Appendix W

Dr. Delvin DeBoer's Presentation on Petroleum Impacts on Plastic Waterlines

Petroleum Impacts on Plastic Waterlines

SD Underground Pipeline Task Force
September 22, 2008
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Literature (Environmental Exposure)

- Journal of Vinyl & Additive Technology
- Journal of Materials Processing Technology
- Materials and Structures
- Journal of Testing and Evaluation
- Proceedings of Symposium on Buried Plastic Pipe Technology

Literature (Hydrocarbon Exposure & Permeation)

- Journal of the American Water Works Association
- American Water Works Association Research Foundation
- Ground Water Monitoring & Remediation
- Water Research
- EPA Office of Research and Development

Water Pipeline Materials

- Pipes
  - Cast/Ductile Iron
  - Plastic
    - Polybutylene
    - Polyethylene (sometimes used for service connections)
    - Polyvinyl chloride (very common)
- Gaskets
  - Styrene butadiene rubber (SBR)
  - nitrile butadiene rubber (NBR, Buna-N)
  - fluoroelastomer rubber (FKM)
  - ethylene propylenediene monomer (EPDM)
  - Neoprene

Impacts on Pipelines

- Permeation impacts
  - Tastes and odors
  - Violate drinking water standard
- Permeation Routes
  - Pipe wall
  - Gaskets
- Strength
  - External pressure (soil structure)
  - Internal pressure (continuous vs. transients)

Permeation Impacts

- Violate Drinking Water Standards
  - Benzene – 0.005 mg/L
  - Toluene – 1 mg/L
  - Ethylbenzene – 0.7 mg/L
  - Xylenes – 10 mg/L
- Tastes and Odors
  - TON for benzene varies from 23 µg/L to 190 µg/L (AwwaRF 2008)
  - Likely smell or taste contamination at concentrations higher than the drinking water standard

Permeation Studies

- Berens (1985). "Prediction of Organic Chemical Permeation through PVC Pipe." Journal of the American Water Works Assoc., 77(11), p. 57.
- Glaza and Park (1992). "Permeation of Organic Contaminants Through Gasketed Pipe Joints." Journal of American Water Works Assoc., 84(7), p. 92.
- Ong, Gaunt, Mao, Cheng, Esteve-Agelet, Hurburgh (2008). Impact of Hydrocarbons on PE/PVC Pipes and Pipe Gaskets, Awwa Research Foundation, Denver, CO. (herinafter called the AwwaRF 2008 Study)

Berens (1985)

- Studied permeation of organics through sheet PVC and absorption of organics using weight gains
- Conclusions
  - Permeation is likely dependent on the concentration of organics
  - PVC pipe may be appreciably permeated in a matter of days or weeks if exposed to nearly pure strong swelling agents or solvents
  - Except in the case of a gross spill, rigid PVC pipe is an effective barrier
- Observations (in the Discussion of the paper)
  - What is a gross spill?
  - PVC may be subject to swelling or bursting because of structural failure under normal water system pressures after only a few months of exposure to a gross spill
  - More work needed
  - Polyethylene pipe failures cited

Glaza and Park (1992) Experiments

- Ductile Iron Pipe segments with SBR and NBR gaskets buried in sand saturated with gasoline and a mix of solvents
  - permeation through gasket into water inside the pipes
- Gaskets directly immersed in gasoline and solvents
  - adsorption through weight gain
  - material strength tests

