

Investigation on District Heating Pipes

- Failure Mechanisms After (?) Losing the Adhesion & Effects of Loads on Cushions
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Stefan Hay | Workshop on Ageing of DH Pipes in Stockholm | 18th April 2023

Failure Mechanisms After (?) Losing the Adhesion

- » Pipes installed in 2000/2002
- » Operating temperatur 123-127 °C (constant)
- » A defective bond between the steel service pipe and the rigid PUR foam was found on the pipe system and proven by measurements in 2014.

- » **Further investigations in 2019:**
 - Analization of available operating data
 - Repeat test in defined (additional) areas of the DH network
 - Taken samples for material testings in the laboratory
 - PE-casing bows
 - PUR foam (bow & straight pipe)
 - cushions



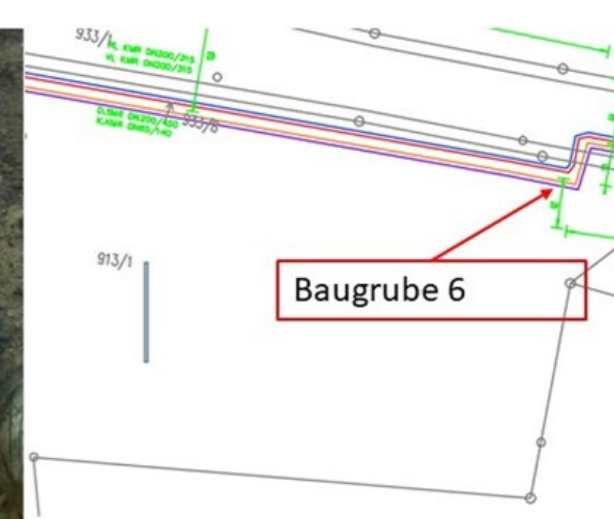
Measurement of the relative movement between the steel pipe and the PE casing for the purpose of proving the defective bond 2013/14, source: EVN

» Impressions of extraction point „number 6“

- Already part of the investigations in 2013
- Built in 2000, refurbished 90°-bow in 2013



Measurement of the relative movement between the steel pipe and the PE casing for the purpose of proving the defective bond 2013/14, source: EVN



- » What happens when pre-fabricated DH pipes lose their adhesion?
- » Free expansion of the steel pipe
- » Higher stresses and strains in T-pieces, bends, branching for house connection lines a.s.o. → breakage??
- » No breakage
→ pipe is reducing the thickness of PUR-foam in the bows



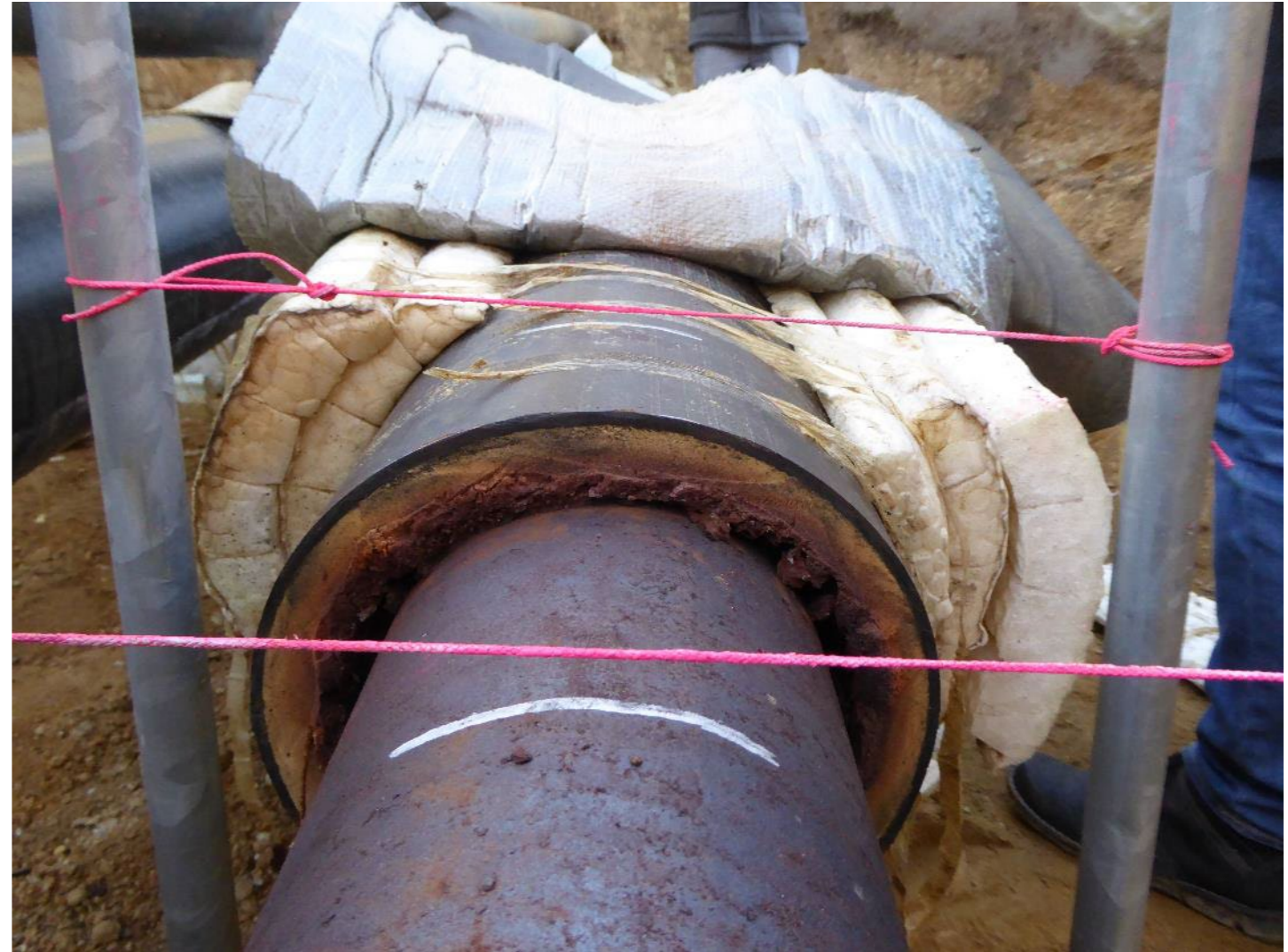
Investigation in a DH network 2017, source all pictures: EVN & AGFW

