THE PROPERTIES OF SOLIDS

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All material handling systems begin with a thorough review of the particulate solid(s) being handled or processed.

Once the flow properties of a solid are quantified, flow problems that occur with a given material can be predicted and handled, preferably in the initial design stage.

Understanding a material's characteristics and how to apply these properties is essential for a safe, efficient and trouble free system.

Particle solid materials can be divided into (5) five distinct classifications.

Each material classification possesses properties which set it apart from the others.

Material classification is the first step in evaluating a particulate solids ability to flow with or without problems. The main properties of the five material classes are most directly related to particle size and shape, and adhesive/cohesive tendencies.

These five general classifications are for particle solid materials considered ready for processing.

Any bulk materials that do not specifically fit into one of these five classifications are those materials that may require size reduction (or pre-treatment) in order to be further processed.

Merely placing a material into one of five groups however is not the only consideration needed for proper equipment or system design. The unique properties of the material being handled must now be thoroughly evaluated, and consideration made as to how it effects the system and flowability.


Abrasive Materials


Materials which Fluidize or Liquify


Hazardous Materials


Large Particles


Contamination-Sensitive Products


Products which Pack, Cake Smear or Plug


Non-Free Flowing Materials


Free-Flowing Materials


Moist, Sticky Materials


Heterogenious Mixtures


Friable Materials

CLASS 1- GRANULAR, FREE-FLOWING

These are the easiest types of materials to store, discharge and convey. Uniform particle size may vary from 1/16" to ¾". These granular materials are generally "hard" particles that exhibit minimum degradation in storage under head loads or any cohesive/adhesive tendencies. Particle length to diameter ratio are close to 1:1.

Uniform particles refer to a single bulk material whose particles posses the same size and shape. A granular material is a bulk material comprised of individual particles which can be visibly discerned. These may be crystalline as well (of geometric shape or multi-faced regular shape).

Typical examples are:
•Plastic Pellets
•Coated Prills (cylinder, spheres, or hot melts).
•Coarse Silica Sand (FRAC SAND)
•Uniform Aggregate (crushed stone)
•Pelletized Feed (Pet Food)
•ION Exchange Resin
•Agglomerated and Cured Powders

A natural repose angle of up to 20 degrees


Coarce Salt


Plastic Pellets


Pelletized Feed


Coarse Frac Sand


Coated Prills


ION Exchange Resin


Uniform Aggregate

CLASS 2 – POWDERS, SLUGGISH

These materials are powders (a bulk material comprised of individual particles which cannot be readily discerned), ranging in size from 20 – 200 mesh.
They posses a slight cohesive tendency but are generally handled without too much of a problem.

This may be a non uniform particle distribution (a single bulk material whose particle size and shape may vary). These are materials that have fairly uniform handling properties.
These may be angular (sharp-edged or having a multi-faced, irregular shape) particles, or out of round.

Typical examples are:
•Baker's Flour
•Limestone
•Fluorspar
•Pulverized Ore
•Ground Coal or coke
•Soda Ash

A natural repose angle of up to 35 degrees.

Ground Coal or coke

Baker's Flour

Limestone

Pulverized Ore

Fluorspar

Soda Ash

Ground Coal or coke

CLASS 3 – POWDERS, FLUIDIZABLE

These materials are generally of fine particles size, 200-325 mesh (or smaller). They are slightly permeable (Definition- The permeability of a bulk material is a degree to which air (or other gas) may be passed through the void spaces between the particles of the material). Gas entrained during conveying does not readily "percolate" out.

Air retention capability can vary between zero to several days, depending upon other physical properties. The entrained gas gives the material a "liquid" or fluidized appearance.

"Fluidized" describes the state some materials achieve when gas has entrained into the void spaces between the particles of the material. This phenomenon results in special hydraulic loads being applied to system equipment which are not generally present under standard bulk density levels.

Typical examples are"
•Hydrated Lime
•Cement
•Silica Gel
•Starch
•Fly Ash
•Fine Clays
•Polymers
•Powdered Sugar
•Carbon Black

Starch

A natural repose angle of 30 – 40 degrees.

