Understanding pneumatic conveying lingo

Have you ever wondered about the difference between pneumatic conveying terms like *saltation velocity* and *minimum conveying velocity*? To make sure you and your coworkers are talking the same pneumatic conveying language, check out CEMA's definitions for the terms in this glossary.

Two categories of pneumatic conveying terms are defined: general and material characterization. [***Editor's note:*** Unless otherwise noted, the term *system* designates a pneumatic conveying system throughout this glossary.]

General

Material mass flowrate: The material mass flowrate is the mass of material conveyed over a specific time period, usually expressed in tons per hour or pounds per minute. This is also called *conveying rate* or *system capacity*.

Actual gas velocity: The actual gas velocity is the conveying gas's volume flowrate at pressure and temperature conditions per unit cross-sectional area of the empty pipe and is normally expressed in unit distance per unit time. Actual gas velocity varies throughout the pipeline's entire length.

Saltation velocity: A bulk material's saltation velocity is the actual gas velocity in a horizontal pipeline at which particles mixed homogeneously with the conveying gas will begin to fall out of the gas stream.

Choking velocity: A bulk material's choking velocity is the actual gas velocity in a vertical pipeline at which particles mixed homogeneously with the conveying gas will settle out of the gas stream.

Minimum conveying velocity: A bulk material's minimum conveying velocity is the lowest gas velocity that can be used to ensure stable pneumatic conveying conditions for the material. Because the minimum conveying velocity occurs at the system's material feed point, this velocity is also known as the *pickup velocity*. These terms are generally applied to dilute-phase systems.

Terminal gas velocity: The terminal gas velocity is the velocity of the gas as it exits the system. This is also known as the *ending gas velocity* and *conveying line exit velocity*.

Average gas velocity: A system's average gas velocity (also called *mean gas velocity*) is usually defined as the mean of the beginning gas velocity (also called *minimum conveying velocity* or *pickup velocity*) and the terminal gas velocity.

Material velocity: The material velocity is the velocity of the material itself and is somewhat lower than the gas velocity. The material velocity is usually specified as either average (or *mean*) velocity or terminal velocity. The actual material velocity is estimated because no reliable way to measure it currently exists.

Volumetric gas flow: Be aware that several different terms can be used to discuss volumetric gas flow. The volumetric gas flow during conveying is expressed as *free air delivered (FAD)*. Most air movers, such as blowers and compressors, are specified in terms of FAD, which is measured in standard cubic feet per minute (scfm). FAD is the volumetric gas flow at the suction port of a positive-pressure blower or compressor or at the discharge port of a vacuum blower or vacuum pump.
The volumetric gas flowrate at standard atmospheric conditions (barometric pressure at sea level, 68°F, and 36 percent relative humidity) is measured in scfm. Actual cubic feet per minute (acfm) and inlet cubic feet per minute (icfm) indicate the volumetric gas flow in the actual conditions where the blower or compressor is located. These measurements must be calculated from the scfm, taking into account the location's elevation and maximum summertime ambient conditions. For a vacuum system, also consider the system's pressure drop when calculating the gas flow at the blower inlet.

Conveying pressure: The conveying pressure for any system is that required to overcome resistance in the system caused by the interaction between the conveying gas, the conveyed material, the pipeline, and other system components. This resistance is also called *pressure drop*. The conveying pressure is the difference measured between the system's beginning and end; it applies to both positive-pressure and negative-pressure (vacuum) systems.

Two-phase flow: All systems for bulk materials operate on a two-phase flow principle: a solid phase (the conveyed material) and gaseous phase (the conveying gas).

Dilute-phase conveying: In dilutephase conveying, the conveying gas velocity is generally equal to or higher than the conveyed material's saltation velocity.

Dense-phase conveying: In densephase conveying, the conveying gas velocity is generally lower than the conveyed material's saltation velocity.

Material-to-air ratio: The materialto-air ratio is the ratio of the mass of material conveyed to the mass of conveying gas used. Other terms for this are *phase density, solids loading ratio*, and *mass flow ratio*.

Flotation velocity: The flotation velocity is the velocity at which a bulk material will be suspended in gas. Knowing this velocity is critical to determining *enclosure velocity*, which is the gas's upward velocity in a filter receiver or bin vent. This term is typically used in designing dust collection systems.

Material characterization

Loose bulk density: A bulk material's loose bulk density (sometimes called the *poured bulk density*) is the unit weight per unit volume (usually pounds per cubic foot) measured when the sample is in a loose, noncompacted(or poured) condition. The loose bulk density *can* be close to the "as conveyed" bulk density, but the former is preferred for system design.

Packed bulk density: A bulk material's packed bulk density is the unit weight per unit volume (usually pounds per cubic foot) measured after the sample has been packed or compacted in a silo, bin, or other container or transported in a container. The packed bulk density doesn't compare with the conditions found in a pneumatic conveying system, so loose bulk density is preferred for system design.

Fluidized bulk density: The fluidized bulk density is the apparent bulk density of a material in its fluidized state and is generally lower than either the loose or packed bulk density because air is entrained in the voids between fluidized particles.

Particle density: Particle density is a particle's mass divided by its volume. For a bulk material, the *average particle density* is used, calculated by dividing the material's mass by the material's volume (excluding the voids).

Particle size distribution: A bulk material's particle size distribution is a tabulation of the percentage of particles by mass in each particle size range. The percentage is either that *passing* or *being retained on* a screen with a specific aperture size. Other size analysis methods can be used, especially for powders that are very fine or cohesive (or both). [***Editor's note:*** For more information on these methods, see Dr. Michael Pohl's article, "Technology update: Particle sizing moves from the lab to the process," *Powder and Bulk Engineering,* February 1998, pages 39-46.