- » **What happens when pre-fabricated DH pipes lose their adhesion?**
- » **Reduction of the thickness of PUR-foam in the bow & the distance between steel pipe and PE-casing leads to higher temperatures loads of the PE-casing**
- » **Increase the material deterioration of PE-casing & PE-weldings in the bow??**



Investigation in a DH network 2017, source: EVN & AGFW

- » What happens when pre-fabricated DH pipes lose their adhesion?
- » Ovalisation of the DH pipe itself
caused by the earth pressure of the soil



Investigation in a DH network 2017, source: EVN & AGFW

» What happens when pre-fabricated DH pipes lose their adhesion?



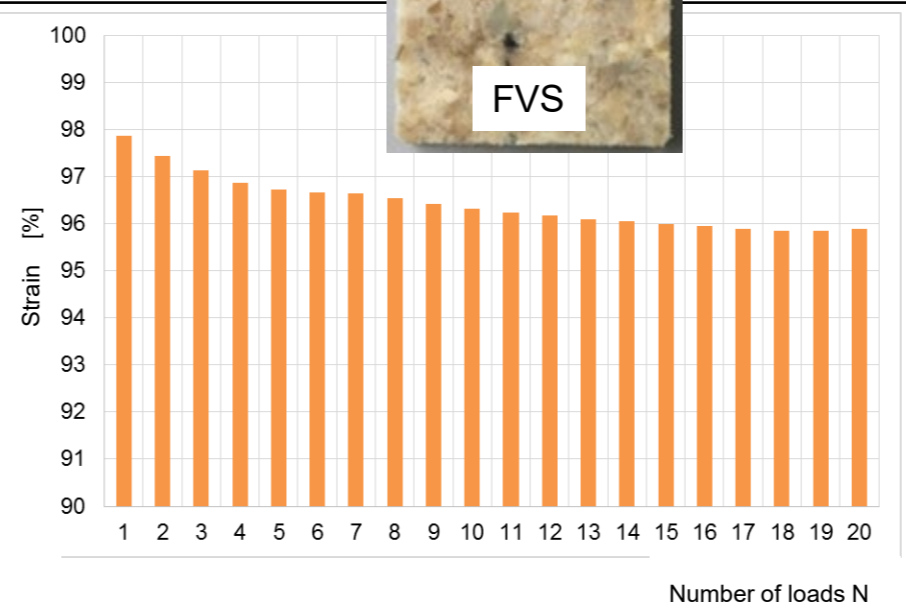
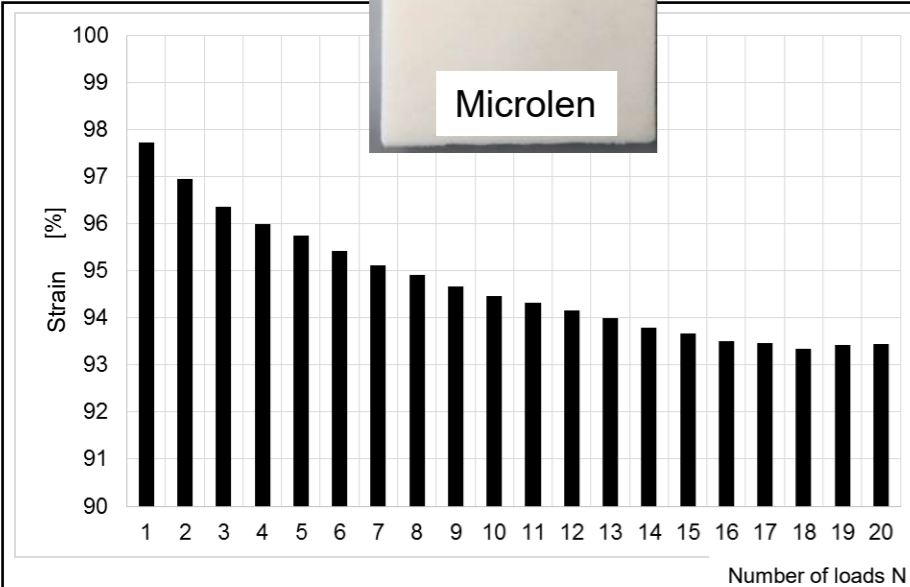
