

*5th International Conference on Smart Energy Systems
Copenhagen, 10-11 September 2019
#SESAAU2019*

Durability of DH pipe systems exposed to thermal ageing and cyclic operational loads

**Effects of Loads on Asset Management of the
4th Generation District Heating Networks**
Smart Energy Systems Conference, Copenhagen
10th September 2019



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Introduction

- A large number of pipes in DH systems are close to the service lifetime limit according the design for 30 years thus utilities have to think about maintenance strategies.
- The transformation of DH systems towards renewable energy sources adds unknown additional loads.
- Service life analysis and life time predictions of buried pipes is described in EN 253, EN 448 and EN 13941.
- The main focus according the standards and recommendations is on the fatigue of the steel service pipe and the deterioration of the shear strength of foam.
- The findings of Swedish and German researchers have led to complete deletion of the accelerated ageing test of DH pipes in the European Standard EN 253 because extrapolation from high temperatures to operating temperatures is not valid.

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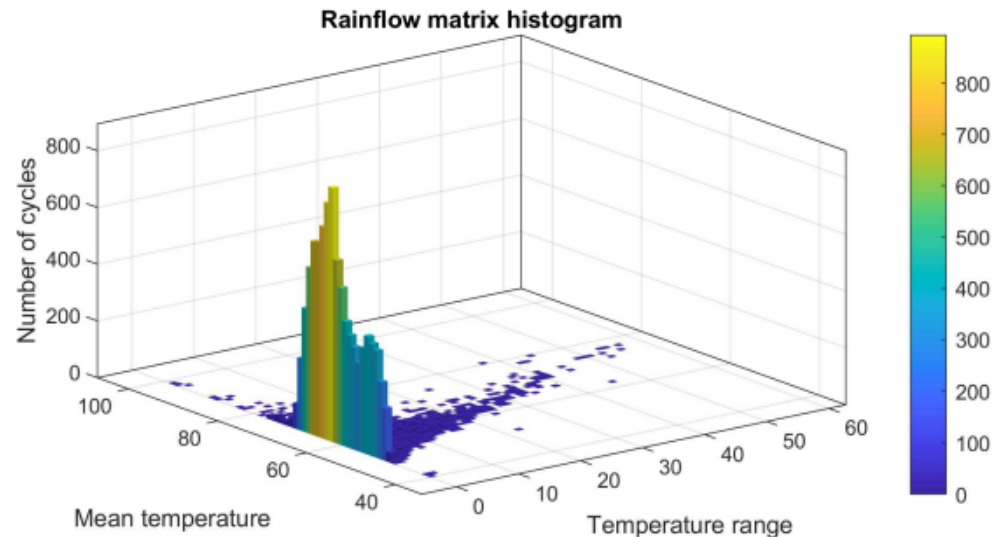
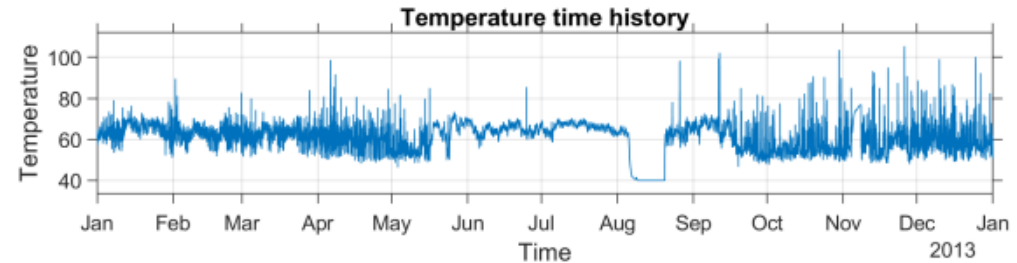


