

# **Long-term performance of vacuum insulations panels in buildings and building systems**

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  - The energy distributor Varberg Energi
  - The pipe producer Powerpipe Systems AB
  - The Swedish District Heating Association

# Introduction

- VIPs interesting for
  - Urban developments with high rental costs
  - Cultural heritage buildings where the space for insulation is limited
  - District heating systems where the heat transfer per meter pipe is expected to decrease
  - In Sweden 20 000 km pipe placed in the ground, facing large renovation needs



# Introduction

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  - Urban developments with high rental costs
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  - District heating systems where the heat transfer per meter pipe is expected to decrease
  - In Sweden 20 000 km pipe placed in the ground, facing large renovation needs
- Ongoing discussions on long-term evaluation procedures
  - Internal pressure and weight of VIPs stored in 23° C and 50% RH initially, after 3 months and after 6 months
  - Accelerated ageing, thermal conductivity only dependent on the increased gas pressure
  - Conductivity after cycling climate for 8 days and then in 80° C for 180 days
  - Real condition of a specific application could be far from these conditions
  - In buildings VIPs often are embedded in materials in the wall, floor or ceiling

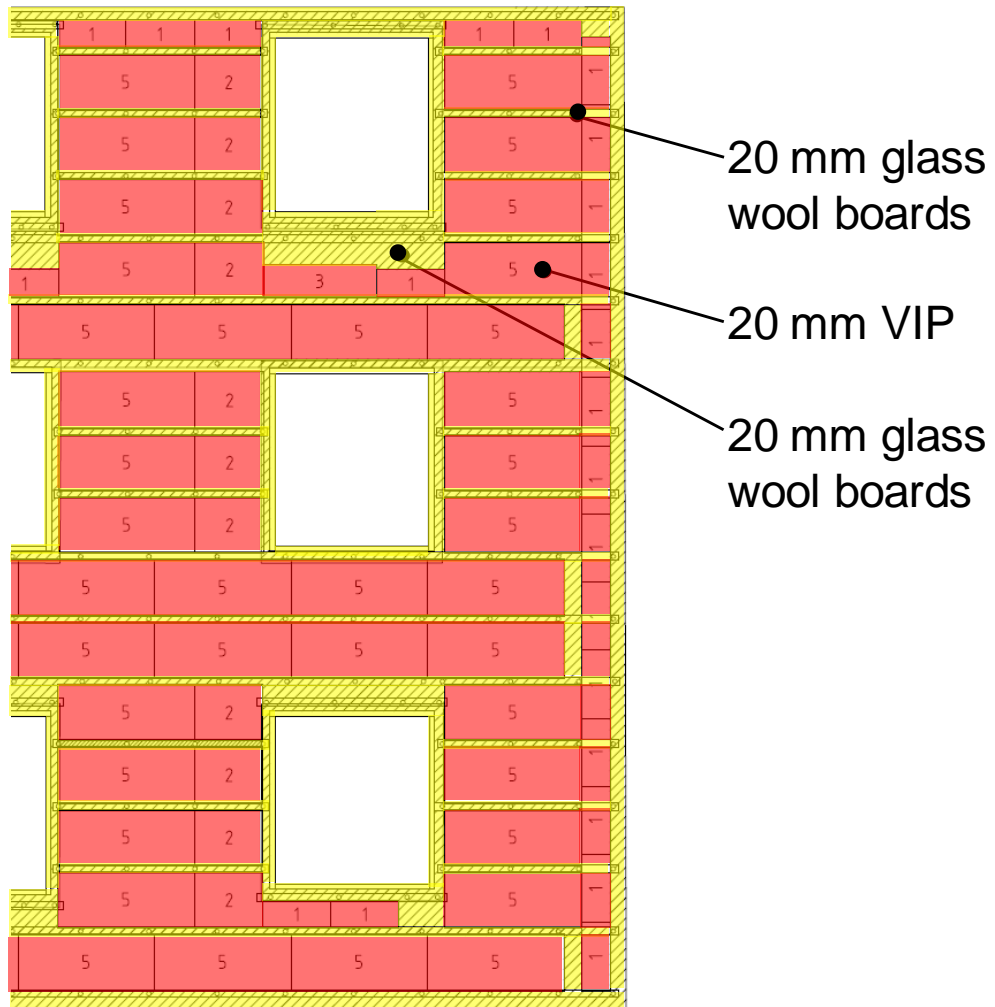


# Aim of this study

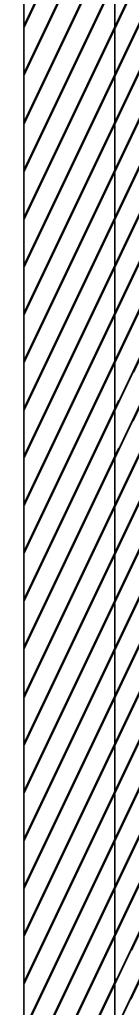
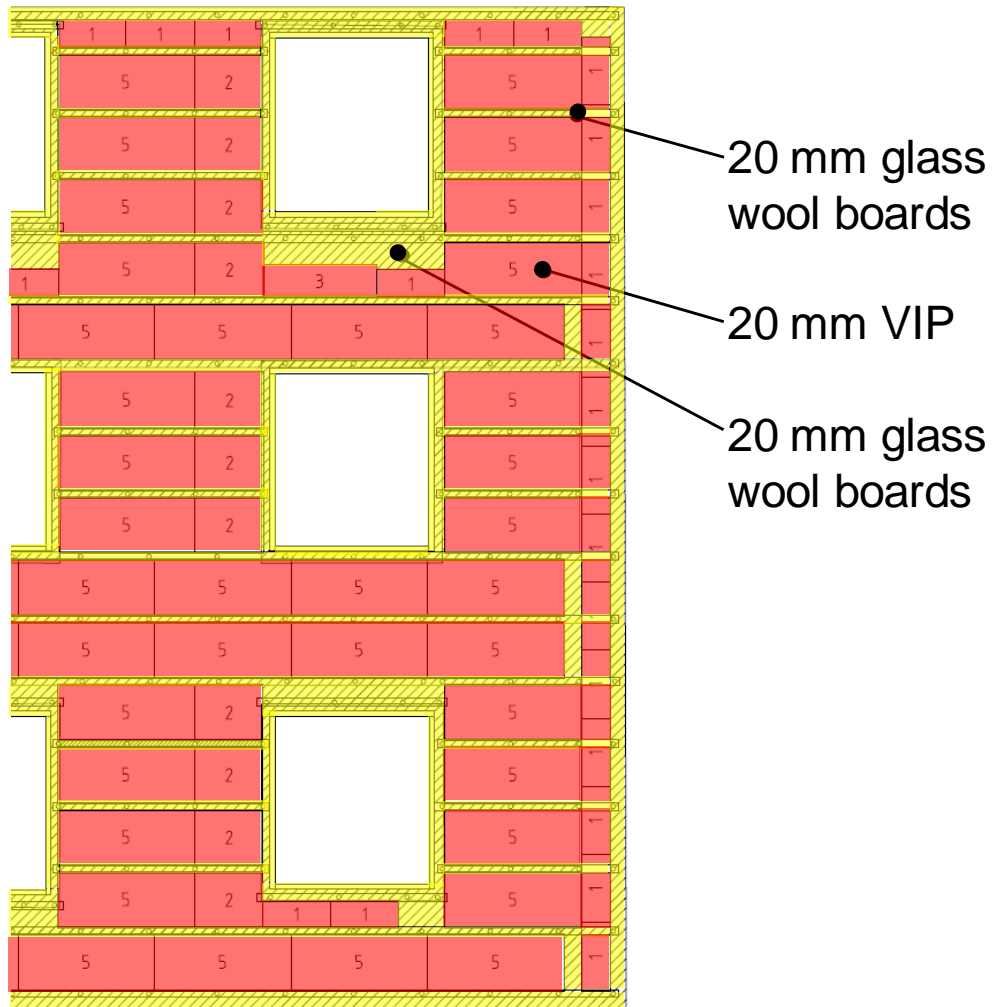
- Discuss and identify the boundary conditions present in buildings and district heating pipes and their effect on the service life of VIPs
- Performance of VIPs based on measurements during the last 5 years
  - The expected service life of both application are more than 50 years
  - The long-term performance of the VIPs is of interest
- Measurements in laboratory and in field
  - Exterior wall retrofitted with VIPs
  - Hybrid insulated district heating pipe



