

Measuring dispersion in black masterbatch

Filter pressure value, why two suppliers' numbers are usually not comparable, and what a lot certificate should actually contain.

Written for compounding and procurement engineers who have to write a dispersion requirement into a purchase specification — and then defend it when two suppliers return different numbers for the same grade.

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About the author's position: E-LUCK is a black masterbatch compounding plant in Huizhou, Guangdong, China. This document is written from the buying side of the table: it explains what the tests can and cannot establish, including the parts that are inconvenient for a supplier to explain.

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1. What this document establishes

Dispersion is the one property of a black masterbatch that cannot be recovered later. A carrier mismatch can be worked around, a moisture problem can be dried out, an MFI difference can sometimes be trimmed with process settings — but if the carbon was never deagglomerated in the compounding step, no downstream adjustment fixes it. It shows up as specks in a film, gels in a fibre pack, a rising screen-pack pressure, or a mechanical result that never reaches the data sheet.

Because of that, dispersion is the property buyers most often try to specify. And it is the property they most often specify badly, for a structural reason: **the standard method for measuring dispersion is deliberately tied to the equipment and conditions used to run it.** The consequence is that two suppliers can each send you a defensible dispersion figure, both correct, neither comparable, and there is nothing in the numbers themselves that tells you so.

This document covers three things:

- What the filter pressure value method measures, and how it is carried out under the current standard.
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- What a lot certificate should carry so that a run of them tells you something about process control, rather than about the day of the audit.

It does not propose a universal "good" number. Section 7 explains why no such number exists across different rigs, and gives the application-based bands that are defensible within a fixed method.

2. Why dispersion is the specification that decides everything downstream

Carbon black is delivered to a compounder as agglomerates — clusters of fused primary particles held together by weaker forces. Dispersion is the process of breaking those clusters apart and distributing the primary aggregates uniformly through the polymer melt. Anything that survives the compounding step travels downstream with the material, and every downstream symptom traces back to it:

Where it shows up	What the buyer sees	Why it is a dispersion symptom
Blown and cast film	Specks, pinholes, optical density variation, unexplained film breaks	An agglomerate is larger than the film thickness; it either shows as a visible defect or becomes a failure initiation point
Fibre and filament	Spinneret blockage, filament breaks, filter pack changes far ahead of schedule	The filter mesh is finer than the agglomerate population, so the pressure climbs until the pack is changed
Pipe and profile	Surface roughness, weld-line defects, low impact results	Large particles disturb flow lines and act as stress concentrators in a part that is otherwise correct
Injection moulding	Gate-area streaks, weak weld lines, inconsistent jetness across a shot	Flow front separation concentrates undispersed material where the melt streams meet
Any extrusion line	Output drift, rising head pressure, higher specific energy	Pressure and energy rise with the same population of undispersed material that causes the visible defects

The commercially important point is the second column: dispersion failures rarely present as "the masterbatch is bad". They present as a film break, a spinneret change, or a customer complaint about specks — problems that are expensive, intermittent, and hard to attribute after the fact. That is precisely why the measurement matters more than the specification language around it.

3. Three different things called "dispersion"

Most unproductive supplier conversations about dispersion happen because two people are using the word for different operations. It is worth separating them, because they have different physics and different remedies.

3.1 Wetting

Wetting is the polymer melt making contact with the carbon black surface and displacing air. Poor wetting leaves air voids and uncoated particles, and it shows up as a low colour yield: you need more masterbatch to reach the same black. Wetting is improved by surface treatment of the pigment and by the carrier system, not primarily by shear.

3.2 Deagglomeration

Deagglomeration is the break-up of the loose clusters into smaller units. This is a mechanical, shear-driven process and it is the step that compounding controls. It is also the step buyers are usually trying to specify when they ask about dispersion.

3.3 Distribution and the limit that cannot be crossed

Distribution is whether the particles that were separated are spread evenly through the melt, or concentrated in bands and flow lines. Note that distribution and dispersion are sometimes treated as synonyms in supplier literature, but they are not: you can have excellent distribution of material that was never properly deagglomerated, and you will still get specks.

The distinction that matters most for a buyer

Carbon black exists as **primary particles** (typically tens of nanometres), which fuse during manufacture into **aggregates** that cannot be broken by compounding shear — the aggregate is the irreducible unit. Those aggregates cluster into **agglomerates**, which can be broken.