Hydrated Lime

Fly Ash

Silica Gel

Carbon Black

Fine Clays

Cement

CLASS 4- POWDER, SLUGGISH, ADHESIVE/COHESIVE

These materials are powders ranging from 50 – 325 mesh (and smaller) that are adhesive and/or cohesive.

The particle shape may be dendritic (having a branched, crystalline shape with the “branches” extending from the faces of the main body) or agglomerated (several individual particles bonded together). The particle configuration may cause both internal cohesion or external adhesion. They posses characteristics that may drastically change during handling due to impact from other property alterations. Changes in environment and process may cause major changes in their flowability.

Examples Are:
•Pigments (TiO2, iron oxide, organic dyes)
•Centrifuge Cake
•Fluorocarbons
•Sludges
•Metal Oxides
•High fat content bakery products
•Calcium Carbonate

Natural repose angle up to 60 degrees.

High fat content bakery products

Titanium Dioxide

iron oxide

Centrifuge Cake

Sludges

•Calcium Carbonate

Fluorocarbons

CLASS 5- FIBEROUS, FLOCULENT or FLAKY

The materials in this group are difficult to handle due to their non-uniform particle size and shape, non-uniform length to diameter ratios and their mechanical (physical) interlocking tendencies. These may be flaky (plate like), needle like, fibrous (regularly or irregularly thread like with a flexible structure).

Their mechanical interlocking properties generally result in the formation of a stable arch or dome inside storage hoppers or vessels causing a major flow problem. These materials will interlock, mat or form large agglomerates. Special designed storage and metering arrangements are needed.

Typical examples are:
•*Wood Chips*
•*Sawdust*
•*Plastic Regrind*
•*Fiberglass*
•*Chopped paper*
•*Peanut hulls.*

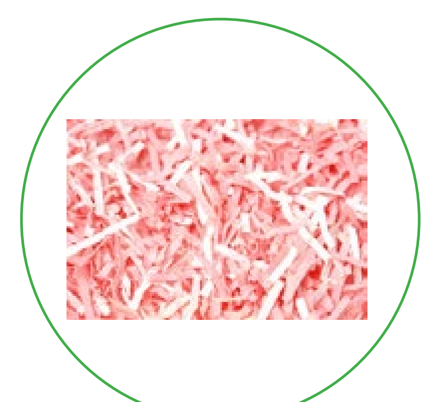
A natural repose angle of up to 90 degrees.

Coal

Wood Chips

Fiberglass

Sawdust



Chopped Paper

Plastic Regrind

Shells

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BASIC MATERIAL PROPERTIES/CHARACTERISTCS
Basic material properties can be readily tested using a number of different methods. ASTM, ASME (and other professional societies) CEMA, PEMA and individual equipment manufacturers also have their own set of standards and test data for determining specific flow properties.

Keep in mind various flow properties are subject to change and may be effected by a number of external variables. These external variables consist of, but are not limited to: moisture content, ambient humidity, temperature, retention time, changes in particles size, HUMAN ERROR, etc.

“Powders” are generally considered to be 100% minus 100 mesh.

Coarser particles are considered “granular”.
It is important to recognize that the basis for flow property testing is the precise definition and classification of materials according to their individual handling characteristics, under a specific combination of conditions, to reduce the variations as reference above.

Some of the properties to be considered are as follows:

