



Standard Terminology Relating to Carbon Black¹

This standard is issued under the fixed designation D3053; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This terminology covers a compilation of definitions of technical terms used in the carbon black and rubber industries. Terms that are generally understood or adequately defined in other readily available sources are not included.

2. Referenced Documents

2.1 ASTM Standards:²

- D1508 Test Method for Carbon Black, Pelleted Fines and Attrition
- D1509 Test Methods for Carbon Black—Heating Loss
- D1510 Test Method for Carbon Black—Iodine Adsorption Number
- D1511 Test Method for Carbon Black—Pellet Size Distribution
- D1513 Test Method for Carbon Black, Pelleted—Pour Density
- D1514 Test Method for Carbon Black—Sieve Residue
- D1566 Terminology Relating to Rubber
- D1618 Test Method for Carbon Black Extractables—Transmittance of Toluene Extract
- D1765 Classification System for Carbon Blacks Used in Rubber Products
- D1799 Practice for Carbon Black—Sampling Packaged Shipments
- D1900 Practice for Carbon Black—Sampling Bulk Shipments
- D1937 Test Method for Carbon Black, Pelleted—Mass Strength
- D2414 Test Method for Carbon Black—Oil Absorption Number (OAN)
- D2663 Test Methods for Carbon Black—Dispersion in Rubber
- D3265 Test Method for Carbon Black—Tint Strength

- D3313 Test Method for Carbon Black—Individual Pellet Hardness
- D3493 Test Method for Carbon Black—Oil Absorption Number of Compressed Sample (COAN)
- D3849 Test Method for Carbon Black—Morphological Characterization of Carbon Black Using Electron Microscopy
- D5230 Test Method for Carbon Black—Automated Individual Pellet Hardness
- D6086 Test Method for Carbon Black—Void Volume (VV)
- D6556 Test Method for Carbon Black—Total and External Surface Area by Nitrogen Adsorption
- D6602 Practice for Sampling and Testing of Possible Carbon Black Fugitive Emissions or Other Environmental Particulate, or Both

3. Terminology

3.1 Definitions:

aciniform, *adj*—shaped like a cluster of grapes.

DISCUSSION—The spheroidal primary particles of carbon black are fused into aggregates of colloidal dimension forming an aciniform morphology.

carbon black, *n*—an engineered material, primarily composed of elemental carbon, obtained from the partial combustion or thermal decomposition of hydrocarbons, existing as aggregates of aciniform morphology which are composed of spheroidal primary particles which exhibit uniformity of primary particle sizes within a given aggregate³ and turbostratic layering within the primary particles.

DISCUSSION—Carbon black exhibits a hierarchy of morphological features: particles (that is, primary particles), aggregates, and agglomerates. While the fundamental building block of carbon black is the primary particle, they almost never exist in isolation, but are strongly fused by covalent bonds into aggregates.³ The primary particles are conceptual in nature, in that once the aggregate is formed the primary particle no longer exists, they are no longer discrete and have no physical boundaries amongst them. Once produced, individual aggregates join together by van der Waals forces to form agglomerates. Agglomerates do not break down into smaller components unless adequate force is applied (for example, shear force). Primary particle and aggregate sizes are distributional properties and vary depending on

¹ This terminology is under the jurisdiction of ASTM Committee D24 on Carbon Black and is the direct responsibility of Subcommittee D24.41 on Carbon Black Nomenclature and Terminology.

Current edition approved Nov. 1, 2013. Published December 2013. Originally approved in 1972. Last previous edition approved in 2013 as D3053 – 13. DOI: 10.1520/D3053-13A.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ The one exception to this general characteristic of manufactured carbon black is thermal black, in which primary particles may exist in isolation and the primary particle sizes within an aggregate are not necessarily uniform.

the carbon black grade. Transmission electron micrographs shown in Annex A1 of Practice **D6602** demonstrate that while primary particle and aggregate sizes vary greatly within a given grade of carbon black, the primary particle size is essentially uniform within an individual aggregate.³

carbon black, carcass grade, *n*—a type of furnace carbon black having an average nitrogen surface area in the range of 21 to 69 m²/g.