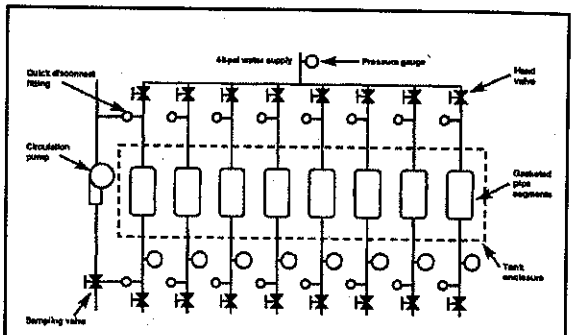
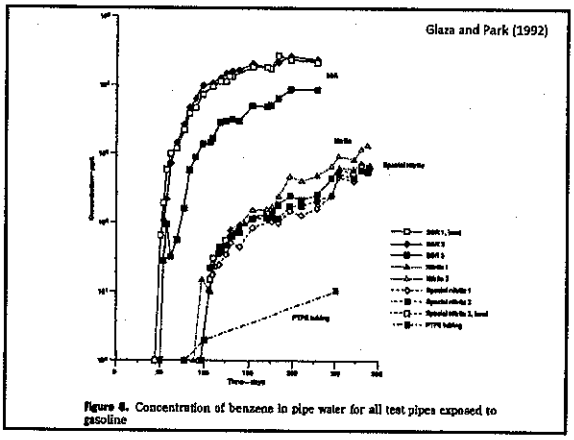


Figure 1. Flow schematic for gasoline exposure tests

Glaza and Park (1992)



Glaza and Park (1992)

Figure 4. Concentration of benzene in pipe water for all test pipes exposed to gasoline

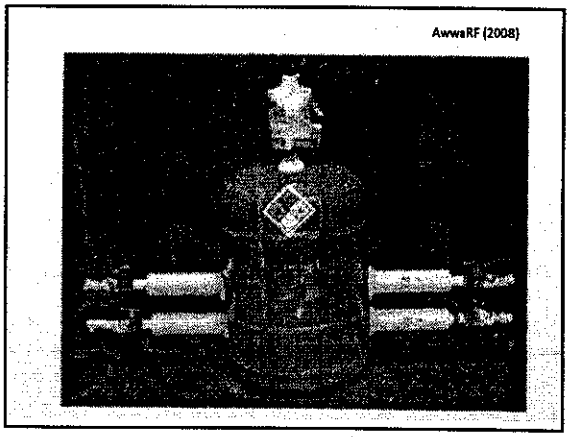
Glaza and Park (1992)

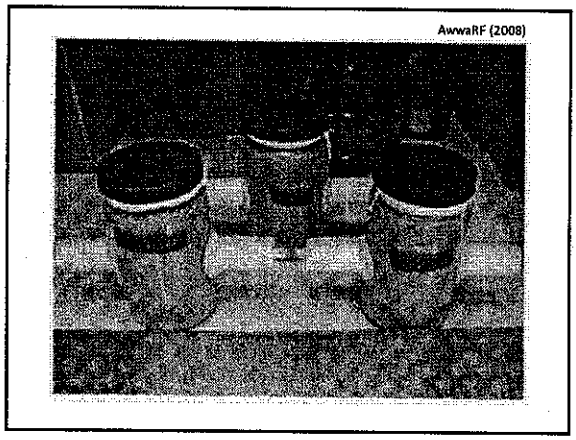
Conclusions (Glaza and Park, 1992)

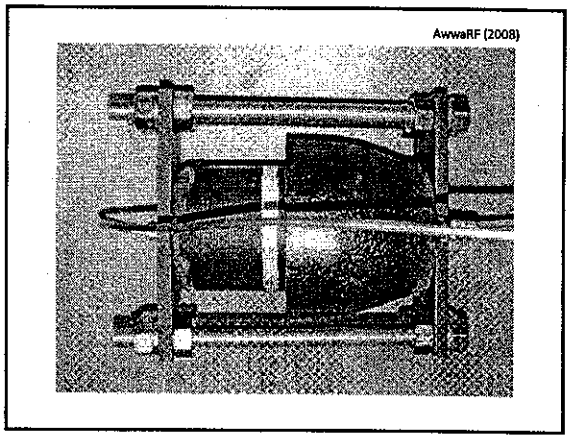
- nitrile butadiene rubber (NBR) more resistant than styrene butadiene rubber (SBR) to permeation by gasoline compounds
- Benzene compounds in pipe water after 8-hour stagnation > 550 µg/L (SBR) and approx. 40 µg/L (NBR)
- Of the gasoline compouneds, benzene permeated the fastest
- Long-term exposure to gasoline caused both gaskets to fail minimum requirements for tensile strength. SBR failed compression and hardness tests.