So compounding can break agglomerates; it cannot break aggregates. This means the carbon black grade you buy sets a **floor** on the fineness you can ever reach, no matter how good the compounding is. A supplier who claims to achieve fine dispersion with a coarse, difficult-to-disperse black is describing a physical impossibility, not a technical achievement.

4. The carbon black properties that set your dispersion ceiling

Two grades both described as "40% carbon black" can behave completely differently, because the loading figure says nothing about the pigment's geometry. Three properties do most of the work:

4.1 Primary particle size

Finer primary particles give higher jetness, better UV screening and — because finer particles have more interparticle contact — a stronger tendency to form agglomerates that are harder to break. Finer is not simply better: it costs more dispersion energy and is more sensitive to compounding quality.

4.2 Structure (aggregate shape and void volume)

"Structure" describes how the primary particles are arranged into aggregates — high-structure blacks are more open and branched, low-structure blacks are more compact. Structure is measured as dibutyl phthalate (DBP) absorption under ASTM D2414, and across the commercial range it runs from roughly 60 to 160 cm³ per 100 g. High structure generally wets faster and disperses more readily, and it also gives higher viscosity and conductivity; low structure gives lower viscosity and better surface finish at the cost of dispersion speed.

4.3 Surface area

Nitrogen surface area (BET) spans a wide range across commercial grades — broadly 70 to 250 m²/g — and correlates with reinforcement and with the amount of polymer the black will tie up. Higher surface area means more carrier and more wetting energy needed.

4.4 Reading a carbon black grade from its designation

Rubber-grade carbon blacks are classified under **ASTM D1765**, where the letter indicates the production variant (N for normal-curing furnace black) and the first digit indicates the particle size class, from 1 for the finest through 8 for the coarsest. This is a rubber classification and it is not automatically the classification a masterbatch grade is sold under — but the underlying parameters (particle size, DBP structure, surface area) are the same ones your masterbatch supplier should be able to state.

A question that separates suppliers quickly

"What is the carbon black's **structure** — the DBP absorption — for this grade?" A supplier who formulates will answer with a figure and explain what it does to viscosity and dispersion in your resin. A supplier who repackages will answer with a particle size claim, which is a different property.

For context on the supply side: over 98% of global carbon black is produced by the furnace process, and the three largest producers — Birla Carbon, Cabot Corporation and Orion Engineered Carbons — together account for roughly half of world capacity. Conductive and superconductive grades come from a smaller set of specialists. This matters to a buyer for one practical reason: if a supplier cannot tell you which producer the black came from, or at least which grade class, you have no way to assess whether the dispersion figure will be repeatable across years, because the feedstock and grade availability behind it can change.

5. Filter pressure value: what the method actually does

5.1 Standard lineage

The filter pressure value (FPV) test was developed by CEN technical committee CEN/TC 298 and published as **EN 13900-5:2005**, "Pigments and extenders — Methods of dispersion and assessment of dispersibility in plastics — Part 5: Determination by filter pressure value test". It was adopted internationally as **ISO 23900-5:2015** and republished in Europe as **EN ISO 23900-5:2018**, which superseded the original European edition. The two names refer to the same procedure; a specification should state which edition it references, because a report citing the 2005 edition and a report citing the 2018 edition are not automatically the same test.

5.2 The rig

The apparatus is deliberately more elaborate than a screen on the end of an extruder. It comprises:

- a **single-screw extruder**, to melt and homogenise the material;
- a **melt (gear) pump**, which forces the melt through the filter at a defined, constant volume flow;
- a **breaker plate carrying the filter package**, with a mesh chosen according to the fineness of dispersion being assessed — commonly in the range of about 5 µm to 40 µm;
- **pressure sensors** upstream of the filter, logged against time.

5.3 The procedure

1. The base polymer alone is run first, to establish a baseline pressure at the filter.
2. The test material is introduced — a mixture of masterbatch and base polymer at a defined pigment content.
3. Pressure at the filter is recorded as the mixture passes. Agglomerates and other oversize material lodge in the mesh, progressively reducing the open area; at constant volume flow, that produces a measurable pressure rise.
4. The maximum is reached once the full quantity of test mixture has passed the filter.
5. Virgin polymer is reintroduced, and the pressure trace falls, marking the end of the measurement window.

5.4 The number

The result is expressed as the pressure rise divided by the mass of pigment in the sample:

$$\text{FPV} = (P_{\text{max}} - P_{\text{start}}) / m_{\text{pigment}} \quad [\text{bar} / \text{g}]$$

A lower value means less material was caught by the mesh, which means finer dispersion. Because the denominator is pigment mass rather than blend mass, the value is intended to be independent of the loading used in the test — which is what makes a bar/g figure worth quoting at all.