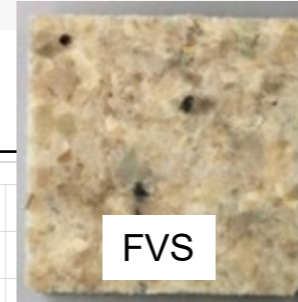
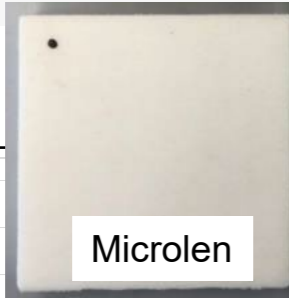
Left: Extraction Point 9, right: Sketch of the extraction points in DH network



- » **Shrink-on sleeves: Leakage of hot-melt adhesive causes leakage of the sealing tapes**
- » **Additional water from outside causing hydrolysis of the PUR-foam**



Effects of Loads on Cushions



Max. compression of the cushion (laboratory testings)

	75%		50%	
	Microlen	FVS	Microlen	FVS
σ_{max} (normiert) [%]	78,7	85,6	90,4	92,9
ϵ_{Ende} [%]	82,8	94,4	94,5	96,3



Cushions after 50 full load cycles
 @ AGFW researche section in Chemnitz
 (origin 80 mm according to the design), source: AGFW

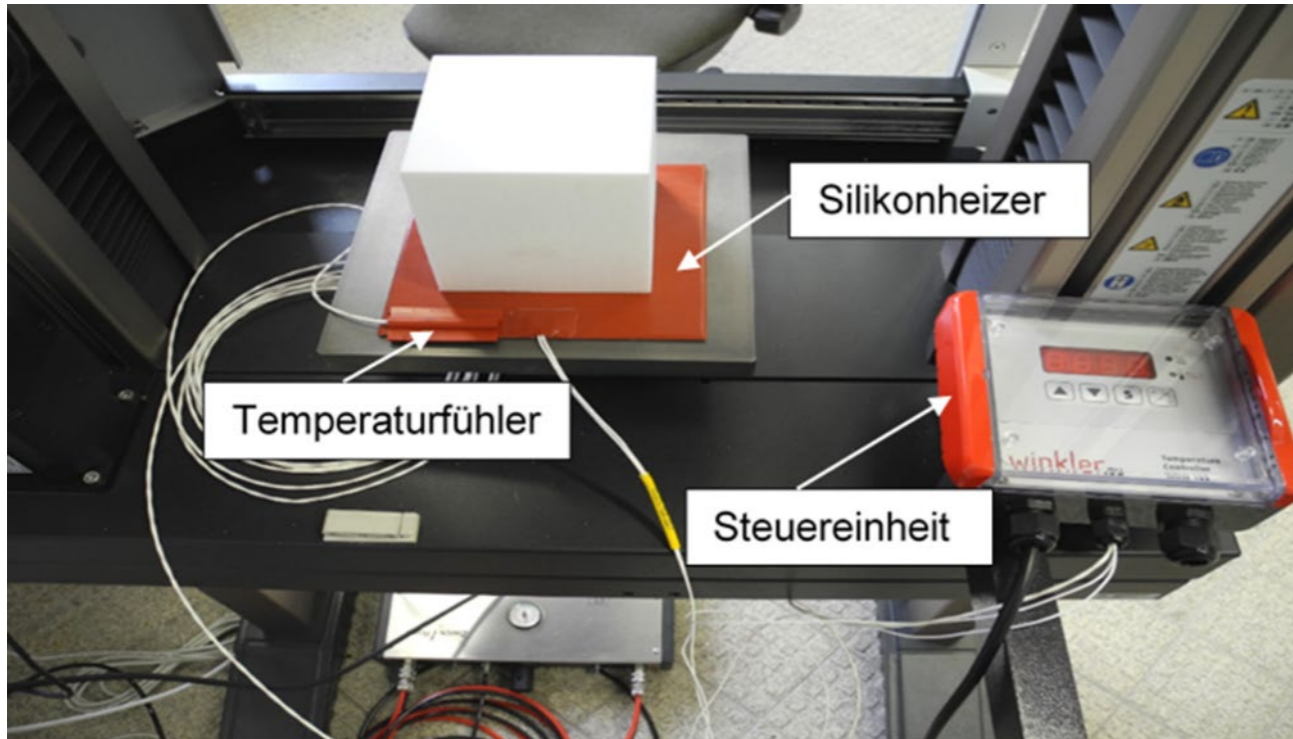
Materials and test parameters for laboratory test

