

The effect of sunlight on the physical properties of PVC-U pipes

Buried pipes are protected from sunlight during their service life, but in the period prior to installation, at the manufacturer's storage facility, the merchant's yard, or on the intended site, any pipes and fittings left exposed are subject to weathering. The impact that this has will depend on the material. This note provides information on PVC-U pipes and fittings.

Background

Unplasticised poly(vinylchloride), PVC-U, is affected when exposed to high-energy UV radiation from sunlight. PVC-U pipes undergo a series of complex reactions within a limited surface region of the exposed face. This can be broadly broken down into two classifications, pigment photodegradation and dehydrochlorination.

Photodegradation of the pigmentation system: PVC-U underground drainage and sewerage pipes and fittings are not intended to be installed above ground, subjected to prolonged exposure. The pigmentation systems used to provide the colour are not required to be colourfast. Pipes and fittings will experience some fading when exposed to normal sunlight. The high-energy ultraviolet (UV) radiation in sunlight affects the chemical bonds in the pigment resulting in a bleaching or fading of the colour. This is exhibited as a lightening of the exposed surface and occurs over a relatively short period.

Polyene formation due to dehydrochlorination: sunlight acting on the surface of a PVC-U pipe can be absorbed by certain chemical groupings within the material. This provides a site for degradation initiation eventually producing polyenes within the surface layer. This process can result in a chain reaction, with the freed chemical groups as a result of polyene formation providing a new catalyst for further dehydrochlorination. PVC-U pipe formulations incorporate stabiliser elements that act to combat this degradation during both the production process and the service life of the product. In PVC-U pipe, this degradation is typically limited to a depth of 0.05 mm (50 µm) and is evident as a light yellowing of the PVC. This occurs over a much longer period than photodegradation of the pigmentation system.

Whilst the bleaching of the exposed surface is aesthetically undesirable, it does not overtly affect the physical performance of the pipe and any further photodegradation of the pipe will be halted once installed underground.

The facts

Several studies have been carried out to assess the effect of sunlight on the physical properties of PVC-U pipes, most notably that by CSIRO in Australia¹. This study involved the exposure of PVC-U pipe samples with varying additions of TiO₂ to extreme weather conditions for a period of 2 years. These exposure conditions far exceed those which would be experienced in the UK environment. Throughout the study, samples were periodically taken and tested to metrics which represent their installation and in-service performance, such as yield strength, ultimate tensile strength (UTS) and impact strength:

- Yield strength along with the pipe diameter and pipe wall provides an indication of the stiffness of the pipe and resistance to external loads.
- Ultimate tensile strength demonstrates the ability of a pipe to withstand internal pressures.
- Impact strength is a measure of the ability of a pipe to survive an impact or sudden blow.

In the CSIRO study, no significant change in yield strength was exhibited after the two years exposure. Indeed, even a completely unpigmented PVC-U formulation was not compromised by two years exposure.

Ultimate tensile strength of samples was observed to be largely unaffected by exposure; a sample with no formulation protection from UV having a performance level of 90% of the original sample after 3 months exposure and retaining 80% of the original strength after 2 years.

Impact strength was observed to decrease over a period of three months before stabilising and samples which had been exposed for two years exhibited similar impact resistance to the as made samples. Short term exposure of some pipe samples actually resulted in increased resistance to impact.

References

1. L.S. Martin, K.G. Martin and S.D. Terrill. Effects of titanium dioxide on the weathering performance of UPVC pipe, CSIRO Division of Building Research.