MASTERBATCHES

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Masterbatch Selection Guide for Irrigation Pipes

Introduction

This “Masterbatch Selection Guide for Irrigation Pipes” provides detailed information about Cabot’s range of black masterbatches specifically designed for use in irrigation pipes.

Performance information on each masterbatch is given relative to important application parameters such as weathering resistance, processability and mechanical properties.

Information is provided on end-user requirements, industry test standards and other matters relevant to the production of irrigation pipes.

The types of irrigation pipes covered by this brochure are:

- Drip irrigation tubing
- Drip irrigation pipe
- Laterals

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Definitions

Drip irrigation: the application of water through emitters as drops or small streams to or below the soil surface via relatively narrow tubing or pipe.

	Tubing	Pipe
wall thickness	100 –500 µm	450 –1250 µm
diameter	15-25 mm	15-25 mm
pressure	low	depends on pipe thickness

Laterals: water delivery pipeline (850 – 3000 µm) that supplies irrigation water from the main line to sprinklers or emitters.

Drip Irrigation

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

Drip irrigation can improve the efficiency of adding agricultural chemicals such as fertilisers. It reduces losses and allows better timing of their application to meet the crops' needs.

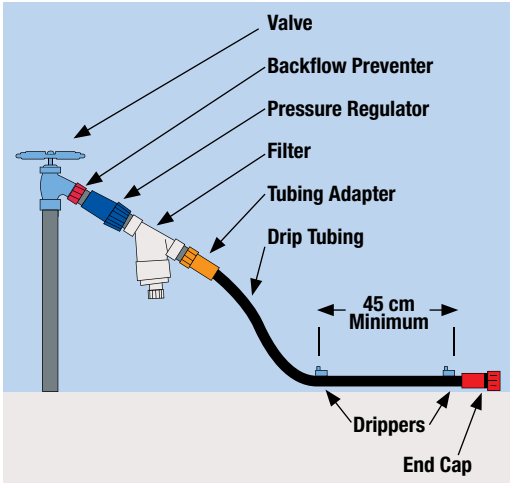
It is possible to completely automate drip irrigation with computerised humidity sensors detecting when irrigation is needed.

Irrigation tubing and pipes usually have a small diameter (16 – 25 mm) and low wall thickness (100 – 1250 µm) giving the advantage of being flexible and coilable so that the pipe can be re-rolled for storage and subsequent re-installation.

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

Figure 1 illustrates a very simple drip irrigation system.

Fig. 1: Drip Irrigation System



Drip Irrigation Production

The production of drip irrigation tubes/pipes is achieved through the extrusion of flexible pipe into which drippers are inserted at specific intervals; the pipe is drilled at each dripper.

During production, 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, inserting drippers into the diehead. Line speed is sufficient to prevent the drippers from melting at the insertion point.

Downstream are a vacuum sizing unit with a water pre-cooling chamber, cooling trough, and a de-watering device to dry the pipe before it enters the drilling unit. The holes are accurately positioned in relation to the drippers within the pipe.

Laterals

Laterals are thicker, pressurised pipes that supply water from the mains, or other source, to sprinklers or emitters. Laterals are thus more rigid and need to be thicker to withstand the required pressures. They are normally fixed and remain in position for many years. Thus they have a higher weathering requirement than that of drip irrigation and are subject to regulations in most countries.

Key Performance Requirements of Irrigation Pipes

The key performance requirements are the following:

- Weathering resistance according to recommended lifetime
- Thermal resistance
- Smooth surface finish
- Excellent mechanical properties

Black Masterbatches

Cabot's range of black masterbatches has been developed to provide the technical performance demanded by the irrigation pipe manufacturer. This is achieved by selection of the appropriate carbon black, additive package and carrier system together with use of state-of-the-art mixing technology.

The table on the left shows Cabot's recommended PLASBLAK® masterbatches for irrigation pipes, that is both drip irrigation and laterals.

Cabot's masterbatches have been specially designed to 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.

Grade	Formulation	Irrigation pipe
LL4932	50% standard carbon black with minimum process aid	Thin-walled drip irrigation tubing
LL6055	50% standard carbon black with process aid and significant antioxidant package to compensate for use of recycled resins	Thin-walled drip irrigation tubing containing recyclate
PE2668	40% small particle size carbon black with process aid and antioxidant package	Thicker drip irrigation pipes and laterals

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

More detailed information on each property is given in the following sections:

Weathering

Irrigation pipes are required to have a durability to match their service life. Some of the current standards suggest that this is achieved by incorporating 2–2.5% carbon black usually of particle size below 25 nm. These criteria can be met using PE2668. If the carbon black particle size is not specified, LL4932 or LL6055 can be suitable grades.