Materials:

- » chemisch vernetztes Polyethylen „Microlen PE 30“ (Microlen),
- » unvernetztes Polyethylen „Polylam 100 RG28“ (Polylam),
- » unvernetztes Polyurethan „VB100“ (Recyclingmaterial Flockenverbundschaum, FVS)
- » chemisch vernetztes und horizontal geschäumtes Polyethylen „Trocellen C30N“ (Trocellen).

Parameter	
Probekörpergeometrie	100 mm x 100 mm x 100 mm (Länge x Breite x Höhe)
Kompressionsgeschwindigkeit	1 mm/min
maximale Kompression	75 % oder 50 % der Ausgangshöhe
Dekompressionsphase	monotonen Prüfungen 24 h, zyklischen 12 h
Zyklenzahlen	N = 4, 12, 20
Vorkompression	7-tägige Vorkompression mit 20 kN/m ²
Einseitige Erwärmung	50 °C
Thermische Voralterung	

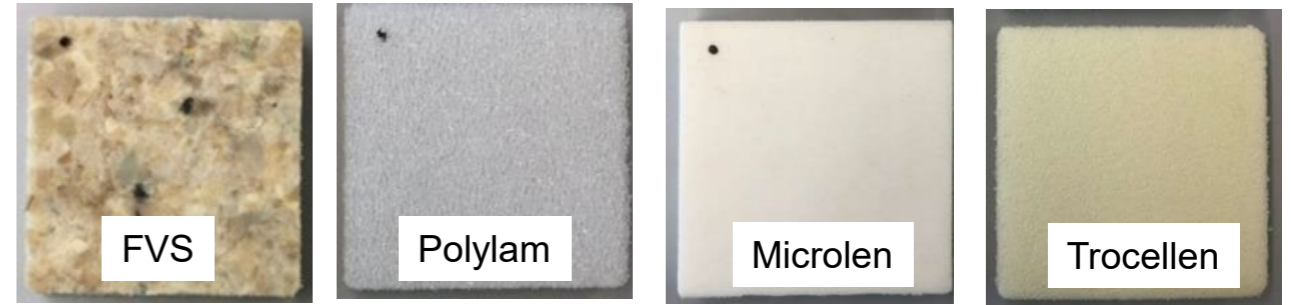
Additional information: test parameters for laboratory test



Extension of the testing machine for combined loading:
Compression + one-sided heating



Extension of the testing machine for combined loading:
Compression + humidity



Tested materials, Source: AGFW

Laboratory tests show that...

- » ...the load level in the cyclic tests influences the degradation of the elastic properties
- » ...the temperature in combination with compression leads to a higher strain deformation residue.
- » ... the material FVS is already exposed to ageing processes due to environmental influences (embrittlement).

