

Carbon Black Masterbatches for Irrigation Pipes

An important application area for carbon black masterbatches is irrigation pipes. By using a carbon black masterbatch, the pipes achieve all of the key technical characteristics demanded by this highly technical application as explained in the following article.

Drip irrigation is used as a means of meeting crop demands giving increased yields and quality whilst efficiently managing water usage. It is of particular importance where water is scarce or expensive as it allows precise water application, minimal evaporation and reduced or eliminated run-off. Drip irrigation also ensures that conditions are less favourable for the onset of diseases due to the reduction in water contact with crop leaves, stems and fruit.

Irrigation tubing and pipes usually have a relatively small diameter (16-25mm) and low wall thickness (100-1250 μ m) so that they are flexible and coilable allowing the pipe to be re-rolled for storage and subsequent reinstallation.

An irrigation system can be installed above or below ground. Under normal operating conditions, the internal water pressure is between 0.5-4bars, depending on wall thickness. The drippers release water at a predetermined and maintained rate whilst the turbulent water flow of the drippers gives a self-cleaning effect with high resistance to clogging.

Fig. 1: Drip Irrigation System

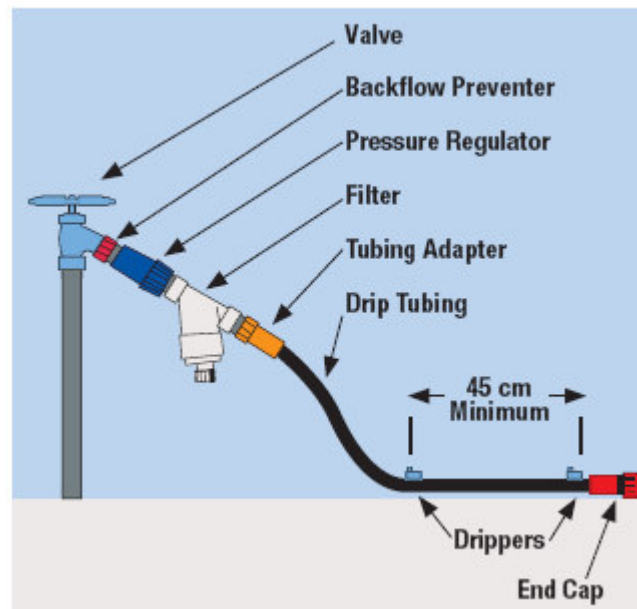


Figure 1 illustrates a very simple drip irrigation system.

Drip irrigation pipes are produced by extruding flexible pipe into which drippers are inserted at specific intervals. Holes are drilled in the pipe at each dripper position. The extruder is normally positioned at right angles to the line of the pipe and feeds a crosshead die. The dripper insertion unit is in line with the direction of extrusion and inserts drippers into the diehead. Line speed is sufficient to prevent the drippers from melting at the insertion point. Thicker, pressurised pipes, known as laterals, supply water from the mains or other source to sprinklers or emitters. Laterals are more rigid and need to be thicker in order to withstand the higher pressures. They are normally fixed and remain in position for many years. Their weathering requirement is therefore higher than that of drip irrigation tubing and they are subject to regulation in most countries.

The key performance requirements of irrigation pipes can be summarised as follows:

- weathering resistance according to the recommended lifetime
- thermal resistance
- smooth surface finish
- excellent mechanical properties

Cabot has a well established range of black masterbatches which have been specially designed to provide the technical performance demanded by the irrigation pipe manufacturer. This has been achieved by careful selection of appropriate carbon blacks, additive packages and carrier systems together with use of state-of-the-art mixing technology.

Cabot’s masterbatches will meet the requirements of different types of irrigation pipes. They have excellent dispersion and surface smoothness characteristics and will meet the necessary weathering, thermal resistance and mechanical properties demanded of them.