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DATA collection

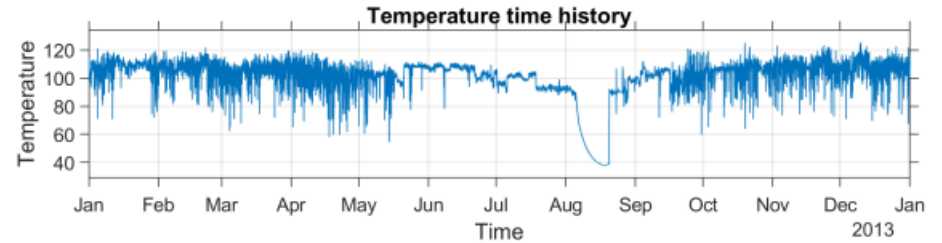
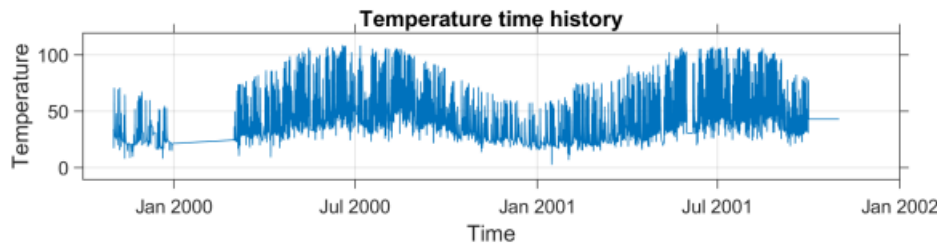
- ✓ Germany
- ✓ South Korea
- ✓ Sweden
- ✓ Norway



Oslo Vika 2013 return pipe	Full temperature cycles N_0	T_{max}	T_{mean}	Damage $\sum N_i / N_{fi}$
$\Delta T_{ref} = T_{max} - 10^\circ\text{C}$	2.02	105.4 °C	60.6 °C	1.08E-05
$\Delta T_{ref} = 110^\circ\text{C}$	1.14			

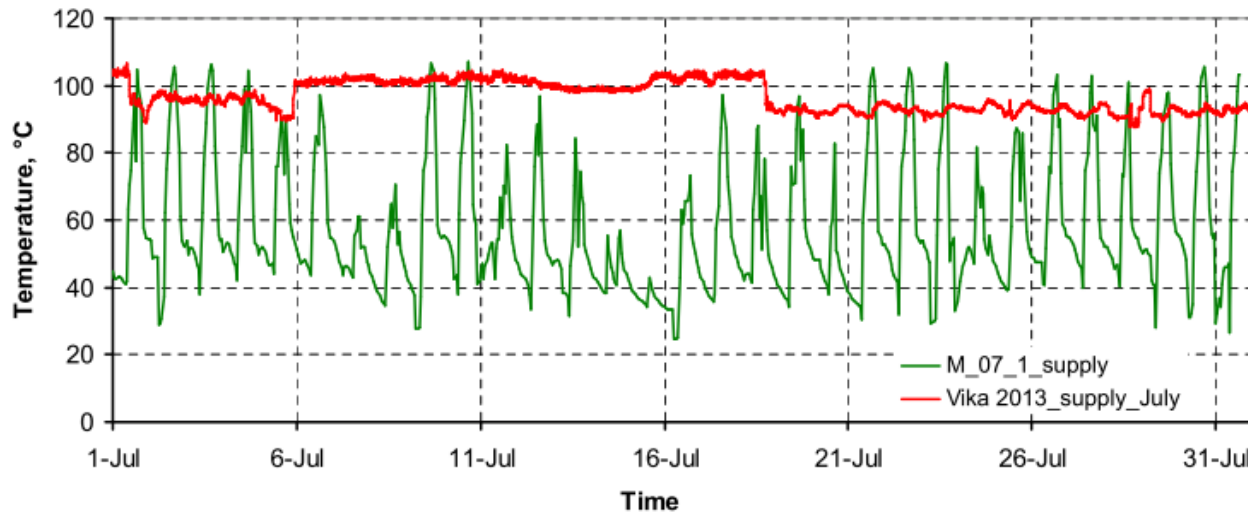


DATA collection



solar circuit supply pipe ($\Delta t = 1\text{-}3\text{h}$)	Full temperature cycles N_0	T_{\max}	T_{mean}	Damage $\Sigma N_i / N_{fi}$
$\Delta T_{\text{ref}} = T_{\max} - 10^\circ\text{C}$	46.66	108.8 °C	43.8 °C	2.87E-04
$\Delta T_{\text{ref}} = 110^\circ\text{C}$	30.37			