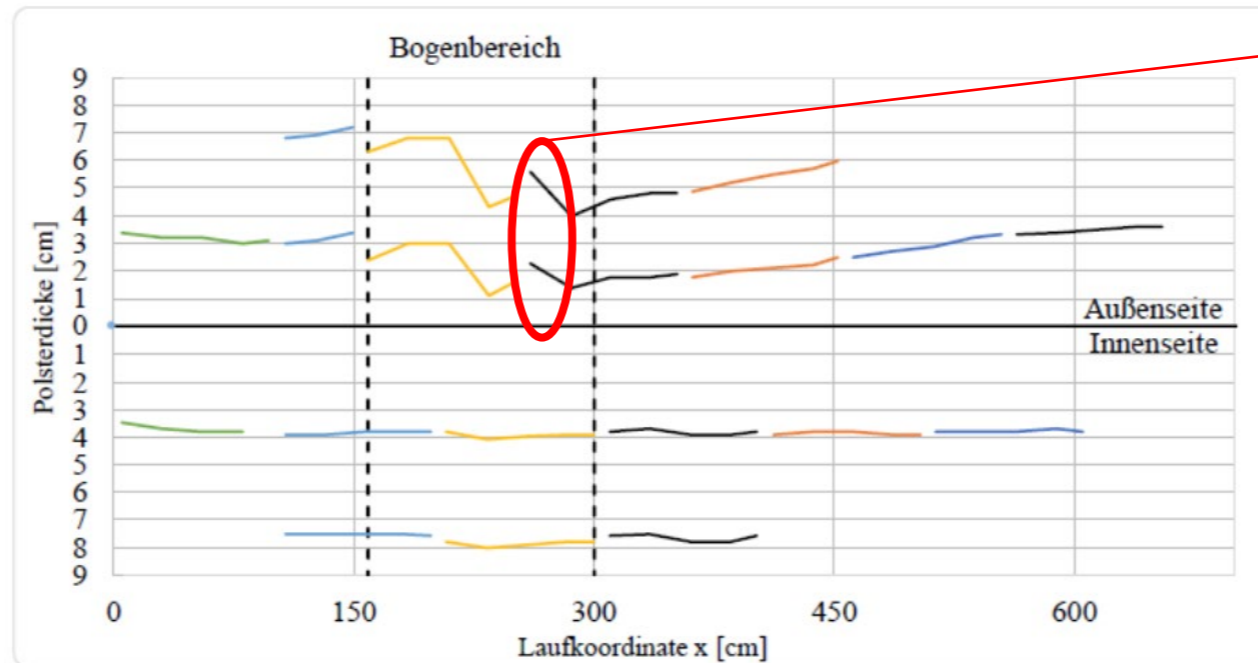
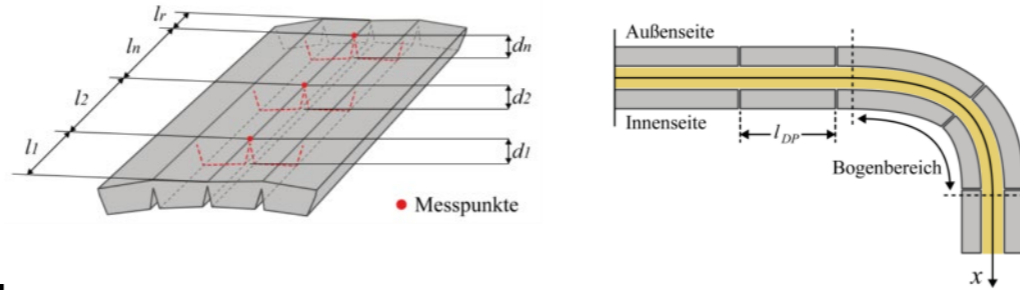
Furthermore, it was shown that...

- » ...Influence of the test speed: the greater the displacement speed, the greater the forces measured for the same deformation.
- » **Reduced coefficients of friction between cushions and PE-casing**
- » Unloading time has an influence on the strain deformation residual, in addition the loading height has an influence on the strain deformation residual

In-situ tests show that...

...after operational stress with...

- » significantly higher load cycles,
- » higher temperatures
- » and a longer duration,



Cushions after 50 full load cycles, measurements in the laboratory, source: IGtH Hannover



Cushions after 50 full load cycles
@ AGFW research section in Chemnitz
(origin 80 mm according to the design),
Investigations done by IGtH Hannover & AGFW

- » there is good qualitative with the laboratory results from combined load (temperature/compression).

The Main Objective of the IEA DHC Task Shared 6 Project



- Collection of research results available
 - Harmonize latest results and make proposals for the improvement of related standards/recommendations
- **Make research results available for DH utilities**
- Identify and close knowledge gaps
 - Involve the international DH community (researchers, experts, municipalities a.s.o.)

→ **We are still looking for further contributions!!!**

For further information: <https://www.iea-dhc.org/the-research/2021-2025-annex-ts6>



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darum fernwärme ...

denn sie ist stubenrein und hilft,
CO₂ zu vermeiden.

fernwärme 
rein ins haus.

Noch Fragen?

www.fernwaerme-info.eu



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