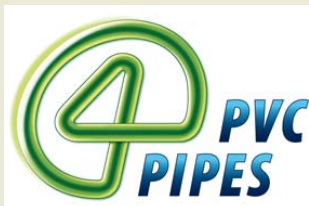


# Performance and Sustainability of PVC-U pipelines

*Henk Meerman*



# Introduction

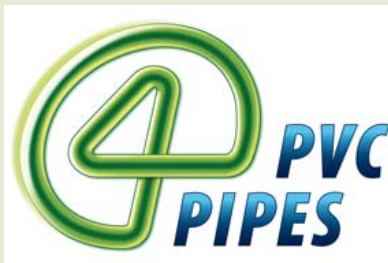
- Performance and Sustainability of PVC-U pipelines
  - ▶ PVC-U pipelines for water supply
  - ▶ PVC-U pipelines for non-pressure applications
- PVC-U pipelines in the Netherlands
  - ▶ In service > 50 years

# Service of pipelines

○ Can this happen with PVC-U pipelines?



Yes!!



11/01/2010

Lifetime expectancy of PVC-U pipelines

# Project set up

## ○ TNO-project

- ▶ Expected lifetime of existing PVC-U water distribution systems:

- Degradation processes;
- Mechanical loadings ;
- Calculation shows a residual lifetime of

» **At least 100 years!!**

# Excavated PVC-U pipes

## ○ Marking

- ▶ Age: 1973, 1975, 1976, 1985, 1986;
- ▶ Various manufacturers;
- ▶ Known and unknown service as a sewage system
- ▶ PVC-compact in diameters 125 – 315 mm stiffness class 41 and 34 resp. SN4 and SN 8;

## ○ Unknown source is the pipe collection system in the Netherlands

# Visual assessment (1)

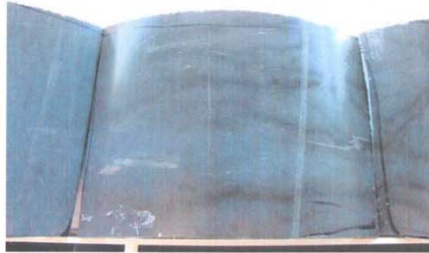


Fig. A.1 Stained pattern on outer pipe wall.

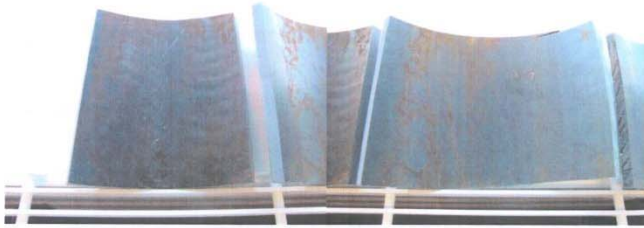


Fig. A.2 Inner surface pipe wall of some parts.



Fig. A.3 Inner wall surface; wear tracks in the length direction of the pipe (shown surface: ca. 10x10 mm).

# Visual assessment (2)

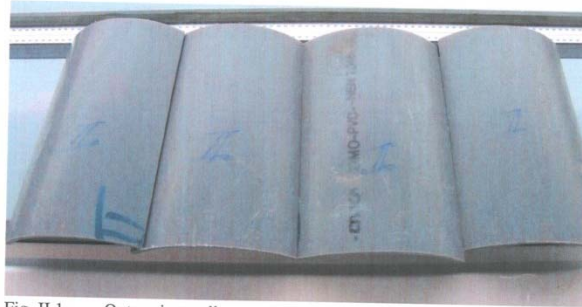


Fig. II.1 Outer pipe wall.



Fig. II.2 Inner pipe wall.

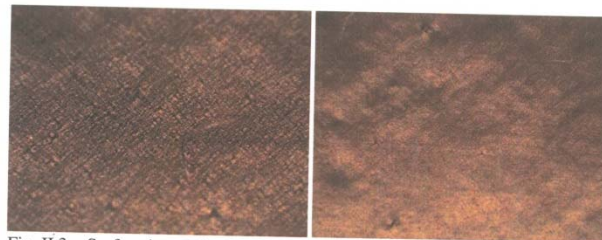


Fig. II.3 Surface inner pipe wall; non-smoothness ascribed to production process (shown surface right: ca. 10x10 mm; left: magnification 6x right photograph).

# Visual assessment (3)



Fig. V.1 Outer pipe wall.



Fig. V.2 Inner pipe wall.

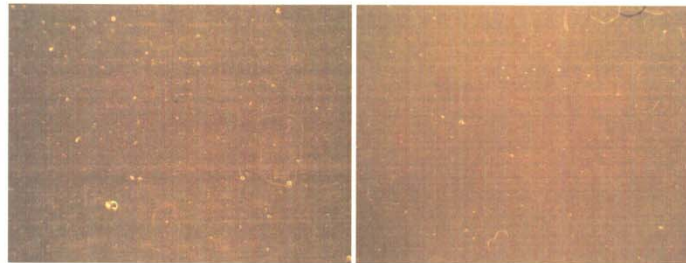


Fig. V.3 Surface inner pipe wall (shown surface right: ca. 10x10 mm; left: magnification 6x right photograph).  
Lifetime expectancy of PVC-U pipelines



# Visual assessment (4)



Fig. V.1 Outer pipe wall.