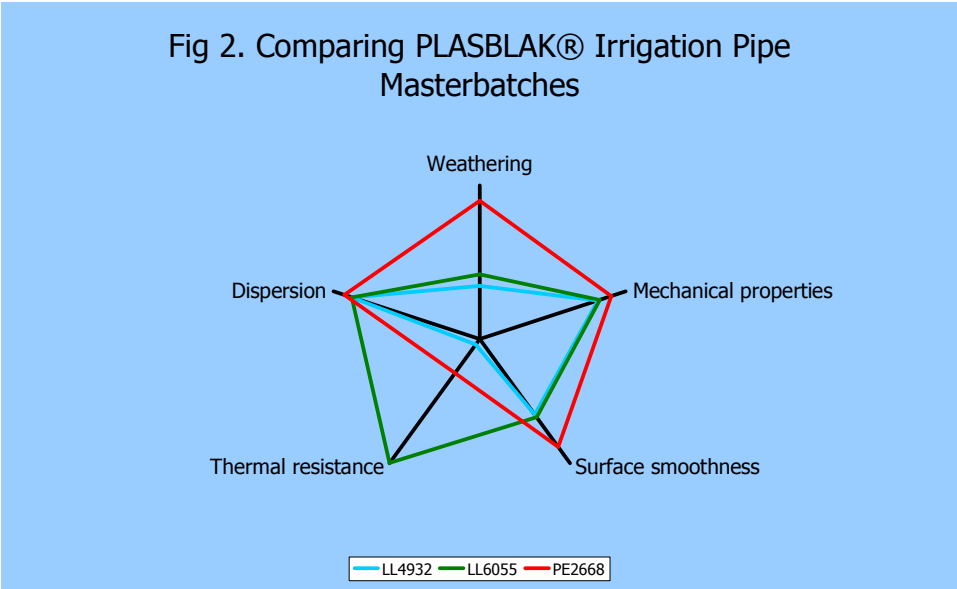


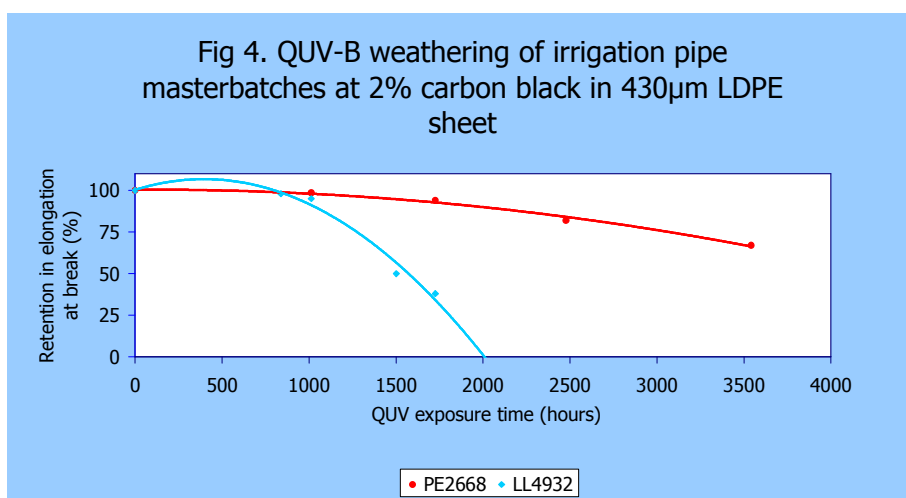
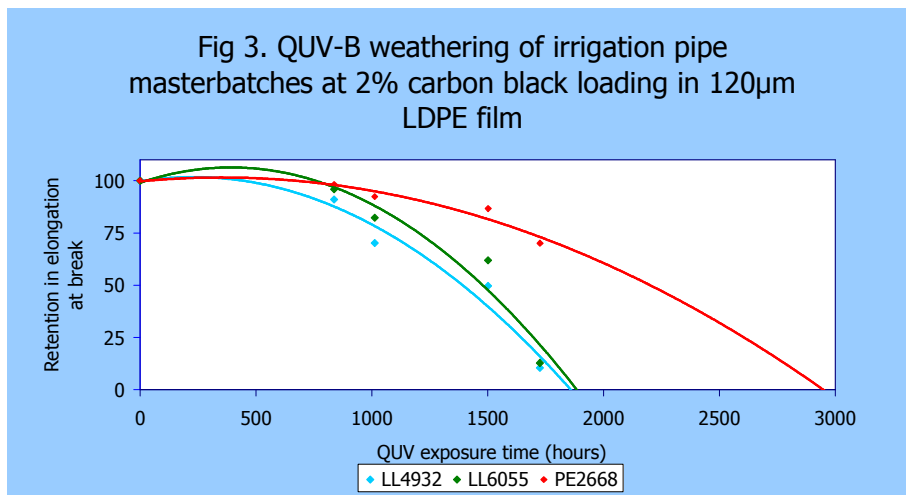
Figure 2 compares the performance of Cabot’s irrigation pipe masterbatches. Performance improves from chart centre.