The weathering performance of Cabot's recommended black masterbatches for irrigation pipes is compared in figure 3 and 4. All grades are compared at 120 µm whilst the higher performing grade is compared at 430 µm with data on LL4932 at 650 µm. This clearly demonstrates the superior performance when 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 these have 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. Full details of the test can be found in the Cabot brochure "Microscopic Dispersion Test for High Performance Pressure Pipes".

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 ISO 18553:2002
LL4932	2.7
LL6055	2.6
PE2668	2.2

The lower the rating, the better the dispersion.

Fig. 2: Comparing PLASBLAK Irrigation Pipe Masterbatches

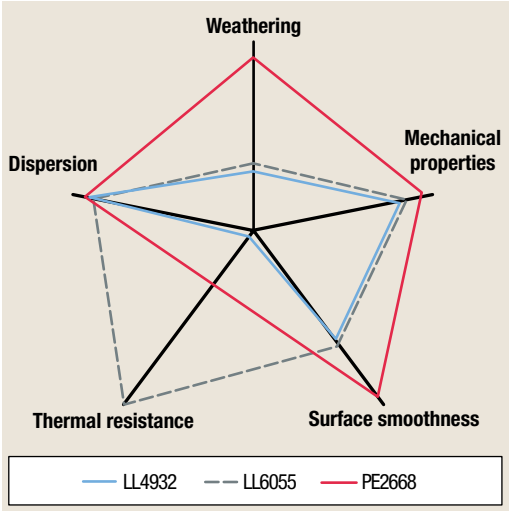


Fig. 3: QUV-B weathering of irrigation pipe masterbatches at 2% carbon black loading in 120 µm LDPE film

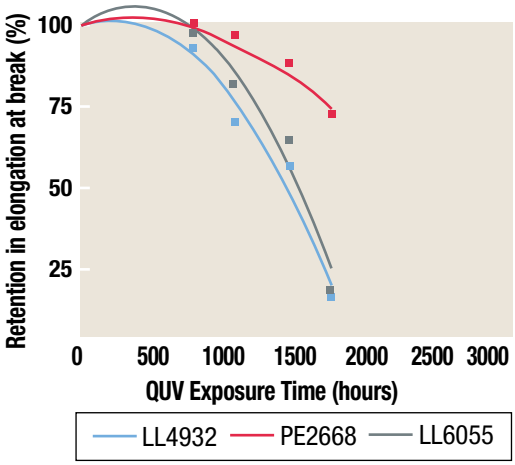
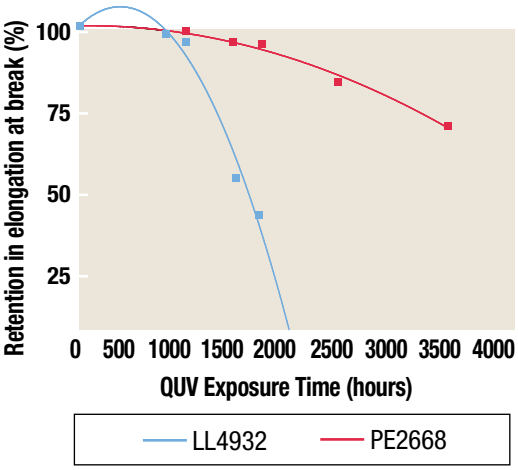


Fig. 4: QUV-B weathering of irrigation pipe masterbatches at 2% carbon black loading in 430 µm LDPE film



*Note: LL4932 results are on 650 µm sheet

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 used 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.

Based on the process aid content of the masterbatches, the surface smoothness will increase in the following order: LL4932 - LL6055 - PE2668.

If additional process aid is required, then up to 1% of a process aid masterbatch such as LL8964 or LL9917 can be used.

Thermal Resistance

Oxidation induction time (OIT) tests were carried out on each of the masterbatches added to give 2% carbon black in LDPE resin (with no further additives). Measurements were made at 170°C and the results are given in minutes in the table below compared to natural LDPE resin, which had received the same thermal history:

Formulation	Measured OIT (in min.)
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

It can be seen that LL6055, which is designed to be used in conjunction with recyclate, gives the best thermal stability whereas the standard grade, LL4932, offers very little thermal stability compared to the natural 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 PLASBLAK irrigation pipe masterbatches diluted in LDPE to give 2% carbon black. Results are shown in figures 5 and 6.

