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Annex X Final report

Improved maintenance strategies for district heating pipe-lines

Short title: IMPROVED MAINTENANCE OF DH-PIPES

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Executive Summary

There are many district heating networks in Europe that are anticipated to be close to their end of life. In order to estimate their remaining technical life, it is crucial to get sufficient information and facts about all parts of the piping systems in advance. The main objective of this project has been to establish facts and tools, which could help us to obtain and predict present and future technical status of pre-insulated bonded district heating pipes in operation. In order to simulate ageing of polyurethane (PUR) insulation an accelerated thermal ageing method was used. Accelerated ageing was performed by applying three different elevated temperatures to the service pipes. The effect of the diffusion of oxygen through the casing was examined by ageing district heating pipes manufactured by Logstor with two different thicknesses of the casing pipes. For investigating naturally ageing, pipes from networks managed by KDHC in Korea and Statkraft in Norway were used.

The project has provided a framework for forecasting future technical status, maintenance needs and energy losses based on knowledge about present technical status, today's maintenance needs and estimated future operating temperatures. Theoretical calculations and information from Korea and Norway DH-pipe networks were used to demonstrate the model.

The evaluation of the technical status of the pipes after artificial or natural ageing was done by measuring the shear strength between the PUR foam and the steel service pipe (adhesion). The tangential shear strength test method was mainly used to evaluate the status of the pipes. The SP plug test method, which is a cheaper and more practical method in the field, was also used, and the results were compared with those from the tangential shear strength test method.

The shear strength was measured for unaged and artificially aged pipes after 4, 8, 14, 18, 27, 36 and 54 weeks of ageing at 130, 140 and 150 ºC in the service pipes and at an elevated ambient temperature 70 ºC. Our results show that the shear strength deterioration of the pipes follows different slopes. The shear strength decreases rapidly in the beginning (the first 8 weeks), then it obtains a stable level, and finally it slightly increases towards the end of our experimental time. The difference between the results of the shear strength for thin and normal casing is not significant. The results of the measured shear strength of the artificially aged pipes after various ageing times and temperatures indicate a similar tendency of deterioration for both tangential shear strength and SP-plug test methods.

For the artificially aged pipes, neither the raising of the ambient temperature from 10 to 70 °C nor the decreasing of the thickness of the casing from 3 mm to 0.13 mm could demonstrate the thermo-oxidative reaction of PUR by speeding up the diffusion rate of oxygen. Results of the shear strength tests for naturally aged supply pipes that are 1-38 years of age show a slow deterioration rate.

In the framework for improved maintenance strategies, loss of adhesion between polyurethane and the service pipe was considered as the failure mechanism. The deterioration of the adhesion was assumed to be a thermo-oxidative process governed by an Arrhenius relationship. In order to show how the development of faults related to adhesion and costs of heat losses in a district heating distribution network, a simplified model of the network in Goyang in Korea was used.

The model was used to forecast the status of the network in the year 2030. The temperature levels in the flow pipe were assumed to increase by 5 °C. This means that the reaction rate will increase by more than 50%. The year, when end of life is reached, was calculated. The number of faults or maintenance actions related to adhesion in the example treated was estimated to increase by a factor of 3.9. The heat losses were estimated to increase by 15%.

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