Weathering

The weathering performance of irrigation pipes is very important and must match their service life. Some of the current standards suggest that this is achieved by the incorporation of 2-2.5% carbon black, usually of particle size 25nm or lower. These criteria are met by PLASBLAK® PE2668. Where the carbon black particle size is not specified, LL4932 or LL6055 can be suitable grades.

Figures 3 and 4 compare the weathering performance of Cabot's recommended black masterbatches for irrigation pipes. Figure 3 compares the 3 grades at 120µm whilst Figure 4 compares the higher performing PLASBLAK® PE2668 at 430µm with PLASBLAK® LL4932 at 650µm. This clearly demonstrates the superior performance obtained by using a small particle size carbon black as in PE2668.

Nevertheless, the standard carbon black masterbatches, LL4932 and LL6055, are suitable for the thinner drip irrigation tubing as this has less rigorous weathering requirements than the thicker pipes or laterals.



Dispersion

Microscopic dispersion of carbon black in irrigation pipes is very important as the presence of undispersed carbon black agglomerates in the pipe wall can lead to premature failure of the pipe. The microscopic dispersion is usually assessed by a so-called “press-out” method involving the examination of thin hot-pressed compound samples under an optical microscope using transmitted light.

The comparative performance of each of Cabot’s irrigation pipe masterbatches is shown in the following table:

Cabot masterbatch diluted in LDPE melt 0.3 at 2.5% carbon black using a single screw extruder	Microscopic dispersion rating according to Afnor NFT51-142 or ISO 11420
LL4932	2.7
LL6055	2.6
PE2668	2.2

Surface Smoothness

The surface smoothness of the inner and outer walls of the pipe is important both for aesthetics and for fluid flow properties. This can be impacted by the carbon black dispersion quality, the carrier resin and, most importantly, the type and level of process aid in the masterbatch.

The process aids use in pipe applications are normally fluoroelastomers. A fluoroelastomer will preferentially adhere to the metal of the pipe extruder thus coating the barrel, screw and die. The polymer melt will therefore have less drag at the metal surfaces and the flow will be more even. This eliminates problems such as “sharkskin”. It also reduces power consumption and melt temperature, helps to increase output and, most importantly, improves gloss of the pipes.

