ENVIRONMENT EFFECTS ON THE FRACTURE BEHAVIOUR OF POLYMERS AND POLYMER BASED COMPOSITES USED IN PIPING SYSTEMS

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Abstract. Polymer and polymer-based composites are the materials of choice for water transportation, handling and distribution. Polyethylene (PE), High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC) and more recently Chlorinated-PVC (CPVC) pipes are extensively used for water distribution, wastewater, and in limited applications for gas distribution. Higher pressures and harsher environments require the use of reinforcement of polymer matrices mainly with glass fibers, namely Glass Fiber Reinforced Polymers (GFRP). Pipes fabricated from Chlorinated-PVC, HDPE and GFRP are designed to withstand relatively high service pressures and temperatures. However, their utilization in harsh environmental conditions such as those of North Africa and Arabian Peninsula requires a thorough understanding of these special weathering effects on their mechanical behavior.

The present work presents a summary of the results of an extensive experimental program designed to study the effects of harsh natural and accelerated environments on the mechanical behavior of two thermoplastics (CPVC, HDPE) and two thermoset composites used for water applications (GFR-Epoxy, GFR-Vinyl ester).

The results show that while the tensile strength and modulus of elasticity of CPVC were unaffected by harsh environment, the deterioration of the fracture strain and fracture toughness are very noticeable at the beginning of the exposure time. The crack growth resistance of HDPE pipe material was found to decrease with increase in temperature resulting in failure by collapse above 70^{o} C.

Exposure of GFRE and GFRV pipes to outdoor environmental conditions have resulted in post-curing of the pipe resin and consequently in improvement of their strengths. However, exposure to saltwater, UV and high temperature led to a reduction of tensile and stress rupture strengths of GFR-Epoxy pipe specimens. Fractographic analysis of failed specimens showed a combination of mode I and mode II failure characterized by inclined hackles as well as large amount of fiber breakage. High temperature and moisture absorption decreased fiber-matrix interface strength and caused degradation at the fiber level resulting in lower strength and stiffness of the GFRP.