WHITE PAPER

WHITE COATED POLYETHYLENE PIPES FOR EXPOSED ABOVE GROUND APPLICATIONS

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May 2022

Learn how a white coating can protect HDPE pipes in exposed above ground applications

There are numerous applications that require above ground pipelines for the conveyance of fluids under pressure, many of which operate in particularly hot climatic conditions. The mining industry has widely adopted PE100 pipe installed above ground to carry slurries, dewater open-cut mines, or to move water around the site. The above ground distribution of water is also important in the farming and agricultural sectors. Suitably rated PE100 pipe containing carbon black offers long-term resistance to solar UV making it a popular system for above ground use over its intended design service life. A white coating on PE100 pipes significantly reduces the absorption of ultra-violet (UV) radiation compared to black pipes. The white coating greatly lowers the surface temperature of the pipe and its contents and limits excessive thermal expansion and contraction of the pipe system due to environment temperature variations. The properties of white High Density Polyethylene (HDPE) compounds suitable for long term performance under UV exposure are outlined in this paper.

POLYETHYLENE PE100 IS A DURABLE AND TOUGH PIPE MATERIAL—THAT IS WHY IT IS SPECIFIED FOR SOME OF THE MOST DIFFICULT INSTALLATION CONDITIONS SUCH AS EARTHQUAKE PRONE AREAS, SLIP AREAS, COAL SEAM GAS INSTALLATIONS, SUB-MARINE INSTALLATIONS AND UNDER RIVER CROSSINGS. FOR ABOVE GROUND APPLICATIONS IN HOT CLIMATES WHERE GREATER UV RESISTANCE IS NEEDED, WHITE COATED PE100 PIPE CAN BE SPECIFIED IN LINE WITH INDUSTRY STANDARDS.

PE100 is not affected by environmental factors such as moisture, soil resistivity, pH, dissolved oxygen and microbial activity that can cause the corrosion of metal pipes. It is also resistant to an extensive range of chemicals. PE100 has well understood and predictable performance characteristics at elevated temperatures and in dynamic load conditions. PE100 pipelines can be installed using a fully welded joint system, enabling installation in long continuous lengths employing either trenchless, open trench or above ground techniques. Fully welded joints also allow for installation with no need for anchor blocks. These features, combined with a long service life, make PE100 the material of choice across many utility, mining, industrial, gas and agricultural applications, not just in Australia but worldwide. PE100 is fast becoming the material of choice for the conveyance of fluids under pressure.

This white paper focuses on the properties of HDPE compounds needed for PE100 pipe that is installed above ground and exposed to ultra-violet (UV) solar radiation and elevated temperatures for extended periods.

THE NEED FOR PE100 PIPELINES WITH HIGH LEVELS OF UV-RESISTANCE

In Australia, black PE100 compounds and black PE100 pipes must conform to the requirements specified in AS/NZS 4131 and AS/NZS 4130 standards, respectively (1, 2). Pipes made from standard compliant PE100 compounds provide good resistance to UV-induced degradation and associated loss of strength. The resistance of PE100 to sunlight is due to the incorporation of carbon black in its structure. To ensure adequate protection of the pipe against UV solar radiation, product standard AS/NZS 4131 outlines the specifications for carbon black particle size and required content of carbon black in the PE100 compound (1).

Research and experience suggest that black standards compliant PE100 pipe can provide a service life of 50 years in applications where pipe is installed above ground and exposed to solar UV radiation during continuous outdoor service (3). However, if black pipe is exposed to very high ambient temperatures over prolonged periods, the PE100 will soften, causing it to lose some of its strength.

THERMAL EFFECTS OF SOLAR RADIATION ON BLACK PE100 PIPES

The black-color of pressure pipe contributes to it absorbing heat when operating above ground and exposed to UV solar radiation. The temperature of pipe installed above the ground was recorded over 24 hours, as shown in Figure 1. The results show that the outside pipe wall reached ~70°C when the ambient temperature approached 40°C (4).

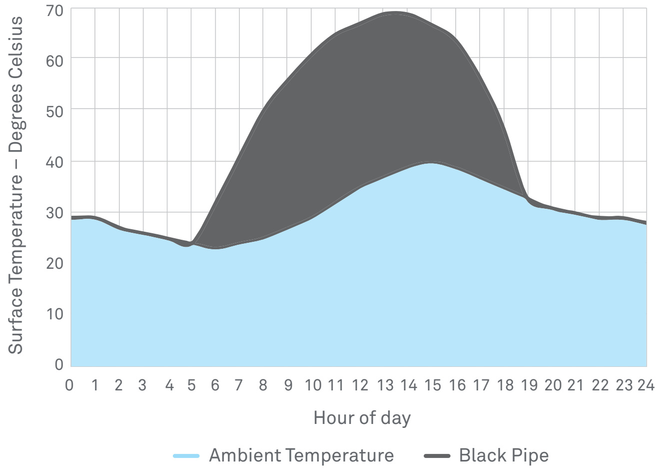

Figure 1. Typical thermal effects of solar radiation on black pipe over 24 hours

If black PE100 pipe is expected to operate at higher than the standard design temperature of 20°C, it is common practice to apply a derating Design Factor during the design stage to account for the effect of temperature. Thicker walled pipe would be needed to compensate for any loss of strength of PE100 associated with increasing temperature.

Temperature changes in the outside environment throughout the day and night also affect the expansion and contraction and consequently the length of the PE100 pipeline. The changes have important implications for the structural integrity and operational safety of the pipeline, including the structural integrity of joints. If significant differences in temperature are expected to occur in service, any changes in pipeline length due to temperature need to be considered during the design stage.