# Wall insulated on the exterior



# Wall insulated on the exterior

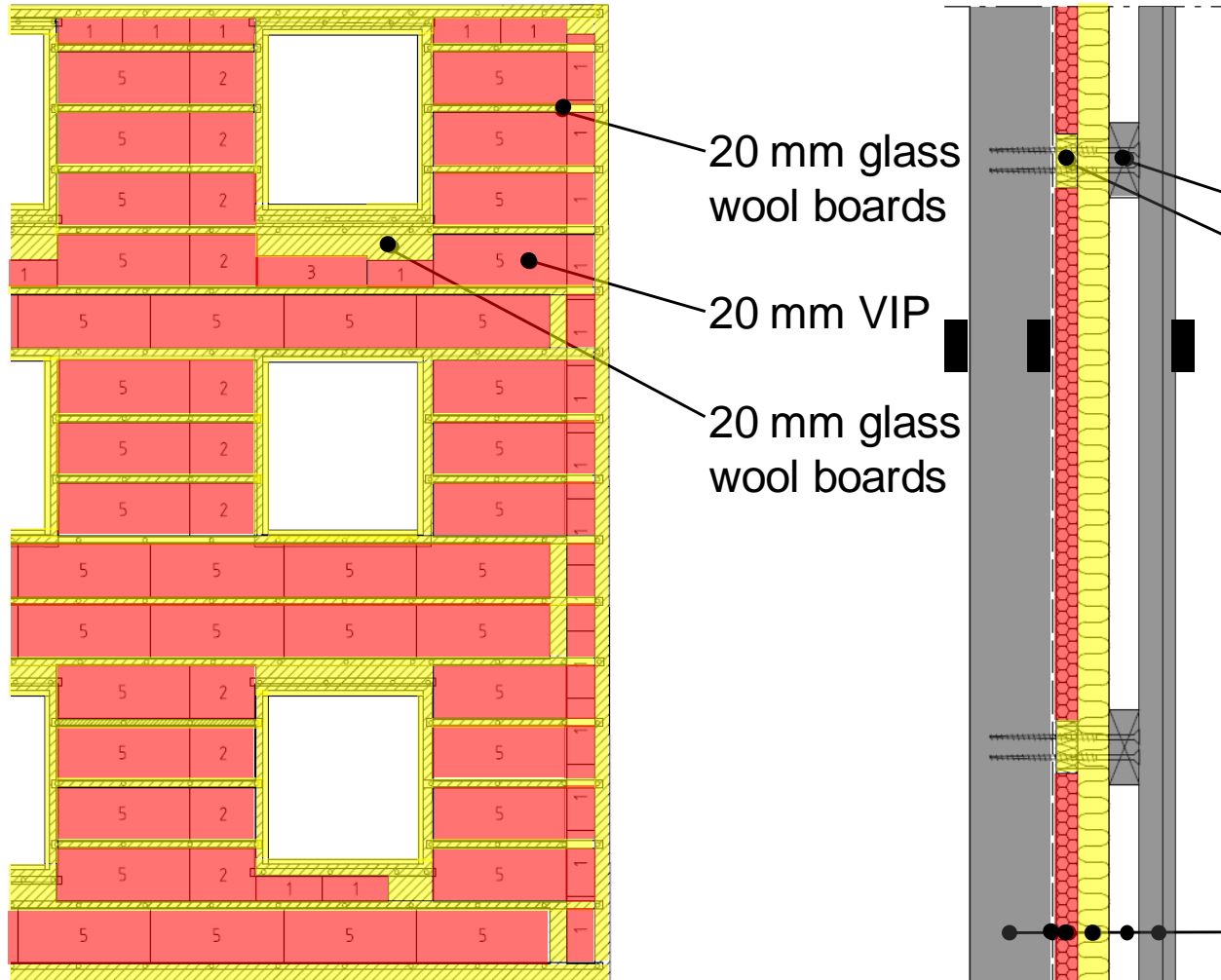


Technical drawing of a wall cross-section showing insulation layers and structural elements. The drawing includes a detailed view of the wall assembly with various insulation materials and structural components. The layers are labeled as follows:

- 20 mm glass wool boards
- 20 mm VIP
- 20 mm glass wool boards
- 28x70 mm wooden lath
- 20 mm glass wool boards
- 22 mm wooden cover boarding
- 28 mm air space
- 30 mm glass wool boards
- 20 mm VIP
- 0.2 mm polyethylene foil
- Structural timber/brick