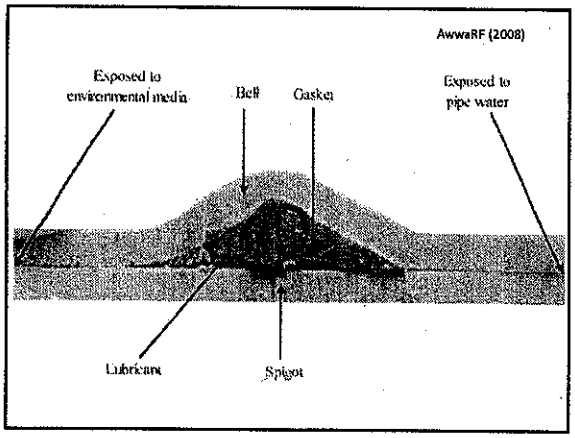
AwwaRF (2008) study

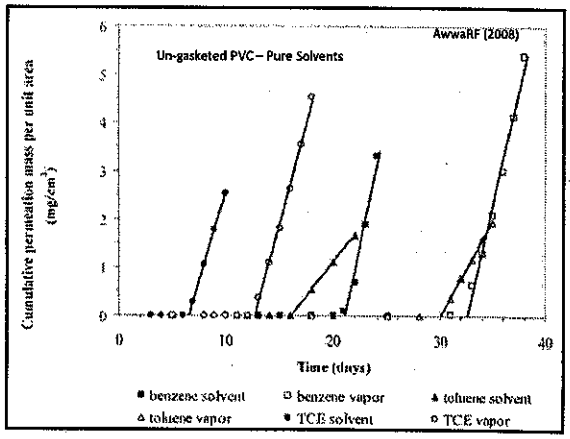
- Focused on polyethylene and PVC pipes
- Exposed to pure gas and BTEX along with water/solvent mixtures
- Studied gasket joints and ungasketed pipe
- Focused on permeation (exceeding drinking water standards) under field conditions (flowing water and stagnant water)

