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# Standard Terminology Relating to Manufactured Carbon and Graphite[1]

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**across (or against) grain,** *n*—the direction in a body with preferred orientation due to forming stresses that has the maximum *c*-axis alignment as measured in an X-ray diffraction test.

**agglomerate,** *n—in manufactured carbon and graphite product technology*, a composite particle containing a number of grains.

**ash,** *n—in carbon and graphite technology*, the residue remaining after oxidation of a carbon or graphite.

**binder**—a substance, usually an organic material such as coal tar pitch or petroleum pitch, used to bond the coke or other filler material prior to baking.

**carbon**—an element, number 6 of the periodic table of elements, electronic ground state $1s^2 2s^2 2p^2$.

**carbon**—*in carbon and graphite technology*, an artifact consisting predominantly of the element carbon and possessing limited long range order.

DISCUSSION—The presence of limited long range order is usually associated with low electrical and thermal conductivity and difficult machinability when compared with graphite.

**coke**—a carbonaceous solid produced from coal, petroleum, or other materials by thermal decomposition with passage through a plastic state.

**compressive strength**—a property of solid material that indicates its ability to withstand a uniaxial compressive load.

**defect**—*of a manufactured carbon or graphite product*, any irregularity in the chemistry, microstructure, or macrostructure.

**defective**—having flaws or dimensional deviations greater than acceptable for the intended use.

**electrographite,** *n—in carbon and graphite technology,* a synonym for manufactured graphite.

**extruded**—formed by being forced through a shaping orifice as a continuous body.

**filler**—*in manufactured carbon and graphite product technology*, carbonaceous particles comprising the base aggregate in an unbaked green-mix formulation.

**flaw**—a defect sufficiently greater than those typical of the morphology of a carbon or graphite body to influence a property.

**flexural strength**—a property of solid material that indicates its ability to withstand a flexural or transverse load.

**flow line**—a defect induced by discontinuous flow velocities during forming of molded or extruded bodies.

**grade**—the designation given a material by a manufacturer such that it is always reproduced to the same specifications established by the manufacturer.

**grain,** *n—in manufactured (synthetic) carbon and graphite*, a particle of filler material (usually coke or graphite) in the starting mix formulation. Also referred to as granular material, filler particle, or aggregate material. The term is also used to describe the general texture of a carbon or graphite body, as in the descriptions listed below:

*coarse grained*—containing grains in the starting mix that are substantially greater than 4 mm in size.

*medium grained*—containing grains in the starting mix that are generally less than 4 mm in size.

*fine grained*—containing grains in the starting mix that are generally less than 100 µm in size.

*superfine grained*—containing grains in the starting mix that are generally less than 50 µm in size.

*ultrafine grained*—containing grains in the starting mix that are generally less than 10 µm in size.

DISCUSSION—All of the above descriptions relate to the generally accepted practice of measuring the sizing fractions with a criterion that 90 % of the grains will pass through the stated screen size in a standard particle sizing test.

**graphene layer**—*in carbon and graphite technology*, a single carbon layer of the graphite structure, describing its nature by analogy to a polycyclic aromatic hydrocarbon of quasi-infinite size.

DISCUSSION—The term graphite designates a modification of the chemical element carbon in which planar sheets of carbon atoms, each atom bound to three neighbors in a honeycomb-like structure, are stacked in a three dimensional regular order. For a single layer, it is not correct to use the term graphite, which implies a three dimensional structure.

**graphite**—an allotropic crystalline form of the element carbon, occurring as a mineral, commonly consisting of a

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hexagonal array of carbon atoms (space group P $6_3$/mmc) but also known in a rhombohedral form (space group R 3m).

**graphite**—*in carbon and graphite technology*, an artifact consisting predominantly of the element carbon and possessing extensive long range order.

DISCUSSION—The presence of extensive long range order is usually associated with high electrical and thermal conductivity in the hexagonal plane and relatively easy machinability when compared with carbon.

**graphitic**—*in carbon and graphite technology*, all varieties of substances consisting predominantly of the element carbon in the allotropic form of graphite irrespective of the presence of structural defects.

DISCUSSION—The use of the term graphitic is justified if three-dimensional hexagonal crystalline long-range order can be detected in the material by X-ray diffraction methods, independent of the volume fraction and the homogeneity of distribution of such crystalline domains. Otherwise, the term non-graphitic should be used.