Oslo Vika 2013 supply pipe	Full temperature cycles N_0	T_{\max}	T_{mean}	Damage $\Sigma N_i / N_{fi}$
$\Delta T_{\text{ref}} = T_{\max} - 10^\circ\text{C}$	2.83	125.7 °C	101.6 °C	3.27E-05
$\Delta T_{\text{ref}} = 110^\circ\text{C}$	3.46			



July:

- Solar circuit: $N_0=3.38$
- Vika 2013: $N_0=0.002$



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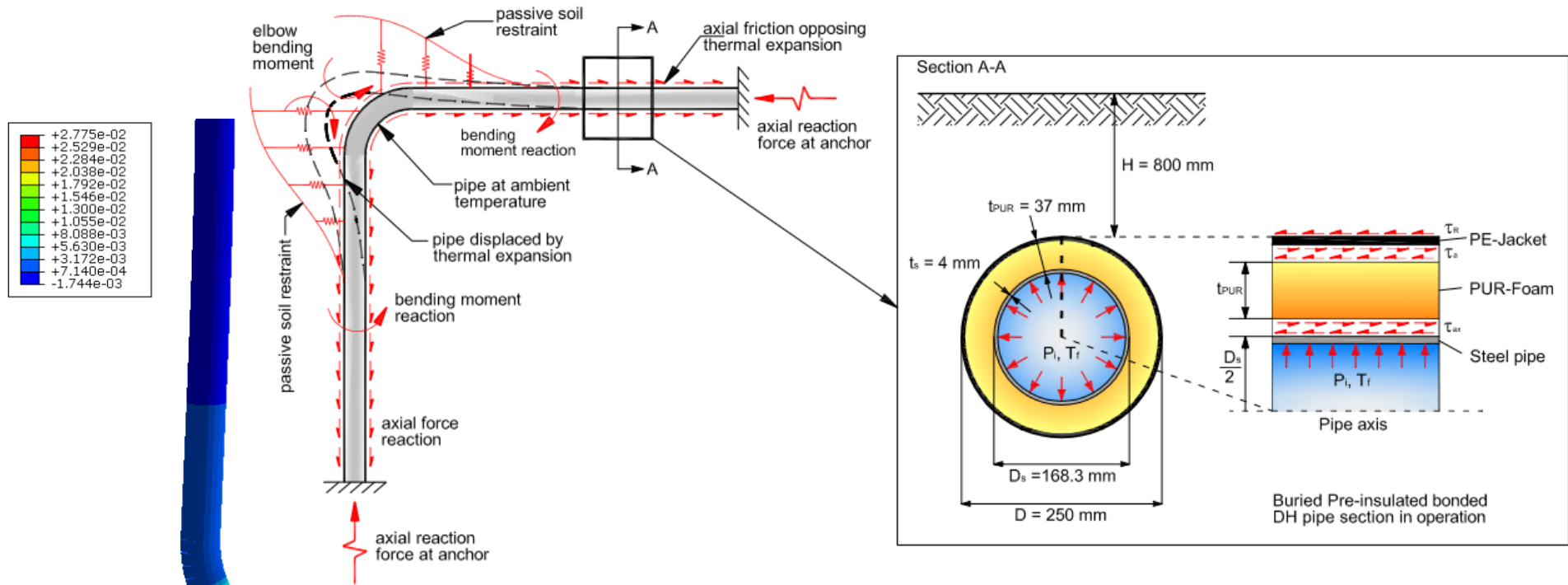
Fonden Energi- & Miljødata
www.emdfonden.dk



