Plastic Failure LABS

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Why Do CPVC and PVC Pipe Occasionally Fail When Used in Hydronic or HVAC Systems?

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Background

CPVC pipes and fittings are designed for use in handling water and aqueous process streams. Although CPVC has high resistance to corrosive chemicals that attack steel piping, CPVC is incompatible with most hydrocarbon chemicals that also contain elements in their molecular structure other than carbon and hydrogen, e.g., oxygen atoms. Therefore the most common root cause of failure of CPVC is contamination of the water with incompatible hydrocarbon chemicals that become absorbed into the pipes and fittings under stress. The absorption of chemicals into stressed pipes and fittings leads to failure due to what is termed environmental stress cracking (ESC).

Exposure to Non-Compatible Chemicals

In a paper titled "Environmental Stress Cracking, 'The Plastic Killer'," 1 Jansen reports that the most common cause of the failure of all plastics is ESC due to exposure of plastic parts to non-compatible chemicals. Jansen explains that ESC failure is characterized by four phenomena:
a. A ductile-to-brittle transition of the material as the non-compatible chemical penetrates into the surface of the plastic.
b. Multiple crack initiation sites forming many tiny cracks that coalesce into a large crack.
c. A smooth morphology of the fracture surface, indicating slow crack growth.
d. Thumbnail-shaped brittle fracture regions in the fracture surface that are often discolored by remnants of the non-compatible chemical agent.

Jansen further explains that the mechanism of ESC failure involves absorption of the chemical into the plastic, resulting in plasticization of the material, which increases polymer chain mobility, allowing the chains to disentangle and lose strength and resulting in localized material embrittlement. The typical localized ductile-to- brittle transition (DBT) of the material caused by penetration of chemicals into CPVC piping is visually displayed in the fracture surface as thumbnail-shaped regions, as shown in *Figure 1.*