

Condition monitoring of uPVC gas pipes

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Introduction

Throughout the Netherlands 22,500 km of unplasticised poly(vinyl chloride) (uPVC) pipes are in use for gas distribution purposes. Physical ageing causes embrittlement of these pipes [1] and can limit their residual lifetime. Replacement is costly, but can only be postponed if the risk on accidents, such as shown in Figure 1, remains very low. The goal of the present study is to investigate whether micro-indentation measurements can be used to measure the condition of uPVC gas pipes.



Fig. 1 Gas explosion in Leiden in 2001.

Micro-indentation

The result of a micro-indentation experiment (see Figure 2) can be used as a measure for the material's resistance against plastic deformation. The calculated development of the plastic zone underneath the tip confirms the non-destructive character of micro-indentation on a macroscopic scale: the measurement leaves a mark of typically 10 μm deep.

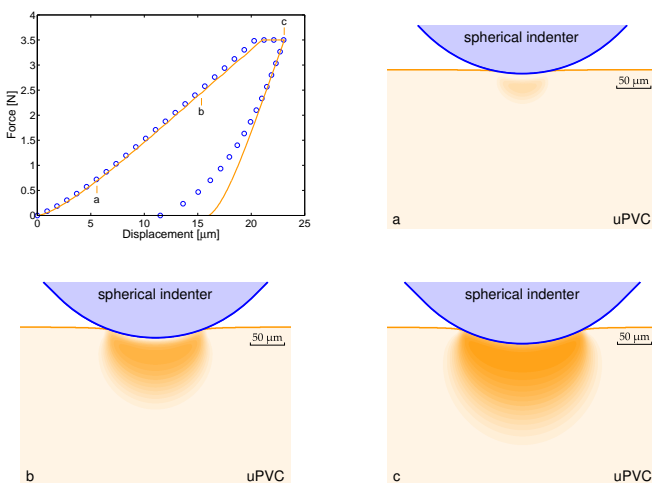


Fig. 2 Micro-indentation curve and development of the plastic deformation zone.

Influence of ageing

Physical ageing causes an increase in the resistance against plastic deformation of uPVC [2]. The hardness that follows from the micro-indentation measurement proves to increase in a similar trend as the yield stress, resulting in a linear relation between the hardness and the yield stress (Figure 3 top left).

Lifetime assessment

The tensile yield stress was found to be a measure for the ductile to brittle transition temperature in a previous study [1]. The residual lifetime can be determined with the following procedure: the yield stress (2) is determined from the measured hardness (1). This yield stress (2) is a measure for the age of the material (3). The residual lifetime follows from assuming a critical transition temperature (4).

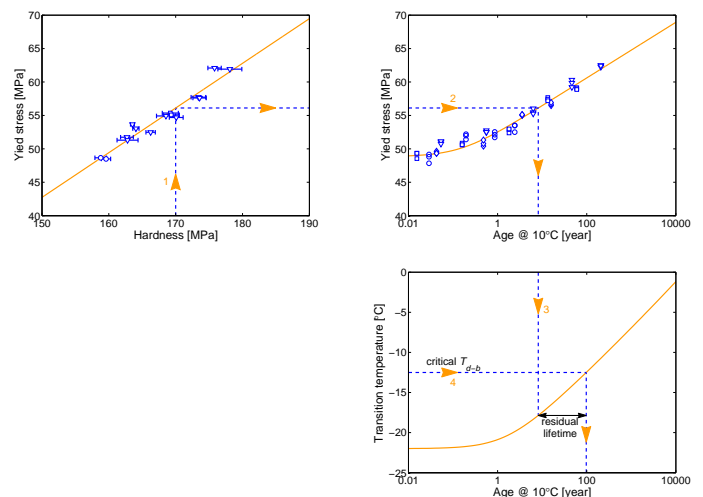


Fig. 3 Procedure to calculate the residual lifetime from a measured hardness.

Conclusion

Micro-indentation is successfully applied as a probe to determine the residual lifetime of uPVC gas pipes. Future work will focus on improvement of the resolution of the procedure.

Acknowledgements

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References:

- [1] R.J.M. HERMKENS ET AL.; *Proceedings of PPXIV* (Hungary, 2008)
- [2] H.A. VISSER ET AL.; *Proceedings of DYFP* (Kerkrade, 2009)