4DH

Combined loads

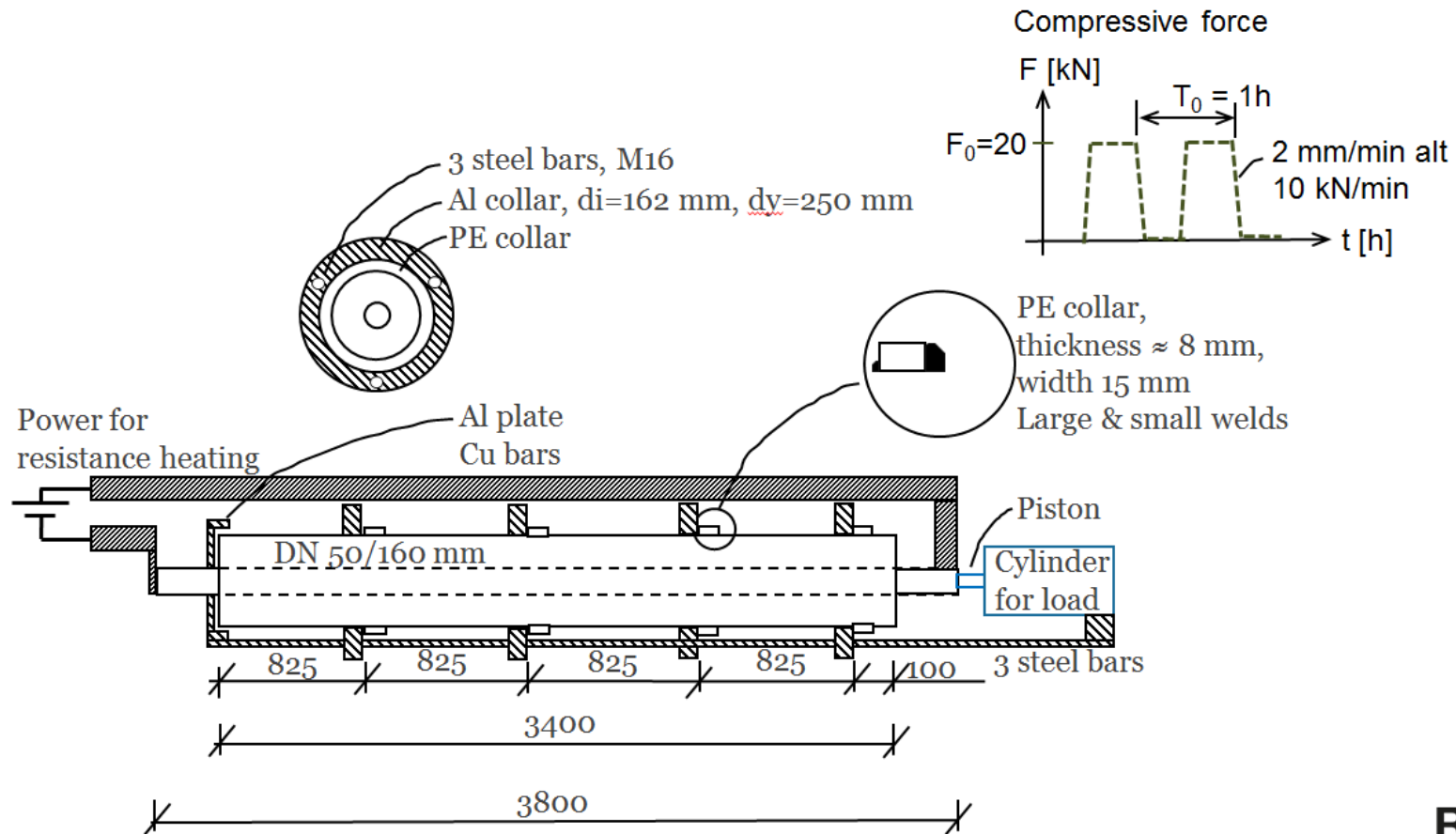
- Cyclic temperature loads.
- Cyclic mechanical loads.



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Test setup



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Test setup

- ✓ Two pipes with rings are;
 - Connected to the heating apparatus and aged at 130 and 140 °C
 - Periodically loaded in axial direction 0-20 KN

- ✓ Two pipes are heated at 130 and 140 °C (without mechanical load)

- ✓ One reference pipe is kept at room temperature for measurements

 -

- ✓ One spare pipe at room temperature.