5.5 Why the melt pump is not optional

Older dispersion tests mounted the screen pack directly on the extruder, without a melt pump. The problem with that arrangement is subtle and it biases results in the flattering direction: as the screen blocks, backpressure rises, and increased backpressure increases mixing inside the screw. The material is therefore being dispersed more thoroughly *because* it is being measured — and the only external sign is a drop in throughput that is easy to miss. A melt pump removes that feedback loop by holding volume flow constant regardless of the pressure the filter develops. This is the single most important mechanical difference between the current standard method and the previous generation of tests, and it is why historical dispersion figures from different test vintages should not be placed side by side.

6. The method-dependence problem

This is the section most buyers have never been shown, and it is the reason dispersion specifications fail in practice. The scope of the standard is explicit that a filter pressure value is not a property of the material in the abstract:

"The filter pressure value (FPV) determined according to this method is valid only for the equipment, conditions and test polymer being used. The use of test conditions differing from those specified may give different results. The method of preparing the colour concentrate is not specified in this standard. The results obtained for individual colorants are therefore comparable only when the same method of preparation for colour concentrates is used."

— scope of the EN 13900-5 / ISO 23900-5 filter pressure value test

Read plainly, that paragraph says three things a buyer needs to act on:

1. **The number belongs to the measurement, not to the material.** Change the rig, the filter mesh, the test polymer, the temperature or the pigment loading in the test mix, and the number changes.
2. **The preparation is part of the result.** How the masterbatch was compounded — screw configuration, feed arrangement, energy input — is inside the figure. The standard does not fix it, so it must be fixed by agreement.
3. **Comparability requires identical method.** Two numbers are comparable only if both were produced the same way.

6.1 What the preparation effect looks like in practice

This is not a theoretical concern. Published compounding trials on carbon black masterbatch show the same carbon black producing markedly different filter pressure values depending on how it was fed to the extruder: at a 5 µm mesh, a premix route returned 0.53 bar/g while a split-feed route on the same material returned 0.84 bar/g — a difference of roughly 60% from process configuration alone. Nothing about the pigment changed.

The practical implication for a buyer is uncomfortable but useful: **a filter pressure value quoted in an email tells you what one rig produced on one day, and nothing more.** That is not a reason to ignore the figure. It is a reason to write it into a specification in a form that can be checked.

Eight items to fix before a filter pressure value means anything

1. The exact standard and edition referenced (for example EN ISO 23900-5:2018).
2. The filter mesh used, in micrometres.
3. The base polymer the test is run in, with its grade — not just "PE".
4. The pigment mass fraction in the test mixture.
5. The melt temperature and the volume flow at the pump.
6. Whether the tested material is a laboratory sample or a production lot, and from which lot.
7. The number of determinations, and whether the reported figure is a single result or a mean.
8. The maximum acceptable value, stated in bar/g, at that mesh, in that polymer.

7. Reference values, and how to use them honestly

Given section 6, no table of "good" filter pressure values can be transferred between rigs. What can be transferred is the relationship between the figure and the application, and the order of magnitude different classes of product occupy. The figures below are published or commercially quoted values, reproduced with their conditions, precisely so that their conditionality is visible:

Material / context	Reported FPV	Conditions as stated
General colour concentrates, industry reference point	around 2 bar/g	Widely quoted order of magnitude for concentrates; no single standard condition
PCB (carbon black) masterbatch for fine PET fibre	should not exceed 1 bar/g	10 µm screen mesh; stated as the acceptance limit for fibre-grade PET carbon black
Carbon black in PET — premix compounding route	0.53 bar/g	5 µm mesh; measured on a single-screw + melt pump arrangement
Carbon black in PET — split-feed compounding route	0.84 bar/g	5 µm mesh; identical carbon black, different feed configuration
High-performance organic pigment (yellow), supplier claim	0.2 bar/g	Vendor data sheet; presented as an exceptionally low value for the pigment class

Two observations follow from reading that table carefully rather than copying a number out of it.

First, mesh size is not a detail. A figure quoted at 5 µm and a figure quoted at 10 µm are measuring the retention of different particle populations, and the finer mesh will always produce the higher number for the same material. When a supplier quotes a low value, the mesh is the first question to ask.