IMPROVED PIPE PERFORMANCE USING WHITE PE100 COMPOUNDS

The application of a highly reflective white layer on the external diameter of black pipe significantly reduces the absorption of solar radiation, ensuring that the pipe remains cooler than uncoated pipe when exposed to sunlight. A comparison of coated and uncoated pipes with different wall thicknesses showed solar reflectance to be ~58% for the white coated pipe and ~4% for the common black pipe (Table 1). The solar reflectance results were independent of the pipe wall thickness, indicating that Radiation Absorptance for common black pipe is ~96% and ~42% for white coated pipe (5).

> TEST RESULTS SHOWED SOLAR REFLECTANCE TO BE ~58% FOR THE WHITE COATED PIPE COMPARED TO JUST ~4% FOR BLACK PIPE.

Table 1. Solar radiation reflectance, transmittance and absorptance values for PE pipe

Pipe Type	Solar Reflectance (%)[1]	Transmittance (%)[1]	Radiation Absorptance (%)[1]
Black PE pipe	3.8	0	96.2
Co-extruded white coated PE pipe	58.2	0	41.2

[1] The uncertainty in each value of solar reflectance, transmittance and absorption is estimated to be ±0.5%.

The reduced solar radiation absorption of white coated pipe accounts for the substantial reduction in pipe surface temperature compared to regular black pipe under the same service conditions in above ground applications. Using a white coating to minimise the temperature of the pipe reduces the need for temperature derating and reduces thermal expansion and contraction. Reducing the need for temperature derating offers material and cost savings due to reduced wall thickness requirements. However, as the environmental conditions of each operating site depends on its location, specific design data is required for any given project. Installers or specifiers of white coated PE100 pipes should seek the advice of the manufacturer to determine the likely temperature reduction for any specific project.

In the following example, the ambient temperature and surface temperature of white coated pipe and common black pipe both installed above the ground were recorded over a 24-hour period. The data in Figure 2 shows that the outside pipe wall temperature of the white coated pipe was significantly lower than the common black pipe (4).

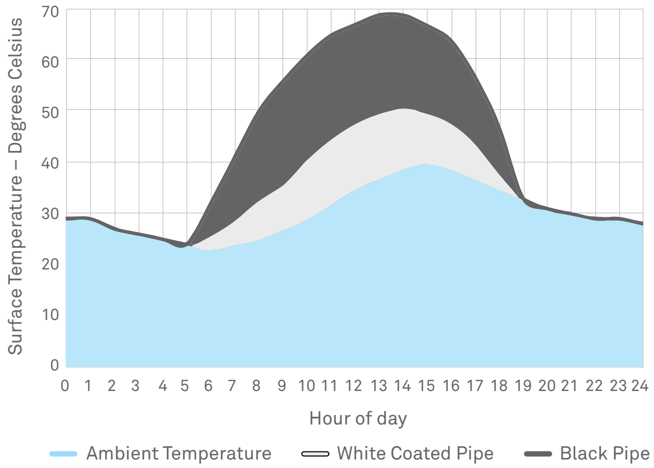

Figure 2. Typical thermal effects of solar radiation on white coated pipe and black pipe over 24 hours

MATERIAL REQUIREMENTS FOR WHITE HDPE COMPOUND FOR PE100 PIPE

Coated and striped PE100 pipe that is used for below ground applications must comply with the requirements of AS/NZS 4130 (2). The Plastics Industry Pipe Association of Australia (PIPA) has identified additional requirements for white HDPE compounds that are intended for surface applications (6). The requirements that are shown in Table 2 are for white jacket materials designed for long term exposure to sunlight for periods exceeding 15 years.

Table 2. Material requirements for white PE jacket compounds suitable for long term UV exposure

Attribute	Requirement
Base Resin	Base resin used to produce compound conforming to AS/NZS 4131
Melt Flow Rate	←30% shift from parent material
Thermal Stability	→40 min. @ 200°C
Dispersion	Not worse than Micrograph B Av. max. ← 60μm (Grade 3)
Weathering Resistance	Minimum 0.3% HALS (Hindered Amine Light Stabilisers) and a minimum of 3% TiO_2
Colour	White

FURTHER CONSIDERATIONS FOR THE QUALITY OF WHITE JACKET PE100 COMPOUNDS

In addition to the requirements outlined in Table 2, it is important to consider other design factors when extruding an integrated pipe comprising of a white outer pipe coat and the black inner pipe.

- Scratches to the integrated pipe system during installation or from rock impingement in service create spots where cracks can initiate and propagate through the pipe wall via the slow crack growth mechanism. PE100 high stress crack resistant (HSCR) resins should be considered, as they are designed to prevent premature brittle failures of pipe in the field where stress concentrators may be present
- The white coating should have the same performance characteristics as the inner pipe, including enhanced resistance to slow crack growth. As the inner pipe is made using a fully standard compliant PE100 HSCR pipe compound, the same polymer base can also be used to make the white compound.

HOW THE RESIN MANUFACTURER CAN HELP

Qenos manufactures a range of PE100 polyethylene grade resins for use in pressure pipes, including Alkadyne HCR193WTE – a white pigmented, UV stabilised high density polyethylene compound with high stress crack resistance (HSCR) properties. HCR193WTE is suitable for use as a striping or jacketing compound for PE100 HSCR pressure pipes. It offers the outstanding toughness expected of PE100 HSCR compounds and has excellent resistance to the effects of UV light exposure during prolonged pipe storage.

Qenos has invested in a large pipe pressure testing facility where pipe is extruded for testing, and then subjected to high pressures and heat for up to three years, providing confidence in the long term performance of its pipe resins under realistic operating conditions.

REFERENCES

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