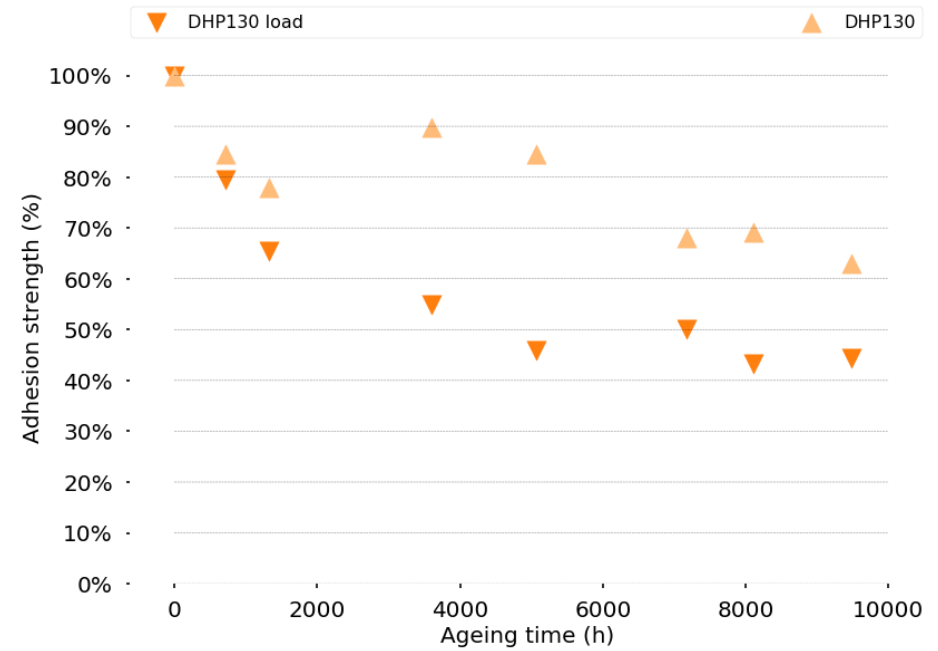
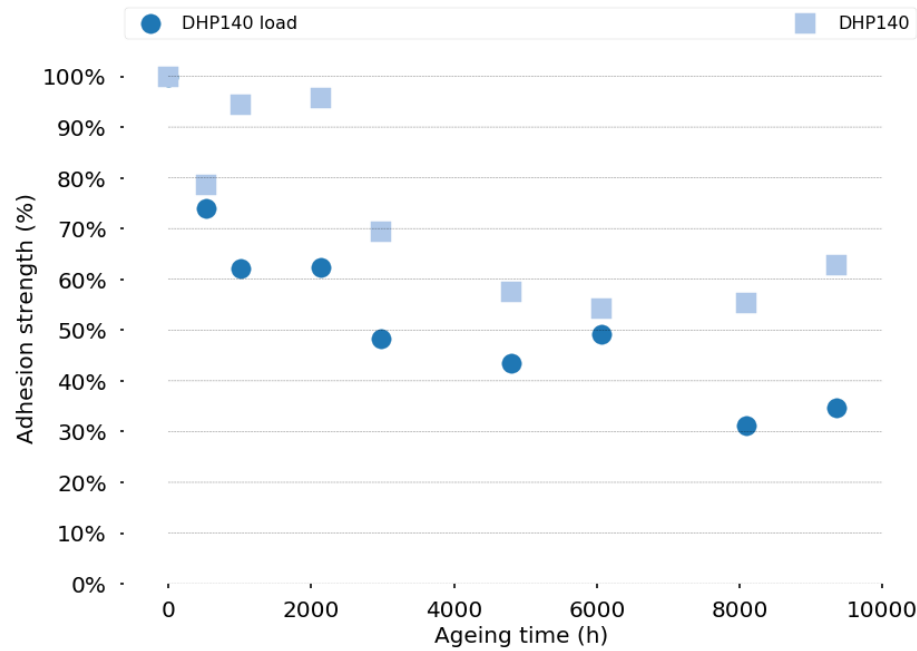


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140 °C

130 °C



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Conclusions

- 4th generation pipelines (solar circuit) are susceptible to greater accumulated damage, requiring proper consideration in the design phase.
- A large measuring time interval in the temperature data may lead to an underestimation of the number of full temperature cycles, and associated fatigue damage, depending on the particular operating conditions of the DH pipes.
- Synergistic effects in degradation of foam in accelerated ageing test due to combined effects of temperature and mechanical loads are evident.

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