Second, the application sets the target, not the market. Fibre spinning and thin film are the applications where dispersion genuinely dominates, because the filter mesh in the process is fine and the consequence of a defect is a line stop. Thick-section pipe or a large moulding can tolerate a materially higher figure and never show a symptom. Specifying a fibre-grade FPV for a pipe application buys dispersion you cannot use and pays for it in compounding energy, colour cost and — as the next section explains — possible polymer damage.

8. Dispersion against polymer damage

Everything that improves deagglomeration is also a way to damage the polymer, and a dispersion specification that ignores the second half of that sentence is incomplete.

Dispersion is driven by shear and by residence time under shear. Increasing either improves the filter pressure value. Both also raise melt temperature and mechanical stress on the polymer chain, and the effect is not symmetric: published compounding trials on carbon black in PET show that a more aggressive screw configuration at higher speed continued to heat and shear the material with barely any further improvement in dispersion, while the intrinsic viscosity — the measure of how much the polymer itself has been degraded — fell below the level considered acceptable. In that application the working requirement was to keep intrinsic viscosity as far above 0.5 dl/g as achievable while still meeting the dispersion target.

The one-line version

A dispersion improvement that arrives together with a viscosity loss is not automatically an improvement. When you ask a supplier to make the filter pressure value better, ask what happened to MFI or intrinsic viscosity at the same time. If there is no answer, the improvement was not measured — it was asserted.

This is also why a high FPV is not simply a supplier's failure. Coarse blacks, high loadings and heat-sensitive carriers all push the number up legitimately. The useful question is never "why is your number worse than theirs" but "what does your number do in my process, in my resin, at my mesh".

9. What belongs on a lot certificate

A certificate of analysis has two jobs, and most of them only do the first one. Job one is to state what is in the bag. Job two — the one that supports process control — is to state it in a form that can be compared with the previous bag. A certificate without a lot number and a method reference cannot do job two at all.

Property	How it is established	What the lot certificate should state
Lot identity	Producer's internal lot system	Lot number and production date. A unique identifier that can be traced back to raw material batches
Carbon black content	Thermogravimetric analysis, ashing, or dissolution — these are not interchangeable measurements	The measured value, the tolerance band, and the method used. Two correct laboratories can report different figures for the same lot if the methods differ
Carrier resin	Formulation record	The carrier and its grade, and whether any regrind is present
Melt flow index	ISO 1133 / ASTM D1238 type capillary method	The measured value with temperature and load stated — an MFI without test conditions is not a number
Moisture	Loss on drying or Karl Fischer	Measured value and the drying conditions used
Ash content	Ashing at defined temperature	Measured value. This is the figure that separates genuine carbon loading from carbon plus mineral filler
Dispersion	Filter pressure value per EN ISO 23900-5, or an agreed equivalent	The FPV in bar/g with mesh size, base polymer and pigment loading in the test mix — an FPV quoted without these is not checkable

Three of those entries are worth pressing on specifically.

- **Carbon content without a method is ambiguous.** Thermal residue, ashing and dissolution approach the same question differently and can return different figures outside their stated uncertainty. If the purchase specification names a figure without naming the method, the first disputed lot will be argued rather than resolved.
- **MFI without conditions is not a measurement.** Temperature and load change the value substantially. A certificate that reports MFI alone has not reported anything you can compare.
- **Dispersion without conditions is not checkable.** As section 6 sets out, that is not pedantry — it follows directly from the scope of the method.

What does *not* belong on a lot certificate: values described as "typical" with no lot linkage, figures carried over from a qualification trial rather than measured on the shipment, and any dispersion statement that is a sentence rather than a number with conditions.

10. Reading a run of certificates rather than one

A single certificate tells you a lot passed. A run of certificates tells you whether the process is controlled, which is the property you will actually live with. The reasoning is the same as any control chart, and it needs no statistics software:

1. **Ask for three consecutive lots before you order.** One lot is a best case; three is a process. The spread between them is the number you should be planning against, not the best of the three.
2. **Plot the values you can compare.** Carbon content, MFI, moisture and FPV across lots. You are looking for two things: whether the values scatter around a stable centre, and whether any one sits visibly away from its neighbours.
3. **Distinguish drift from noise.** Values bouncing around a centre are ordinary batch variation. Values moving steadily in one direction — moisture creeping up, FPV trending upward — indicate a change in raw material supply, drying or screw wear, and they are worth a question long before they reach the tolerance limit.
4. **Treat a single apparent outlier as a question, not a rejection.** A figure that is far off may be a real process excursion, or it may be a different test condition quietly substituted on that lot. Ask which, and ask for the raw trace.
5. **Compare the trial lot against the first three production lots.** This is where bait-and-switch shows up. If the trial lot's dispersion figure is materially better than every production lot that follows, the trial was not representative — and you found that out at the price of a trial, not a container.