Thermal Resistance

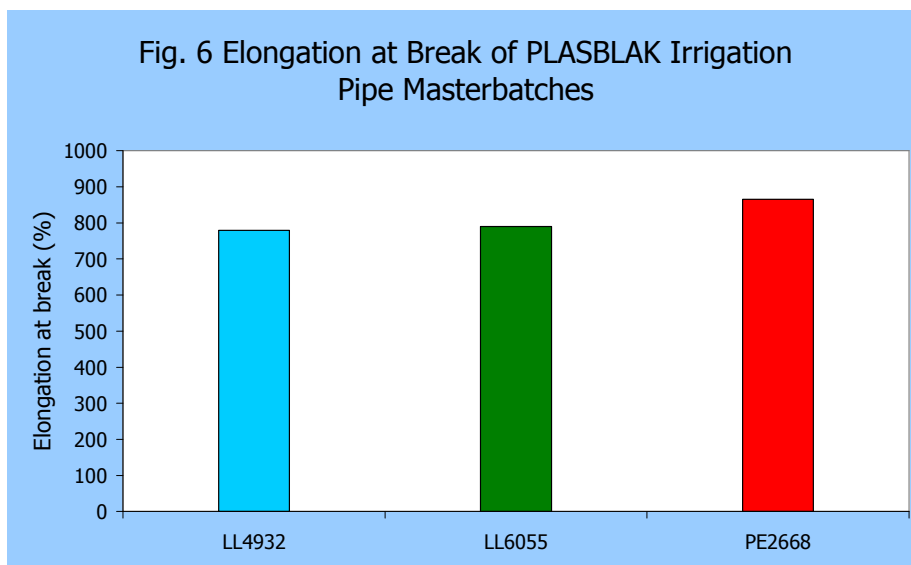
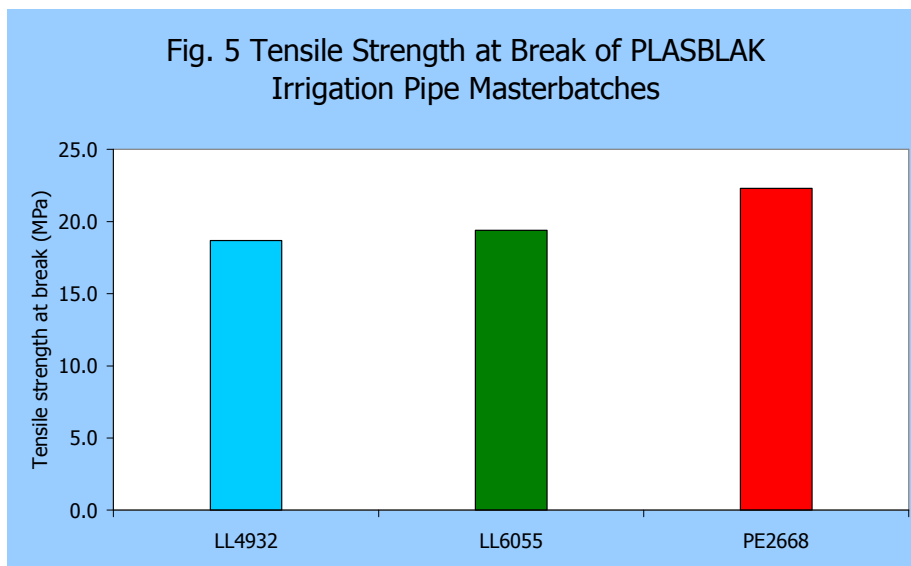
Oxidation induction time (OIT) is a good indication of thermal stability, the higher the value, the better the stability. Tests were carried out on LDPE samples containing each masterbatch added to give 2% carbon black. Measurements were made at 170°C and the results are given in the table below compared to natural LDPE resin, which received the same thermal history:

Formulation	Measured OIT (in mins)
Natural LDPE resin	12.1
4% LL4932 in LDPE resin	18.3
4% LL6055 in LDPE resin	> 360
5% PE2668 in LDPE resin	109.8

LL6055 is particularly suited to use in conjunction with recycled resin.

Mechanical Properties

It is important for the carbon black used in irrigation pipes to be well dispersed, not only to give maximum UV protection but so as not to be detrimental to the mechanical performance of the pipes. Tensile strength and elongation at break measurements have been made on 120 μm film samples produced using the irrigation pipe masterbatches diluted in LDPE to give 2% carbon black. Results are shown in Figures 5 and 6.



In conclusion, it can be seen that the choice of carbon black masterbatch is critical in this demanding application to ensure that the pipes have the required thermal and weathering resistance, smoothness and mechanical properties. The masterbatch should also be chosen to ensure that the pipes comply with International Standards.