Fig. V.2 Inner pipe wall.

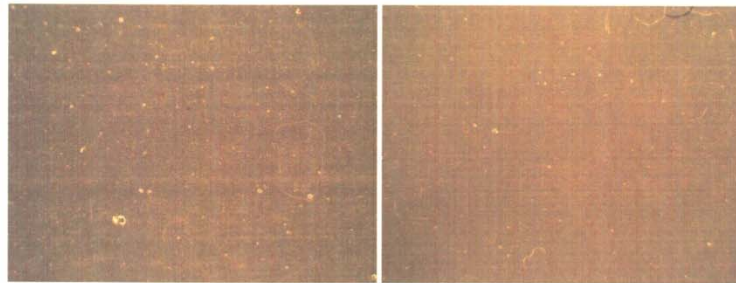


Fig. V.3 Surface inner pipe wall (shown surface right: ca. 10x10 mm; left: magnification 6x right photograph).

# Outer wall surface - summary



## ○ Scratches

- ▶ Probably during excavation
- ▶ Functional properties still intact

## ○ Discolourisation

- ▶ Interaction with ground water
- ▶ Degraded layer  $\leq 10 \mu\text{m}$

# Inner wall surface - summary

## ○ Discolourisation

- ▶ Interaction stabilizer with hydrogen sulphide
- ▶ Degraded layer 10 – 100  $\mu\text{m}$
- ▶ Not harmful for the mechanical integrity

## ○ No polymer degradation

## ○ Functional properties still intact

# Microscopic assessment inner wall surface - summary

## ○ Wear and crazes

- ▶ Thickness reduction of grinding  $\pm 10 \mu\text{m}$
- ▶ Reduction of bending stiffness  $< 1\%$
- ▶ Functional properties still intact

## ○ Mechanical integrity

- ▶ No consequences

# PVC-pipes – General properties

- Out of roundness : ratio maximum and minimum diameter 1.02 – 1.05
  - ▶ Non uniform soil loads
  - ▶ No consequences for hydraulic capacity
- Surface roughness
  - ▶ Scanning over 16 mm ; roughness Ra: 0.3 – 1.0  $\mu\text{m}$
  - ▶ No consequences for hydraulic capacity

# Internal stress in the pipe wall

## ○ Stress gradient expressed as overlap

- ▶ Indication of compressive stress in the outer wall and tensile stress in the inner wall
- ▶ The maximum tensile stress,  $\sigma$ , in the inner surface of this pipe wall is calculated as a function of the overlap
- ▶ A PVC-U pipe 315 mm with an overlap of 25 mm will have an internal stress of 2.6 MPa

# Sustainability PVC-pipelines (1)

- Cradle to grave policy; C2C if recycable
  - ▶ Manufacturing process; extrusion and injection moulding;
  - ▶ Performance in service; installation, service conditions;
  - ▶ End of life treatment; recycling PVC-U; collecting, cleaning, milling,

# Sustainability PVC-pipelines (2)

- Environmental product declaration
  - ▶ Converting process;
  - ▶ Design and Functional Unit;
  - ▶ Life cycle assessment
  - ▶ EPD: comparison for different materials in the same application



# Summary and conclusions (1)



- Combining TNO-reports PVC-U pipelines both for pressure and non-pressure applications
  - ▶ Residual lifetime of PVC-U pressure pipes is not limited by chemical degradation
  - ▶ Influence of physical ageing for well-gelated PVC-pipes is moderate. Resistance for slow crack growth will decrease very slowly in time
  - ▶ Lifetime in service will be  $> 100$  years provided internal and external loads will not exceed in a hoop stress level of  $\geq 12.5$  MPa



# Summary and conclusions (2)

## ○ PVC-sewage pipes

- ▶ Surface discolourisation  $< 10 \mu\text{m}$
- ▶ Moderate surface wear and out of roundness
- ▶ Expected stress levels  $< 6 \text{ MPa}$
- ▶ Internal stress  $< 3 \text{ MPa}$ ;
- ▶ Soil loads  $< 3 \text{ MPa}$  (no point load)
- ▶ Required stress level
- ▶ Craze initiation (aged PVC)  $> 10 \text{ MPa}$
- ▶ Slow crack growth (aged PVC)  $> 12 \text{ MPa}$

Well-installed and no aggressive chemicals



# Summary and conclusions (3)



## ○ Lifetime expectancy PVC-pipelines

- ▶ Integrity of the PVC-pipe is still intact;
- ▶ No chemical degradation was observed;
- ▶ Transport of abrasive particles is limited;

## ○ Confirmation:

- ▶ This investigation confirm the common knowledge lifetime expectancy of PVC-pipe systems will exceed 100 years

End



Thank you for your attention!

Henk Meerman