DISCUSSION—Carcass-grade carbon blacks are produced by the oil furnace process. The use of these grades in the rubber industry is not limited to the carcass portion of the tire. These grades are designated with an “N” first character and a second character of “4, 5, 6, or 7” in Table 1 of Classification **D1765**. See Terminology **D1566** for the definition of carcass.

carbon black, furnace, *n*—a type of carbon black produced by the decomposition reaction of hydrocarbons when injected into a high-velocity stream of combustion gases under controlled conditions.

carbon black, hard, *n*—See **carbon black, tread grade**, the preferred term.

DISCUSSION—All carbon blacks provide some level of reinforcement when mixed in rubber. The amount of reinforcement is a function of the carbon black grade and amount used. See Terminology **D1566** for the definition of reinforcement.

carbon black, semi-reinforcing, *n*—See **carbon black, carcass grade**, the preferred term.

DISCUSSION—All carbon blacks provide some level of reinforcement when mixed in rubber. The amount of reinforcement is a function of the carbon black grade and amount used. See Terminology **D1566** for the definition of reinforcement.

carbon black, soft, *n*—See **carbon black, carcass grade**, the preferred term.

DISCUSSION—All carbon blacks provide some level of reinforcement when mixed in rubber. The amount of reinforcement is a function of the carbon black grade and amount used. See Terminology **D1566** for the definition of reinforcement.

carbon black, surface activity, *n*—the inherent ability of the carbon black surface to interact physically or chemically, or both, with rubber or other molecules.

carbon black, target value, *n*—a consensus value for selected primary properties on which producers center their manufacturing process and users center their specification.

DISCUSSION—Target values for carbon black properties are shown in Classification **D1765** for most rubber grade carbon blacks currently in commerce.

carbon black, thermal, *n*—a type of carbon black produced under controlled conditions by the thermal decomposition of hydrocarbons in the absence of air or flames.

DISCUSSION—These grades are designated with an “N” first character and a second character of “8 or 9” in Table 1 of Classification **D1765**.

carbon black, thermal, acetylenic, *n*—a thermal black produced from acetylene gas.

carbon black, tread grade, *n*—a type of furnace carbon black having an average nitrogen surface area of 70 m²/g or greater.

DISCUSSION—Tread grade carbon blacks are produced by the oil furnace process. The use of these grades in the rubber industry is not

limited to the tread portion of the tire. These grades are designated with an “N” first character and a second character of “0, 1, 2, or 3” in Table 1 of Classification **D1765**.

carbon black, typical value, *n*—a consensus value for those carbon black properties that are not specifically targeted for control in the manufacturing process and that are somewhat dependent upon the targeted properties.

DISCUSSION—Typical values for carbon black properties are shown in Classification **D1765** for most rubber grade carbon blacks currently in commerce. These are consensus values based upon the range in values supplied by the manufacturers. Typical values are useful in making comparisons between grades but they are not the set-point targets for the process and may be expected to differ significantly between producers.

carbon black agglomerate, *n*—a cluster of physically bound and entangled aggregates.

DISCUSSION—See Test Method **D3849**.

carbon black aggregate, *n*—a discrete, rigid, colloidal mass of extensively coalesced particles; it is the smallest dispersible unit.

carbon black microstructure, *n*—arrangement of carbon atoms within a carbon black particle.

carbon black particle, *n*—a small spheroidally shaped (paracrystalline, non-discrete) component of a carbon black aggregate; it is separable from the aggregate only by fracturing.

carbon black particle diameter, *n*—arithmetic average of the diameters of particles within a carbon black aggregate as measured by electron microscopy.

DISCUSSION—See Test Method **D3849**.

carbon black pellet, *n*—a relatively large agglomerate mass that has been densified in spheroidal form to facilitate handling and processing.

