Polymer Services Group
Innovation, Application, Evaluation

CPVC Stress Cracking

When is service, a pipe is under stress --- by the stress of applied pressure, and installation stresses, as well as frozen-in processing stresses. These stresses stretch, or strain, the material like a stretched rubber band. In time (usually a very long time) this strain will relax resulting in pulling the material apart causing crazes (porosity) and ultimately developing cracks. This is the normal failure process for polymers like CPVC.

This failure process can be accelerated by increasing the temperature. Higher temperatures help the polymer molecules move more easily thus the relaxation proceeds at a faster rate and failure will occur sooner. Solvents, analogous to heat, do the same thing.

Environmental Stress Cracking (ESC) requires strain in the material. The ESC agent can be a good solvent, a poor solvent (plasticizer), or a surfactant (a material which affects the surface tension of a liquid). In each case, the ESC agent is capable of relaxing the localized strain leading to porosity (crazing) and ultimately cracking. Temperature should also be considered as an accelerating factor.

ESC is strain-sensitive. Like a rubber band, the more it's stretched the more likely it is to fail. For each material-ESC agent combination there is a particular minimum strain threshold necessary before ESC can occur. Also, straining beyond the material's proportional limit (yield) will generally interfere with the onset of ESC. Shear yielding interrupts the length to which a craze can grow, thus inhibiting crack formation.

Differences in processing can result in a significant increase in residual, frozen-in axial and/or circumferential strain in the pipe. The additional strain in the pipe may not cause it to be defective under normal conditions, but may cause it to be more susceptible to ESC, particularly under elevated temperature conditions. Consider setting a maximum allowable strain by measuring circumferential and axial shrinkage after heat reversion.

ESC can be concentration sensitive. High concentration is not always the worst condition. Particularly with water-soluble ESC agents, low concentrations can produce more severe ESC conditions. When determining compatibility with CPVC, test the material at full concentration as well anticipated diluted concentration. Also consider using temperature as an accelerating factor -- maybe 60°or 80°C.

"Stray" organics appear to have been a problem in many installations. These materials may come from oil on the surfaces of pumps or pipe threads, organics leached from

gaskets, seals, caulks, and thread sealants used in the installation, cleaning solutions, as well as coatings applied to steel piping in the system. The ESC agent could even be a voluntary or involuntary additive from water treatment or transmission (infiltration from the soil). Consider recommending the installation of an activated carbon filter at the beginning of the CPVC fire-sprinkler system to filter organics from the system fluid.

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