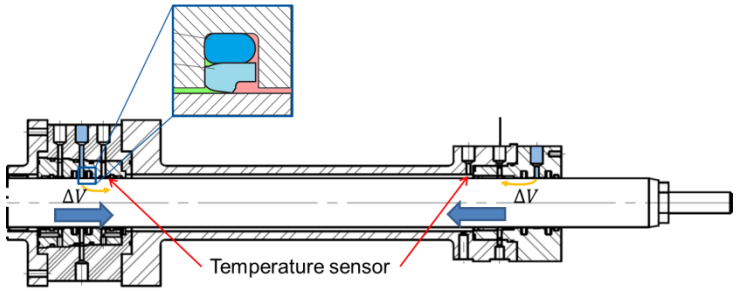
➔ Main impact on water entrainment is pressure





- Investigation of other sealing concepts
  - Double sealing concept
  - Groove ring
- Investigation of the impact of wipers on the water entrainment





Thank you for your attention!

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