DISCUSSION—See Test Method **D1511**.

carbon black reinforcing, *n*—See **carbon black, tread grade**, the preferred term.

DISCUSSION—All carbon blacks provide some level of reinforcement when mixed in rubber. The amount of reinforcement is a function of the carbon black grade and amount used. See Terminology **D1566** for the definition of reinforcement.

carbon black structure, *n*—the quality of irregularity and deviation from sphericity of the shape of a carbon black aggregate.

carbon black weight mean particle size, *n*—ratio equal to the sum of individual particle diameters, each raised to the fourth power, divided by the sum of the individual particle diameters, raised to the third power.

compressed oil absorption number (COAN), *n*—See **oil absorption number of compressed sample**, the preferred term.

dispersion, *n*—degree of uniform distribution of a filler’s primary unit (i.e., aggregate of carbon black) into a compound. See also **macro-dispersion**, **micro-dispersion**, and **visual dispersion**.

finer, *n*—that portion of pelleted carbon black that passes through a specified sieve under standard conditions.

DISCUSSION—See Test Method **D1508**.

heating loss, *n*—mass loss, in percent, when carbon black is heated at 125°C for 1 h; the heating loss is primarily attributed to moisture content.

DISCUSSION—See Test Methods **D1509**.

individual pellet hardness, *n*—the force required to fracture or crush a carbon black pellet.

DISCUSSION—See Test Methods **D3313** and **D5230**.

iodine adsorption number, *n*—the number of grams of iodine adsorbed per kilogram of carbon black under specified conditions.

DISCUSSION—See Test Method **D1510**.

lot, *n*—a quantity of carbon black that is essentially uniform in composition and characteristics.

lot sample, *n*—a quantity of carbon black selected to represent a lot for testing purposes and taken in accordance with Practice **D1799** or **D1900**.

macro-dispersion, *n*—degree of distribution of filler into a compound that can be assessed with the aid of instrumentation including but not limited to a light microscope, profilometer, or interferometric microscope, generally on a scale of less than 100 µm but greater than 2 µm.

DISCUSSION—See Test Methods **D2663**.

mass strength, *n*—a measure of the tendency for carbon black pellets to pack together and to influence flow in a bulk handling system.

DISCUSSION—See Test Method **D1937**.

material, *n*—a quantity of carbon black with unique composition and characteristics.

moisture content, *n*—the percentage, by mass, of water absorbed and adsorbed by carbon black.

DISCUSSION—See **heating loss**.

micro-dispersion, *n*—degree of distribution of a filler's primary unit (that is, aggregate of carbon black) into a compound that can be assessed with the aid of instrumentation including but not limited to an electron microscope or scanning probe microscope, generally on a scale of less than 2 µm.

nanomaterial, *n*—material with any external dimension in the nanoscale or having internal structure or surface structure in the nanoscale.

DISCUSSION—Carbon black exhibits aciniform morphology composed of spheroidal “primary particles” strongly fused together to form discrete entities called aggregates.⁴ The primary particles are conceptual in nature, in that once the aggregate is formed the “primary particle” no longer exists, they are no longer discrete, and have no physical boundaries amongst them. The aggregates are loosely held

together by weaker forces forming larger entities called agglomerates. The agglomerates will break down into aggregates if adequate force is applied (for example, shear force). Aggregates are the smallest dispersible unit.⁴ Carbon black is placed on the market in the form of agglomerates. Following the definition and using the terminology of the ISO Technical Committee 229 “Nanotechnologies,” carbon black is considered a nanostructured material (material having internal or surface structure in the nanoscale).

nanoparticle, *n*—a nano-object with all three external dimensions in the nanoscale size range (that is, approximately 1 to 100 nm).

