



# Standard Terminology of Powder Metallurgy<sup>1</sup>

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## 1. Scope

1.1 This terminology standard includes definitions that are helpful in the interpretation and application of powder metallurgy terms.

## 2. Referenced Documents

2.1 *ASTM Standards:*

**B331 Test Method for Compressibility of Metal Powders in Uniaxial Compaction**

## 3. Terminology

3.1 *Powder*—Terms associated with production, characterization, use, and testing of metal powders.

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#### 3.1.2 General:

*agglomerate, n*—several particles adhering together.

*metal powder, n*—particles of elemental metals or alloys, normally less than 1000  $\mu\text{m}$  (1 mm) in size.

*particulate matter, n*—see **powder**.

*PM, n*—the acronym for powder metallurgy.

*powder, n*—particles that are usually less than 1000  $\mu\text{m}$  (1 mm) in size.

*powder metallurgy, n*—the production and utilization of metal powders.

#### 3.1.3 Processes to Produce Powder:

*air classification, n*—the separation of powder into particle size fractions by means of an air stream of controlled velocity.

*atomization, n*—the dispersion of a molten metal into particles by a rapidly moving gas or liquid stream or by mechanical means.

*chemical deposition, n*—the precipitation of one metal from a solution of its salts by the addition of another metal or reagent to the solution.

*chemically precipitated metal powder, n*—powder produced by the reduction of a metal from a solution of its salts either by the addition of another metal higher in the electromotive series or by other reducing agent.

<sup>1</sup> This terminology is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.01 on Nomenclature and Technical Data.

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*classification, n*—separation of a powder into fractions according to particle size.

*disintegration, n*—the reduction of massive material to powder.

*gas classification, n*—the separation of powder into particle size fractions by means of a gas stream of controlled velocity.

*granulation, n*—the production of coarse metal particles by pouring the molten metal through a screen into water (shotting) or by violent agitation of the molten metal while solidifying.

*milling, n*—the mechanical treatment of metal powder, or metal powder mixtures, as in a ball mill, to alter the size or shape of the individual particles or to coat one component of the mixture with another.

*pulverization, n*—the reduction in particle size of metal powder by mechanical means, a specific type of disintegration.

*reduced metal powder, n*—metal powder produced, without melting, by the chemical reduction of metal oxides or other compounds.

#### 3.1.4 Types of Powder:

*atomized metal powder, n*—metal powder produced by the dispersion of a molten metal by a rapidly moving gas, or liquid stream, or by mechanical dispersion.

*carbonyl powder, n*—a metal powder prepared by the thermal decomposition of a metal carbonyl.

*comminuted powder, n*—a powder produced by mechanical attrition of solid metal or powder.

*completely alloyed powder, n*—see **pre-alloyed powder**.

*composite powder, n*—a powder in which each particle consists of two or more distinct constituents.

*dendritic powder, n*—particles, usually of electrolytic origin, having the typical pine tree structure.

*diffusion-alloyed powder, n*—a partially alloyed powder produced by means of a diffusion anneal.

*electrolytic powder, n*—powder produced by electrolytic deposition or by the pulverization of an electrodeposit.

*hybrid-alloy powder, n*—a pre-alloyed or diffusion-alloyed powder to which either elemental or master-alloy metal powders have been admixed.

*hydrogen-reduced powder, n*—powder produced by the reduction of a metal oxide in an atmosphere containing hydrogen.

*master-alloy powder, n*—a powder with high alloy concentration, designed to be diluted when mixed with a base powder to produce the desired composition.

*matrix metal, n*—the continuous phase of a polyphase alloy or mechanical mixture; the physically continuous metallic constituent in which separate particles of another constituent are embedded.

*mechanically alloyed powder, n*—a composite powder produced by mechanically incorporating other constituents which are generally insoluble within the deformable particles of the matrix metal.

*mixed powder, n*—see **powder mixture**.

*nanopowder, n*—a powder consisting of particles typically less than 100 nm in size.

*partially alloyed powder, n*—a powder in which the alloy addition or additions are metallurgically bonded to an elemental or pre-alloyed powder.

*powder mixture, n*—a powder made by mixing two or more powders of differing chemical composition, particle size distribution, particle shape, or a combination of these characteristics.

*pre-alloyed powder, n*—powder composed of two or more elements that are alloyed in the powder manufacturing process in which the particles are of the same nominal composition throughout. Synonymous with **completely alloyed powder**.

*premix, n*—a uniform mixture of ingredients to a prescribed analysis, prepared by the powder producer, for direct use in compacting powder metallurgy products.

*sponge iron, n*—a coherent, porous mass of substantially pure iron produced by solid-state reduction of iron oxide (for example, iron ore or mill scale).

*sponge iron powder, n*—ground and sized sponge iron, which may have been purified or annealed or both.

*spongy, n*—a porous condition in metal powder particles usually observed in reduced oxides.

#### 3.1.5 Shapes of Powder Particles:

*acicular powder, n*—needle-shaped particles.

*flake powder, n*—flat or scale-like particles whose thickness is small compared with the other dimensions.

*granular powder, n*—particles having approximately equidimensional nonspherical shapes.

*irregular powder, n*—particles lacking symmetry.

*needles, n*—elongated rod-like particles.

*nodular powder, n*—irregular particles having knotted, rounded, or similar shapes.

*platelet powder, n*—a powder composed of flat particles having considerable thickness (as compared with flake powder).

*spherical powder, n*—globular-shaped particles.

#### 3.1.6 Additives to Powder:

*binder, n*—a cementing medium; either a material added to the powder to increase the green strength of the compact, and which is expelled during sintering; or a material (usually of relatively lower melting point) added to a powder mixture for the specific purpose of cementing together powder particles which alone would not sinter into a strong body.