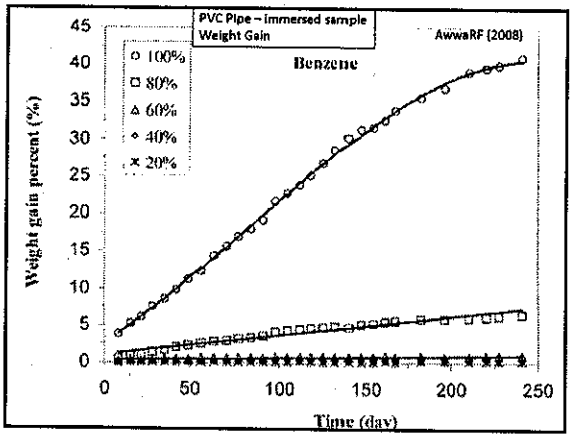


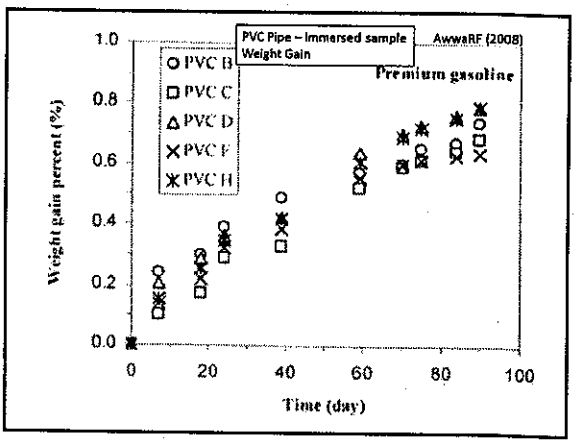


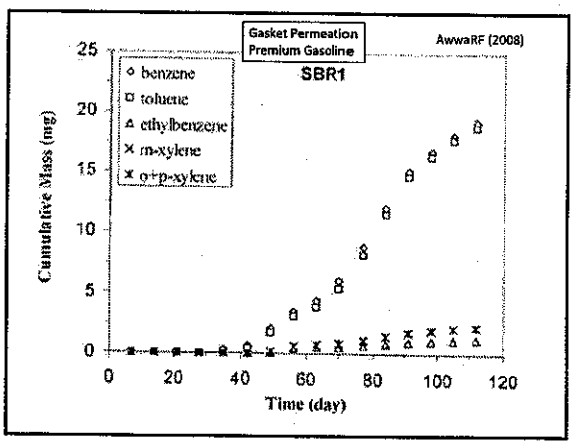


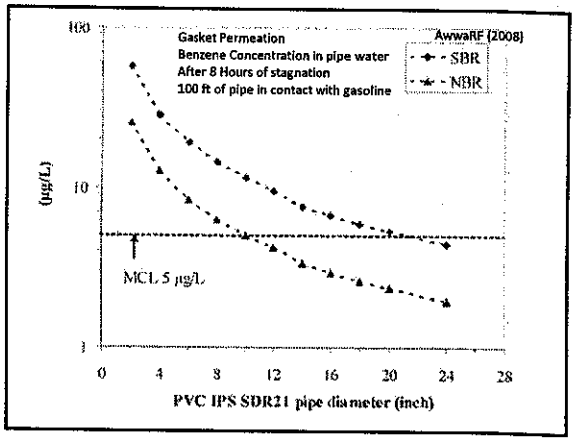


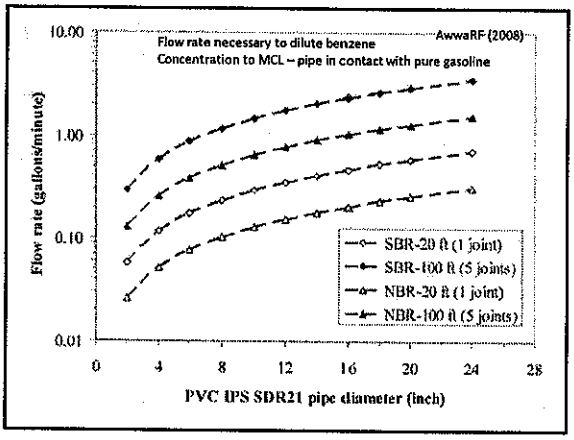












Conclusions - AwwaRF (2008)

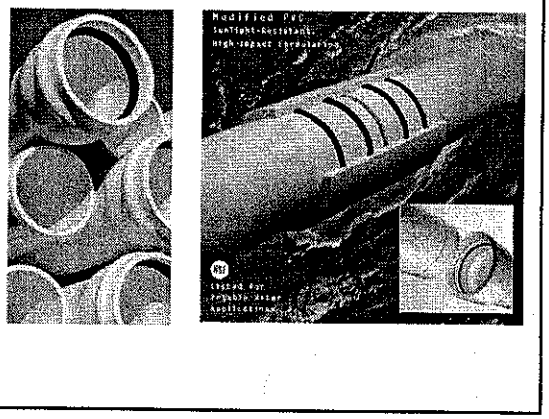
- Permeation through Pipe Wall
  - PE Pipe
    - Rapid permeation (also documented in case studies)
  - PVC pipe
    - Depended on concen tration of BTEX
    - Pur e solvents permeated in a matter of days (toluene 16 days, benzene 20 days) – pipes noticeably swollen
    - Gasoline (BTEX) did not permeate in 2 years (due to lower concentrations of BTEX than in pure solvent)

Conclusions - AwwaRF (2008)

- Hydrocarbon Permeation through gaskets in PVC pipe
  - IS a source of contamination
  - NBR more resistant to permeation than SBR gaskets
  - Under stagnant-flow conditions, can exceed MCL for Benzene when submerged in free product gasoline
  - Water flow through pipe dilutes benzene below MCL (required flow depends on pipe size)
  - Less potential for contamination if ground water dilutes the gasoline

Unknowns

- What is the impact of non-gasoline petroleum products on permeation through PVC pipe and gaskets?
- What are the permeation characteristics of other pipe configurations (joints and fittings)?
- What is the impact of petroleum products on pipe strength characteristics?



RWSRC Project

- Examine impacts of petroleum products on small diameter PVC pipe characteristics
  - Restrained joint systems (permeability of gaskets)
  - Pipe strength?
  - Non-gasoline petroleum products?