DISCUSSION—Carbon black exhibits aciniform morphology composed of spheroidal “primary particles” strongly fused together to form discrete entities called aggregates.⁴ The primary particles are conceptual in nature, in that once the aggregate is formed the “primary particle” no longer exists, they are no longer discrete, and have no physical boundaries amongst them. The aggregates are loosely held together by weaker forces forming larger entities called agglomerates. The agglomerates will break down into aggregates if adequate force is applied (for example, shear force). Aggregates are the smallest dispersible unit.⁴ Carbon black is placed on the market in the form of agglomerates. Following the definition and using the terminology of the ISO Technical Committee 229 “Nanotechnologies,” carbon black is considered a nanostructured material (material having internal or surface structure in the nanoscale).

nitrogen surface area (NSA), *n*—the total surface area of carbon black that is calculated from nitrogen adsorption data using the B.E.T. theory.

DISCUSSION—See Test Method **D6556**.

oil absorption number (OAN), *n*—the number of cubic centimetres of dibutyl phthalate (DBP) or paraffin oil absorbed by 100 g of carbon black under specified conditions.

DISCUSSION—The OAN value is proportional to the degree of aggregation of structure level of the carbon black. See Test Methods **D2414** and **D3493**.

oil absorption number of compressed sample (COAN), *n*—the number of cubic centimetres of dibutyl phthalate (DBP) or paraffin oil absorbed by 100 g of carbon black after being compressed four times in a compression cylinder at 165 MPa (24 000 psi) under specified conditions.

DISCUSSION—The COAN value gives some measure of the stability of the structure of the carbon black. See Test Methods **D2414** and **D3493**.

oil furnace process, *n*—a process for producing furnace carbon blacks that uses oil as the source of hydrocarbons for decomposition by injection into a high-velocity stream of combustion gases.

DISCUSSION—Oil or natural gas are typically used as combustion fuel to create the high-velocity stream of combustion gases, although other fuels may be used.

pellet size distribution, *n*—the percentage, by mass, of carbon black retained on each of a specified series of sieve screens arranged with progressively smaller openings.

DISCUSSION—See Test Method **D1511**.

pour density, *n*—the mass per unit volume of pelleted carbon black.

DISCUSSION—See Test Method **D1513**.

sample, *n*—a portion of carbon black selected for use in obtaining a test result.

⁴ The one exception to this general characteristic of manufactured carbon black involves thermal black, where “primary particles” can exist as discrete entities. However, “primary particles” produced via the thermal black process have characteristic diameters in the range of 150 to 500 nm, meaning that primary thermal black particles are of sizes that fall outside the nanoscale region.

sieve residue, *n*—the material collected and quantified after water washing carbon black through a wire mesh screen of specified size, typically No. 325 with 45 μm openings, followed by wet and dry rubbing of the residual material.

DISCUSSION—The residue may include one or more of the following: catalyst fines, refractory, metallic materials, cokes and hard carbon black fragments. See Test Method **D1514**.

statistical thickness surface area (STSA), *n*—the external surface area of carbon black that is calculated from nitrogen adsorption data using the de Boer theory and a carbon black model.

DISCUSSION—See Test Method **D6556**.

tint strength, *n*—the ratio, expressed as tint units, of the reflectance of a standard paste to a sample paste, both prepared and tested under specified conditions.

DISCUSSION—See Test Method **D3265**.

toluene discoloration, *n*—the transmittance, at 425 nm, of the filtrate obtained from the toluene extract of carbon black, compared with that of pure toluene.

DISCUSSION—See Test Method **D1618**.

vacuum, *n*—pressure below atmospheric pressure.

visual dispersion, *n*—degree of uniform distribution of a filler's primary unit into a compound that can be assessed with the unaided human eye, typically on a scale greater than 100 μm .

DISCUSSION—See Test Methods **D2663**.

void volume, *n*—measure of the occluded pore volume within the primary structure of carbon black, characterized by the irregularity and non-sphericity of carbon black aggregates, and expressed as the difference between a sample's compressed or apparent volume at a specified pressure and carbon black's theoretical volume.

DISCUSSION—The theoretical volume of carbon black is calculated as sample mass divided by the true or absolute density of carbon black with an accepted value of 1.9 g/cm^3 . The void volume value is calculated based on 100 g mass. See Test Method **D6086**.

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