*dispersion-strengthened material, n*—a material consisting of a metal and finely dispersed, substantially insoluble, metallic or nonmetallic phase.

*feedstock, n*—in metal injection molding (MIM), a moldable mixture of metal powder and binder.

*lubricant*—material used to reduce inter-particle friction and the friction between the powder mass and the tooling.

*lubricant (admixed), n*—a lubricant incorporated into a powder mixture.

*lubricant (die-wall), n*—a lubricant applied to the tooling surfaces to facilitate ease of movement of the tooling and the removal of the compact or part from the tooling.

*pore-forming material, n*—a substance included in a powder mixture that volatilizes during sintering and thereby produces a desired kind and degree of porosity in the finished compact.

#### 3.1.7 Treatment of Powder:

*blending, n*—the thorough intermingling of powders of the same nominal composition (not to be confused with mixing).

*cross-product contamination, n*—the unintentional mixing of powders with distinct differences in either physical characteristics or chemical composition or both.

*equalizing, n*—see **blending**.

*mixing, n*—the thorough intermingling of powders of two or more materials.

### 3.1.8 Properties of Powder:

*angle of repose, n*—the basal angle of a pile formed by powder when freely poured under specified conditions onto a horizontal surface.

*apparent density, n*—the mass of a unit volume of powder, usually expressed as grams per cubic centimetre, determined by a specified method.

*bulk density, n*—the mass per unit volume of a powder under nonstandard conditions, for example, in a shipping container (not to be confused with apparent density).

*compactibility, n*—a conceptual term, encompassing the powder characteristics of compressibility, green strength, edge retention, and lamination tendency, that relates to the ability of a powder to be consolidated into a usable green compact.

*compressibility, n*—the capacity of a metal powder to be densified under a uniaxially applied pressure in a closed die.

DISCUSSION—Compressibility is measured in accordance with Test Method B331 and may be expressed numerically as the pressure to reach a specified density, or alternatively the density at a given pressure.<sup>2</sup>

*compression ratio, n*—the ratio of the volume of the loose powder to the volume of the compact made from it. Synonymous with **fill ratio**.

*cut, n*—see **fraction**.

*fill ratio, n*—see **compression ratio**.

*finest, n*—the portion of a powder composed of particles which are smaller than a specified size, currently less than 44 µm. See also **superfines**.

*flow rate, n*—the time required for a powder sample of standard weight to flow through an orifice in a standard instrument according to a specified procedure.

*fraction, n*—the portion of a powder sample that lies between two stated particle sizes. Synonymous with **cut**.

*green density, n*—the mass per unit volume of an unsintered PM part or test specimen.

*hydrogen loss, n*—the loss in weight of metal powder or of a compact caused by heating a representative sample for a specified time and temperature in a purified hydrogen atmosphere—broadly, a measure of the oxygen content of the sample when applied to materials containing only such oxides as are reducible with hydrogen and no hydride-forming element.

*impregnated density, n*—the mass per unit volume of a sintered PM part or test specimen, impregnated with oil or other lubricants. Synonymous with **density (wet)**.

*minus sieve, n*—the portion of a powder sample which passes through a standard sieve of specified number. (See **plus sieve**.)

*oversize powder, n*—particles coarser than the maximum permitted by a given particle size specification.

*particle size, n*—the controlling lineal dimension of an individual particle as determined by analysis with sieves or other suitable means.

*particle size distribution, n*—the percentage by weight, or by number, of each fraction into which a powder sample has been classified with respect to sieve number or microns. (Preferred usage: “particle size distribution by frequency.”)

*plus sieve, n*—the portion of a powder sample retained on a standard sieve of specified number. (See **minus sieve**.)

*segregation, n*—the separation of one or more constituents of a powder, for example, by particle size or chemical composition.

*sieve fraction, n*—that portion of a powder sample that passes through a standard sieve of specified number and is retained by some finer sieve of specified number.

*sintered density, n*—the mass per unit volume of a sintered PM part or test specimen not impregnated with oil or other lubricant. Synonymous with **density (dry)**.

*specific surface, n*—the surface area of one gram of powder, usually expressed in square centimetres.

*subsieve fraction, n*—the portion of powder passing through a 45-µm (no. 325) sieve.

*superfines, n*—the portion of a powder composed of particles that are smaller than a specified size, currently less than 10 µm.

*tap density, n*—the apparent density of the powder in a container that has been tapped under specified conditions.

### 3.1.9 Procedures to Evaluate Powder:

*screen analysis, n*—see **sieve analysis**.

*sieve analysis, n*—particle size distribution; usually expressed as the weight percentage retained upon each of a series of standard sieves of decreasing size and the percentage passed by the sieve of finest size. Synonymous with **screen analysis**.

*sieve classification, n*—the separation of powder into particle size ranges by the use of a series of graded sieves.

### 3.1.10 Equipment to Evaluate Powder:

*powder flow meter, n*—an instrument for measuring the rate of flow of a powder according to a specified procedure.

3.2 *Forming*—Terms associated with consolidation of metal powders and mixes, including tooling, equipment, and characterization of sintered compacts.

#### 3.2.1 General:

*blank, n*—a pressed, presintered, or fully sintered compact, usually in the unfinished condition, requiring cutting, machining, or some other operation to give it its final shape.

*briquet, n*—see **compact**.

*compact, n*—an object produced by the compression of metal powder, generally while confined in a die, with or without the inclusion of nonmetallic constituents. Synonymous with **briquet**.

*composite compact, n*—a metal powder compact consisting of two or more adhering layers, rings, or other shapes of different metals or alloys with each material retaining its original identity.

<sup>2</sup> See Test Method B331.