Maximum particle size: Maximum particle size is the maximum lump dimension in inches for a lumpy bulk material; for a bulk powder or granules, it's the maximum sieve size of the largest lump or particle.

Median particle size: The median particle size is the particle size distribution's median size or midpoint.

Particle shape: The shape and form of a bulk material's particles can vary considerably. The following terms describe an individual particle's shape; particles of several shapes are typically found in one bulk material.

■ *Needle-like:* Long, thin, rigid, straight, and pointed.

■ *Angular:* Sharp-edged or multifaced and irregular.

■ *Crystalline:* Geometrically shaped or multifaced and irregular.

■ *Dendritic:* Branched and crystalline, with branches extending from the particle's faces.

■ *Fibrous:* Flexibly structured, thread-like, and either regular or irregular.

■ *Flaky:* Plate-like.

■ *Spherical:* Globe-like.

■ *Out-of-round:* Basically spherical but somewhat deformed and elongated.

■ *Cylindrical:* Cylinder shaped.

■ *Agglomerated:* Several particles bonded together.

Bulk material composition: The following terms describe a bulk material's general composition.

■ *Uniform:* A bulk material in which all particles have the same size and shape.

■ *Nonuniform:* A bulk material with particles of different sizes and shapes.

■ *Granular:* A bulk material in which one can see individual particles.

■ *Powder:* A bulk material in which one can't see individual particles.

■ *Mixed:* A combination of two or more different bulk materials.

Flowability: A bulk material's flowability is the ease with which the material flows by gravity alone.

Cohesiveness: A bulk material's cohesiveness is the material's tendency to adhere to itself. This is caused by any and sometimes all of these factors: electrostatic charging, surface Powder and Bulk Engineering, March 1998 2 tension effects, and interlocking of certain particle shapes, particularly fibrous shapes. Cohesiveness can cause erratic flow from bins, pipeline feeding problems, and adverse effects in some valve types.

Adhesiveness: A bulk material's adhesiveness can be described as *external cohesiveness* — that is, the material's tendency to adhere to other surfaces.

Fluidized: A material is fluidized when a gas has been entrained in the voids between the particles. In a highly fluidized state, the material tends to behave more like a fluid than a solid. Not all materials can be fluidized.

Aeration: Aeration is introducing air (or another gas) to a bulk material by any means. Aeration can cause the material to become agitated or fluidized.

Angle of repose: A bulk material's angle of repose is the angle between the material heap's sloping surface and horizontal. The heap must be allowed to form naturally without any conditioning, usually by gravity flow from a funnel or similar device.

Hardness: A bulk material's hardness contributes to its overall abrasiveness: The harder a material is, generally the more it will erode a conveying pipeline for a given material velocity. Hardness is difficult to quantify and is somewhat subjective when described. The Mohs material hardness scale is used for pneumatic conveying system design.

Abrasiveness: A bulk material's abrasiveness is determined by its hardness factor and particle shape. For instance, a material with a high Mohs hardness factor and sharp angular particles is considered highly abrasive.

Material temperature: The material temperature is the temperature of the material itself, rather than of the conveying gas or system components. For the purpose of system design, the material temperature (in degrees Fahrenheit or Celsius) is that taken at the material's entry point to the system. Most bulk materials are handled at ambient temperature conditions. But in some cases a material is handled at an elevated temperature, which can affect the condition of both the material and its surroundings — particularly of the equipment conveying the material. To effectively handle a high-temperature material, be sure to clearly and accurately state the material's temperature range and any effects temperature has on the material's properties, especially handling characteristics.

Material temperature sensitivity: Material temperature sensitivity is indicated by a change in a bulk material's handling characteristics at a specific temperature.

Hygroscopicity: Hygroscopicity is a bulk material's ability to absorb moisture from its surroundings. Moisture can be absorbed from either the ambient air (especially during high-humidity conditions) or the system's conveying air.

Explosiveness: A bulk material's explosiveness involves the material's explosion risk, reactivity, and fire hazard. In certain conditions, some bulk materials can form potentially explosive mixtures when combined with air. These conditions depend on the material's nature (including the material's ignition temperature, chemical reaction with oxygen, particle size distribution, and so on) and the nature of the operation handling the material. In the US, most states require a Material Safety Data Sheet (MSDS) that details the material's explosion risk, reactivity, and fire hazard to accompany any material that is transported, stored, or tested. When designing a system to handle an explosive material, refer to National Fire Protection Association classifications.1

Corrosiveness: Corrosiveness is the tendency of some bulk materials — when combined with other substances such as air or moisture — to cause the equipment's contact surfaces to chemically deteriorate.

Friability: Friability describes the tendency of a bulk material's particles to easily crumble or pulverize.

Permeability: A bulk material's permeability is the degree to which air (or another gas) can be passed through the voids between the particles.

Air retention: A bulk material's air retention is the material's ability to retain air (or another gas) in the voids between particles after the air or gas supply has been stopped. The time a material retains air can vary from almost no time to several days, depending on the material's other characteristics.

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This tip is adapted from* Pocket Glossary of Pneumatic Conveying Terms, *CEMA Standard 805.

Reference

1. To obtain information or receive copies of the latest editions of National Fire Protection Association guidelines or standards, contact NFPA at 1 Batterymarch Park, Quincy, MA 02269; 800/344-3555.