None of this requires a laboratory of your own. It requires certificates that carry lot numbers, methods and conditions, and the discipline to look at several of them together.

11. A reproducible incoming test protocol

The following sequence is what a buyer can run without owning a filter pressure rig, and it is the sequence we would expect a serious customer to run on us.

1. **Fix the specification before the first order.** Carbon content with method, carrier resin and grade, MFI with conditions, moisture limit, ash limit, and dispersion as an FPV in bar/g at a named mesh in a named base polymer. Include the eight items in the box in section 6.1.
2. **Request three consecutive production lots** for the grade, and read them against each other before placing an order.
3. **Request a sample of the quoted grade at the quoted let-down ratio**, made on your own carrier resin where that is possible. Assess it on your own equipment.
4. **On arrival, verify what you can verify.** Moisture by loss on drying; MFI if you have the instrument; colour development against your reference. Fifteen minutes of incoming checks is cheaper than a day of scrap.
5. **Run the lot at the specified let-down ratio** and record screen-pack pressure behaviour, output stability and the defect count your process normally tracks.
6. **Compare the shipment certificate against the trial lot certificate.** If the dispersion figure and the carbon content have both moved, that is the conversation to have before the next order, not after.
7. **Retain a sealed sample of each lot.** When a dispute arises, the ability to re-test the same material is what turns an argument into a finding.

How to test this document on us

Send the specification in step 1 to **zoe@masterbatchsource.com** and ask for the three-lot history for the grade you need, with dispersion figures at a stated mesh and the polymer the test was run in. If a figure cannot be supported by a method reference and a lot number, it is not worth putting in a contract — ours included.

12. References

1. EN 13900-5:2005, *Pigments and extenders — Methods of dispersion and assessment of dispersibility in plastics — Part 5: Determination by filter pressure value test*. CEN/TC 298. Superseded by EN ISO 23900-5:2018. Scope wording quoted in section 6 is taken from the published scope of this part.
2. ISO 23900-5:2015, *Pigments and extenders — Methods of dispersion and assessment of dispersibility in plastics — Part 5: Determination by filter pressure value test*. International Organization for Standardization.
3. EN ISO 23900-5:2018 (identical adoption of ISO 23900-5:2015). Replaced EN 13900-5:2005 with effect from September 2018.

4. M. Matta and M. Weinmann, "Black and finely dispersed", *Kunststoffe International* 6–7/2015, Coperion GmbH. Source of the premix versus split-feed filter pressure comparison and of the PET intrinsic viscosity discussion in section 8; the PET fibre carbon black limit of 1 bar/g at 10 µm is quoted there.
5. "Now It's Here: An Objective Test of Masterbatch Dispersion", *Plastics Technology*. Source of the description of the melt-pump requirement and of the backpressure feedback problem in section 5.5, and of the comparison with older methods without a melt pump.
6. ASTM D1765, *Standard Classification System for Carbon Blacks Used in Rubber Products*. Basis of the N-series particle size class numbering described in section 4.4.
7. ASTM D2414, *Standard Test Method for Carbon Black — Oil Absorption Number (OAN)*. Basis of the DBP absorption figures for carbon black structure in section 4.2.
8. EN 13900-5 / ISO 23900-5 test equipment documentation (single-screw extruder, gear melt pump, breaker plate, filter mesh range 5–40 µm, evaluation formula $FPV = (P_{\max} - P_{\text{start}}) / m$) — as specified in the standard and implemented in commercial filter testers.

Note on figures. All filter pressure values reproduced in this document are quoted with the conditions under which they were reported. As section 6 sets out, values obtained under different rigs, meshes, test polymers or preparation routes are not directly comparable. They are reproduced here to illustrate the order of magnitude and the sensitivity of the measurement, not as targets to be copied between suppliers.

About E-LUCK. E-LUCK (Guangdong Yijuyuan Plastic Industry Technology Co., Ltd.) operates a black masterbatch compounding plant in Huizhou, Guangdong, China, with a stated capacity of 60,000 tonnes per year. The company supplies carbon black masterbatch, colour masterbatch and additive masterbatch with carriers matched to PE, PP, ABS, PC, PA, PET, PBT, PPA, PPS, TPU and SAN, at carbon black contents from 9% to 60%. Technical enquiries: zoe@masterbatchsource.com.