**graphitizable carbon**—*in carbon and graphite technology*, a non-graphitic carbon, which, upon graphitization, converts into graphitic carbon (also known as a soft carbon).

**graphitization**—*in carbon and graphite technology*, a solid-state transformation of thermodynamically unstable non-graphitic carbon into graphite by thermal treatment.

DISCUSSION—The degree of graphitization is a measure of the extent of long-range 3D crystallographic order as determined by diffraction studies only. The degree of graphitization affects many properties significantly, such as thermal conductivity, electrical conductivity, strength, and stiffness.

DISCUSSION—A common, but incorrect, use of the term graphitization is to indicate a process of thermal treatment of carbon materials at T>2200°C regardless of any resultant crystallinity. The use of the term graphitization without reporting confirmation of long range three dimensional crystallographic order determined by diffraction studies should be avoided, as it can be misleading.

**green carbon**—a formed, but unfired carbon body.

**hardness**—the resistance of a material to deformation, particularly permanent deformation, indentation, or scratching.

**impervious carbon**—the same as impervious graphite with the exception that the base stock has not been graphitized.

**impervious graphite**—manufactured graphite that has been impregnated with a resinous material to make the final article impervious to liquids in the recommended operating range.

**impregnation**—partial filling of the open pore structure with another material.

**isotropic**—*in carbon and graphite technology*, having an isotropy ratio of 0.9 to 1.1 for a specific property of interest.

**isotropy ratio**—*in carbon and graphite technology*, the ratio of a given property value in the against grain direction to its corresponding value in the with grain direction (for example, the ratio of coefficients of thermal expansion).

**lamination**—line of demarcation or elongated void generally parallel to the principal grain direction of a carbon or graphite body.

**longitudinal sonic pulse**—a sonic pulse in which the displacements are in the direction of propagation of the pulse.

**machinability**—a measure of the ease with which a material can be shaped with the aid of cutting or abrasive tools.

**manufactured carbon**—a bonded granular carbon body whose matrix has been subjected to a temperature typically between 900 and 2400°C.

**manufactured graphite**—a bonded granular carbon body whose matrix has been subjected to a temperature typically in excess of 2400°C and whose matrix is thermally stable below that temperature.

**molded**—formed in a closed die by the application of external pressure.

**non-graphitizable carbon**—*in carbon and graphite technology*, a carbon which cannot be transformed into graphitic carbon solely by heat treatment up to 3000°C under inert atmosphere or reduced pressure (also known as a hard carbon).

**orientation (of a crystal)**—the angular position of a crystal described by the angles which certain crystallographic axes make with the frame of reference.

**orientation (of a grain)**—the angular position of a grain described by the angles which a defined set of axes of the grain make with the stated frame of reference. Generally used to characterize the axis of the grain that has the largest physical extent, for example, in a grain of needle coke.

**orientation (of an object)**—the angular position of an object described by the angles which a defined set of axes or surfaces of the object make with the frame of reference.

**oxidation of carbon**—the chemical combination of carbon with oxygen or oxygen-containing compounds.

**particle sizing**—segregation of granular material into specified particle size ranges.

**penetration**—the depths to which one material extends into or penetrates another.

**permeability**—a property measured by the rate of passage of a fluid under a pressure gradient through a material.

**porosity**—the percentage of the total volume of a material occupied by both open and closed pores.

**preferred orientation**—*in manufactured carbon and graphite product technology*, an alignment in the crystal or defect structure of a body leading to variations in physical properties as a function of direction; normally referenced to an orthogonal system where one of the axes is the working direction.

**pulse travel time ($T_t$)**—the total time, measured in seconds, required for the sonic pulse to traverse the specimen being tested, and for the associated electronic signals to reverse the circuits of the pulse-propogation circuitry.

**pyrolytic graphite**—*in carbon and graphite technology*, an artifact consisting predominantly of graphite which was deposited as a solid on a hot surface by cracking of gaseous or liquid hydrocarbons.

**reactivity**—rate at which another material will form compounds with carbon or graphite.

**surface finish**—the geometric irregularities in the surface of a solid material. Measurement of surface finish shall not include inherent structural irregularities unless these are the characteristics being measured.