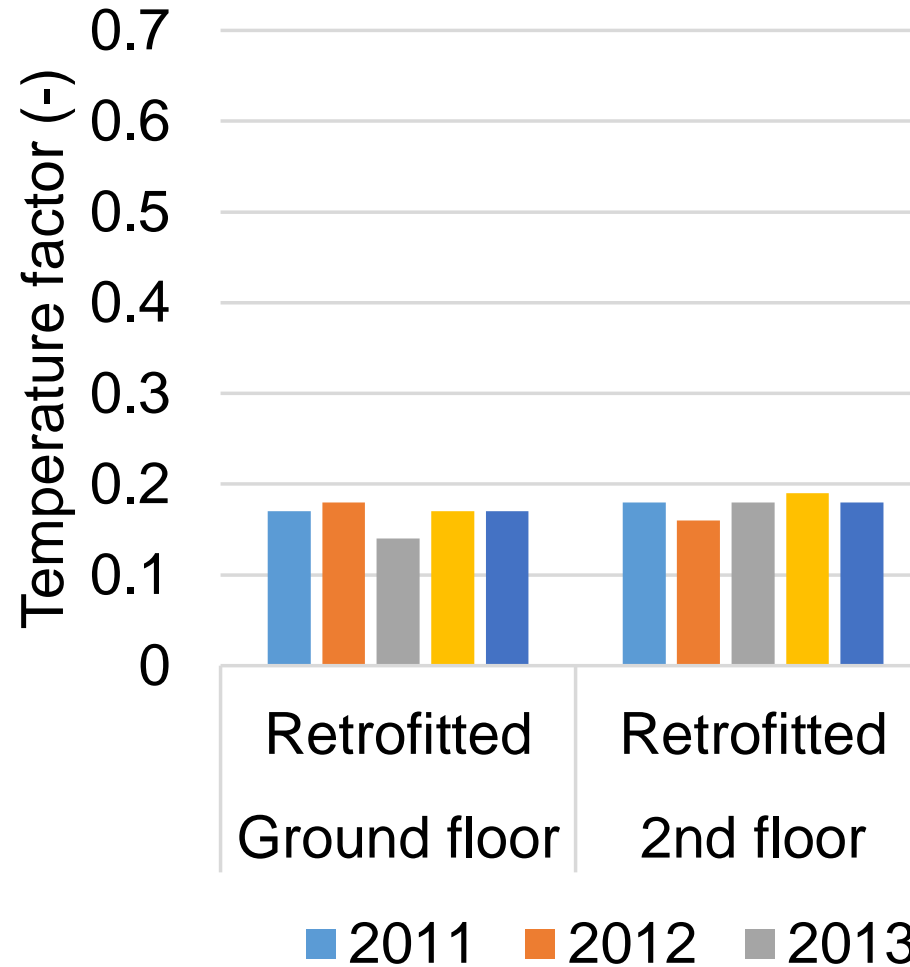
# Wall insulated on the exterior



$$f = \frac{T_{indoor} - T_{sensor}}{T_{indoor} - T_{outdoor}}$$

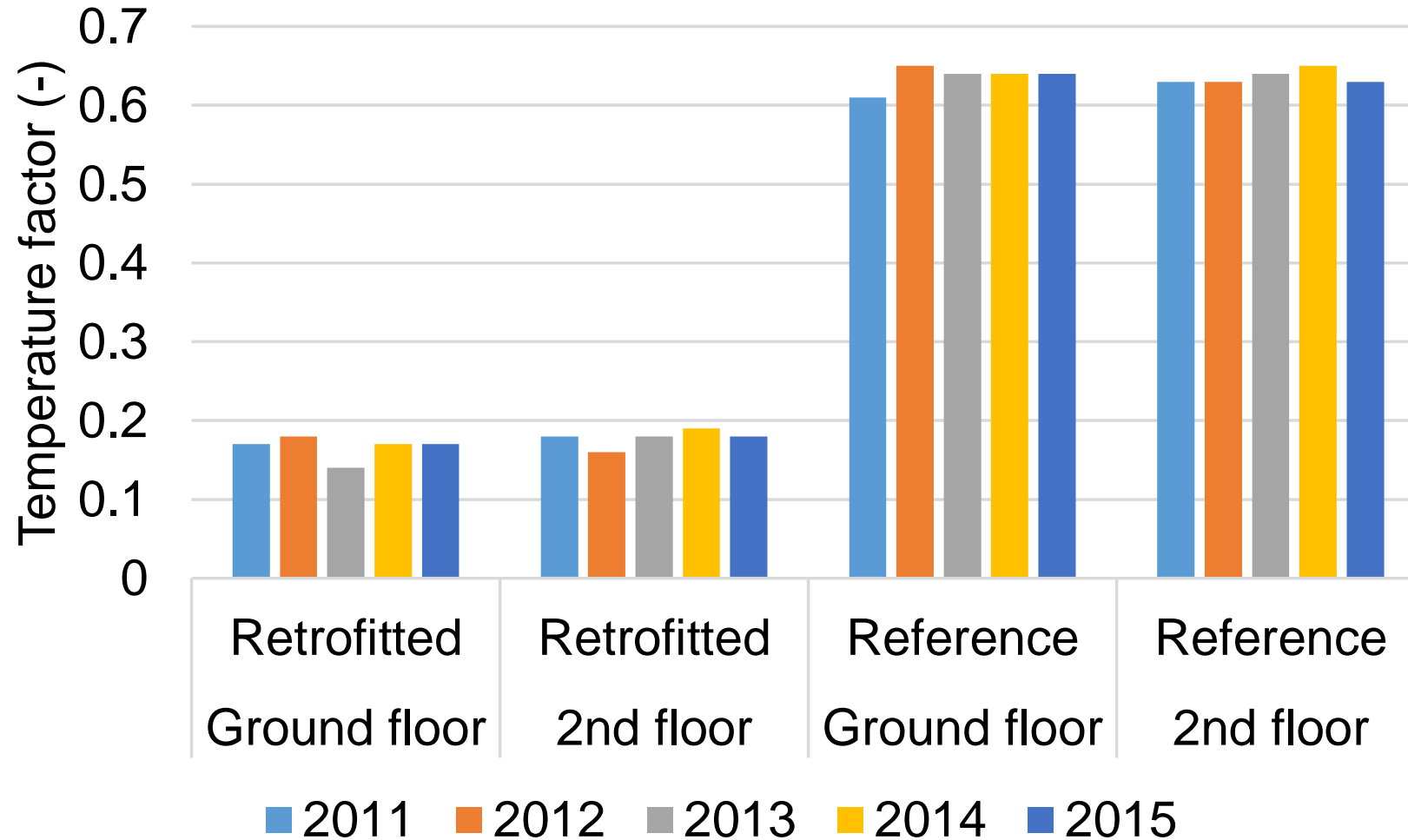
# Temperature factor

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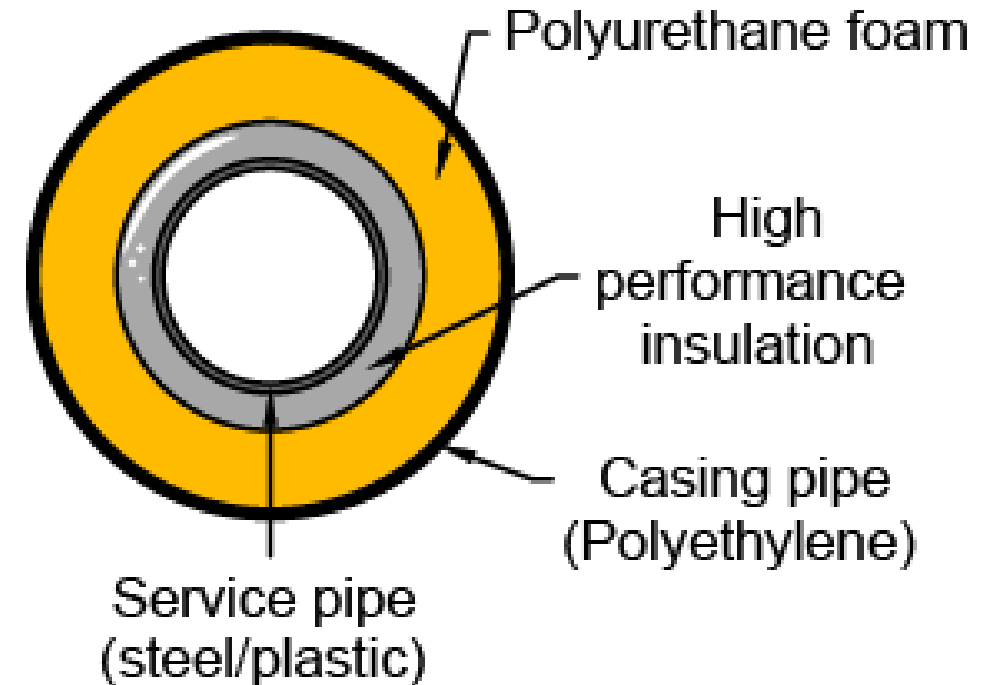
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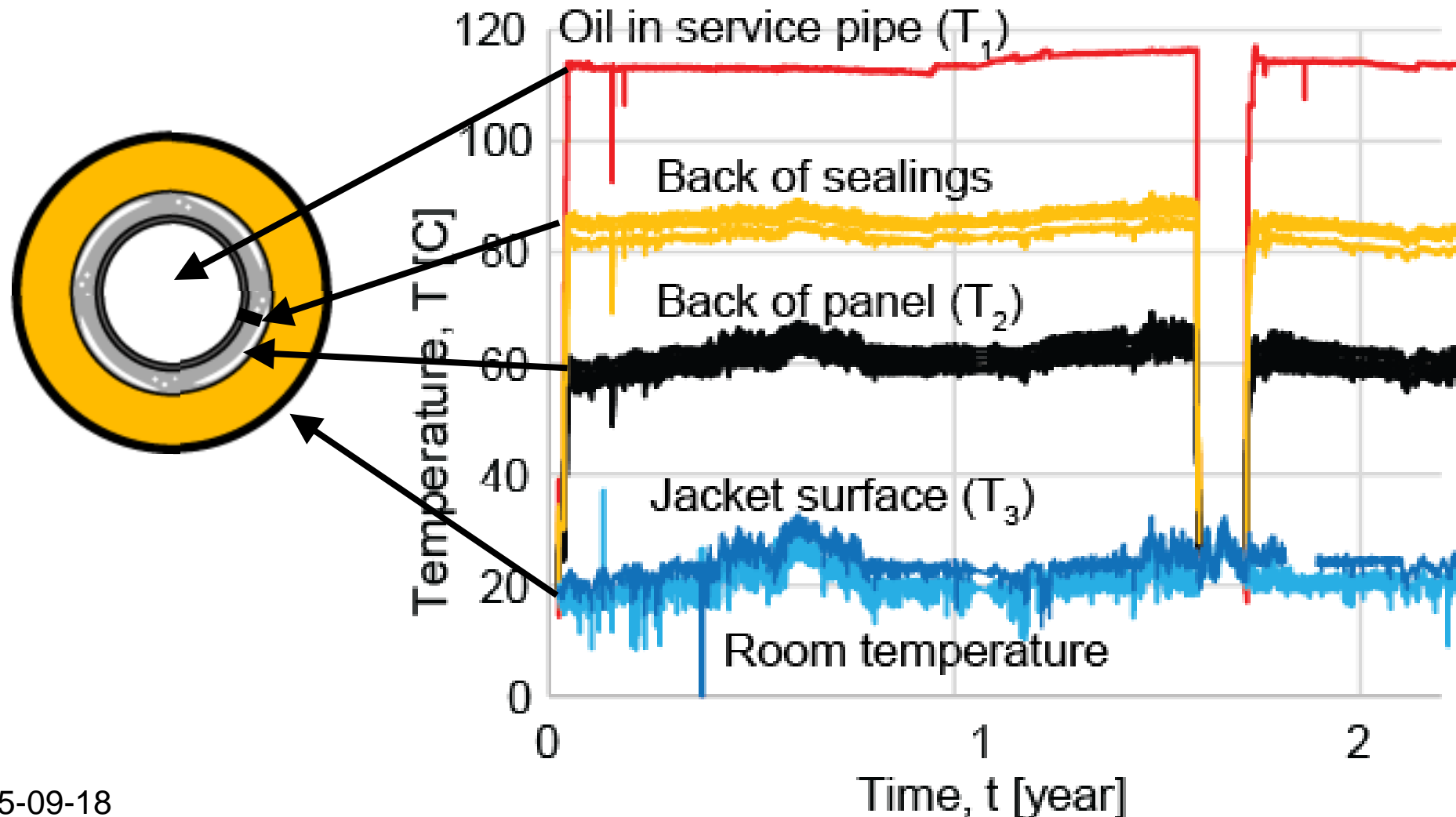
# VIPs in hybrid insulated heating pipe

- The temperature can reach 120° C
- This is higher than the temperature limit for conventional VIP envelopes
- In lab some VIPs lost their vacuum already at temperatures around 70° C
- Strategic location of the sealing could significantly improve the high temperature durability of the VIPs
- Measurements in laboratory (115° C in pipe)

$$p_{\lambda} = \frac{\lambda_2}{\lambda_1} = \frac{(T_1 - T_2) \cdot \ln(r_3/r_2)}{(T_2 - T_3) \cdot \ln(r_2/r_1)}$$



# Hybrid insulation district heating pipes tested in laboratory



*After more than two years, no temperature increase can be detected!*



# Conclusions

- No considerable performance degradation
  - After five years in the wall application
  - After three years in the hybrid insulated pipes
- However, it is still too soon to make final conclusions of the entire service life performance of the applications
- More knowledge and information is needed on
  - Standardized fastening methods to minimize thermal bridges
  - Damages of VIPs during construction and condensation risks in the wall
  - Quality assurance of VIPs if embedded in another material
  - The nature of the film and its properties need better specification
  - The dominant permeation which could be through the sealing and not through the envelope itself