

Introduction

From the the early 60's up to the mid 70's unplasticised poly(vinyl chloride) (uPVC) pipes were installed for gas distribution purposes. Currently, about 22,500 km is still in use, for which the initially estimated service life of 50 years will be reached in the near future. Nevertheless, leak survey data reveals no decrease in the integrity of this part of the distribution network^[1]. Therefore, the question arises if (and how long) the lifetime can be extended without any concessions to safety.

Most leaks occur as a result of excavation activities (third party damage). The lifetime of a uPVC pipe is therefore limited by its impact behaviour: brittle behaviour upon impact will impose a significantly higher risk than ductile behaviour. The impact behaviour is influenced by physical ageing, which occurs during the whole lifetime of a pipe. The **goal of this study** is to determine the influence of physical ageing on the impact behaviour of uPVC pipes.

Impact behaviour

The impact behaviour of uPVC pipe sections is studied using instrumented falling weight tests at a range of temperatures. Three types of failures are observed: ductile (figure 1), semi-ductile (figure 2) and brittle (figure 3) behaviour. With decreasing temperature the behaviour shifts from ductile towards brittle behaviour. This transition is illustrated by plotting the absorbed energy up to the maximum force exerted on a specimen against the temperature of the test (figure 4). The amount of absorbed energy is significantly lower for a brittle fracture than for ductile behaviour.

Influence of ageing

The influence of physical ageing on the fracture behaviour was studied by carrying out impact tests on samples that received different heat treatments. The results for the two most extreme samples are given in figure 4. For the "as received" pipe specimen a transition from ductile into brittle behaviour is observed around -1°C, whereas for "aged" specimen this transition is observed at 1°C. Although the shift might not seem spectacular, it is very relevant in practice as ground works will not be carried out at subzero temperatures. Furthermore, it was observed that the shift seems to take place on a logarithmic time-scale, making changes in the early stages of the lifetime of a pipe most significant.

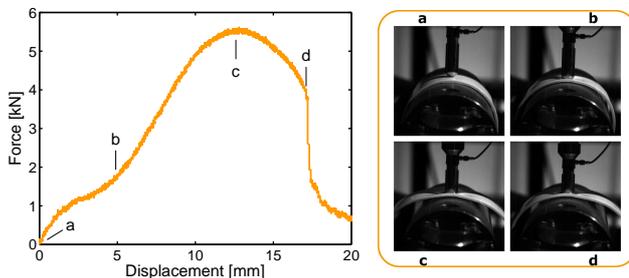


Figure 1 : Ductile fracture behaviour

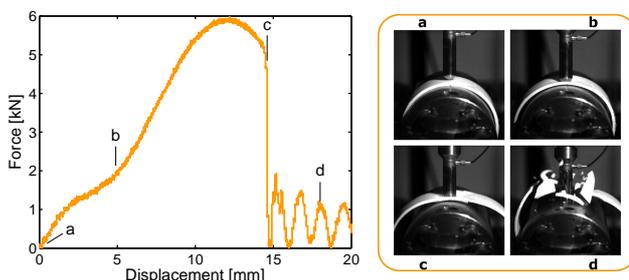


Figure 2 : Semi-ductile fracture behaviour

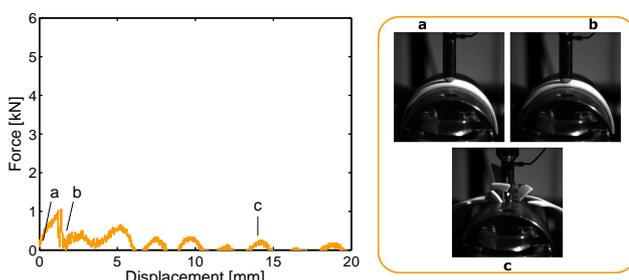
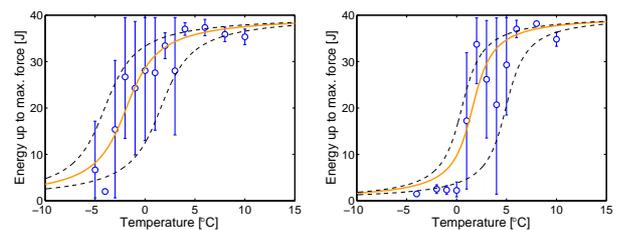


Figure 3 : Brittle fracture behaviour



a) As received specimen b) Aged specimen (~120 years 10⁷ C)
Figure 4 : Ductile-to-brittle transition

Conclusion and future work

Physical ageing can cause the transition from ductile to brittle behaviour to shift towards higher temperatures. Future work will focus on determining the kinetics of this process.

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^[1]H.A. Visser et al.; *Proceedings of IGRC 2008*, Paris, France