Fig. 5: Elongation at Break of PLASBLAK Irrigation Pipe Masterbatches

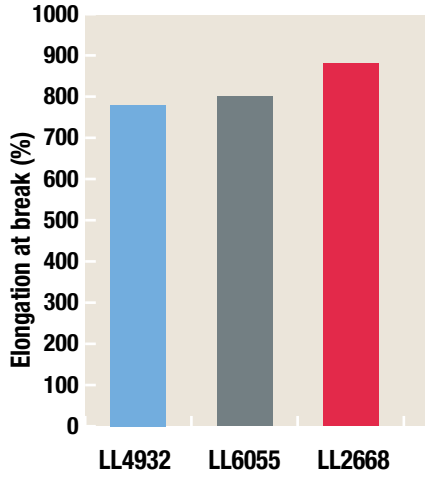
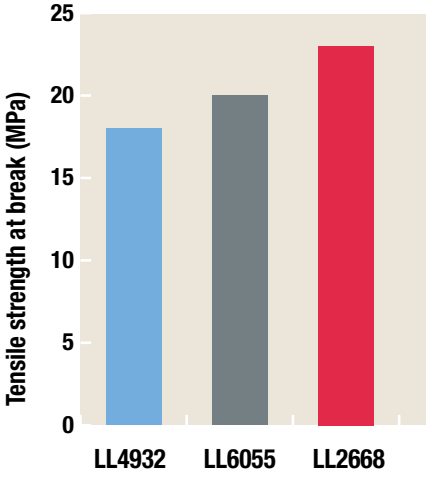


Fig. 6: Tensile Strength at Break of PLASBLAK Irrigation Pipe Masterbatches



Summary of the Main Irrigation Pipe Standards

Country	Reference	Title	Main masterbatch requirements	Suitable Cabot grades
International	ISO 8779:2010	Plastic piping systems - Polyethylene (PE) pipes for irrigation - Specifications	Carbon black 2.25 ± 0.25% Carbon black dispersion ≤ 3 (ISO 18553:2002) OIT ≥ 20 min at 200°C	PE2668 LL6055
International	ISO 9261:2004	Agricultural irrigation equipment – Emitting-pipe systems – Specification and test methods	Opaque and protected against UV degradation	LL4932 LL6055 PE2668
France	NF U51 433-2 October 1999	Irrigation techniques – Reel machine systems – Part 2: Specifications of polyethylene tubes for reel machines	Carbon black 2.3 ± 0.3% Carbon black dispersion ≤ 3 (ISO 18553:2002) OIT ≥ 20 mins at 200°C	PE2668 LL6055
France	NF U51-432 October 1990	Irrigation equipment – Polyethylene (PE) tubes for micro-irrigation equipment – specifications	Carbon black density 1500 – 2000 kg/m3 Carbon black volatiles ≤ 9.0% Carbon black average particle size 0.010 – 0.025 µm Carbon black toluene extract ≤ 0.01% by weight Carbon black 2.3 ± 0.3% Carbon black dispersion ≤ 3 (ISO 18553 : 2002) Antioxidant to meet food contact requirements Antioxidant ≤ 0.3% OIT > 10 min at 200°C	PE2668
Germany	DIN-EN 12324-2:1999	Irrigation techniques – Reel machine systems – Part 2: Specifications of polyethylene tubes for reel machines	Carbon black 2.3 ± 0.3% Carbon black dispersion ≤ 3 (ISO 18553:2002) OIT ≥ 20 mins at 200°C	PE2668 LL6055
Italy	UNI-EN 12324-2:2002	Irrigation techniques - Reel machine systems – Specifications of polyethylene tubes for reel machines	Carbon black 2.3 ± 0.3% Carbon black dispersion ≤ 3 (ISO 18553:2002) OIT ≥ 20 mins at 200°C	PE2668 LL6055
Spain	UNE 68076:1989	Irrigation equipment. Emitting pipe systems. Specifications and test methods	Opaque and protected against UV degradation	LL4932 LL6055 PE2668
Spain	UNE 53367:2005	Plastics. PE32 and PE40 pipes for irrigation. Characteristics and test methods	Carbon black 2.25 ± 0.25% Carbon black 0.010 – 0.025 µm Carbon black dispersion: requirements as shown in standard. OIT ≥ 20 min at 200°C	PE2668
Spain	UNE-EN 12324-2:2000	Irrigation techniques. Reel machine systems. Part 2: Specifications of polyethylene tubes for reel machines	Carbon black 2.3 ± 0.3% Carbon black dispersion ≤ 3 (ISO 18553:2002) OIT ≥ 20 mins at 200°C	PE2668 LL6055

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