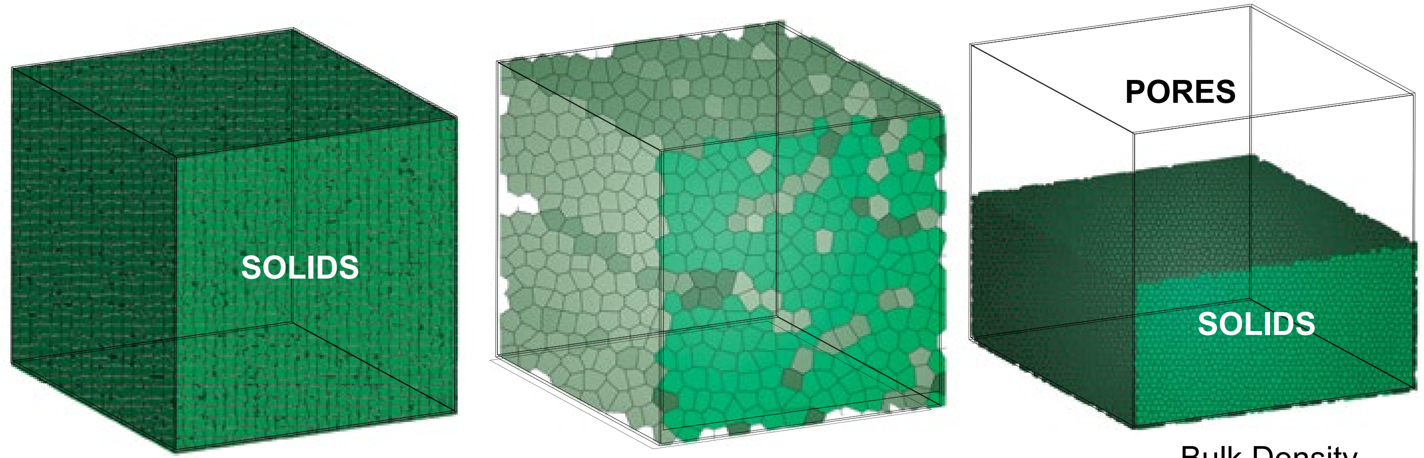
BULK DENSITY

Bulk density is a material’s weight per unit volume (i.e. lbs,/ft^3, gms/cc) and can be obtained in loose, (fluidized) packed or dynamic conditions. When large weight differences exist between the packed and loose bulk density, this may indicate that the material may be easily fluidized or is pressure-sensitive.

Bulk Density is important for:
A) Feed range computations for volumetric/gravimetric feeders
B) Calculating hopper or bin capacity
C) As a factor in determining compressive or compacting strength of a material that can occur in a hopper or bin.
D) Structural loads.

Bulk density should not be confused with specific gravity, since specific gravity refers to the density of an individual particle and not bulk quantities. Particle density is the mass of the particles divided by it’s volume.

Since wide variations can exist in bulk density, which directly affect the material handling system, devices, etc. this characteristic should be fully considered. Bulk density variations can occur within a specific generic material, manufactured by different companies, using different processes, etc



Particle Density

100% Solid
Weight = 2.66 grams
Volume = 1 cm^3

Bulk Density

50% Solid, 50% pore space
Weight =1.33 grams
Volume = 1 cm^3

Loose (fluidized) or Aerated Bulk Density is the material weight per unit volume, of a sample weighed which is in a “loose” or non-compacted condition. This is sometimes called the “poured” bulk density.

Packed Bulk Density is the weight per unit volume of a sample which has been packed or compacted in a vessel due to vibration caused by transportation. Auxiliary machinery, processing, or compressive head loads associated with storage bins.

Since bulk density variations do exist between aerated and packed conditions, dynamic bulk density should be used for calculations involving movement (i.e. of mechanical conveying, metering, etc.) This is also referred to as working bulk density. Note for bin-hopper loading and other structural considerations, packed bulk density is used.

Dynamic bulk density is a function of the aerated and packed density. It is the figure most often in computations.

BDW = (BDP –BDA) C + A

Where: BDW = Working Bulk Density, BDP= Packed Bulk Density, A= Aerated Bulk Density, C= Compressibility Factor.

Bulk density can vary due to changes in particle size distribution, particle shape, moisture content, head loads, flow velocities, material temperatures, friability, etc. Consideration to bulk density variations should be given when selecting metering and discharge devices.

COMPRESSIBILITY

Compressibility is another factor used t determine a flowability of a powder. When materials compress, the gas voids between particles are reduced and the material tends to become a solid mass.

This is very important property when determining flow characteristics of a powder. The more compressible a material is, the less flowable it will be. The less compressible, the more flowable.

When compressibility is above 20%, the powder is no longer considered free-flowing and may have a tendency to bridge in storage vessels, especially during extended storage time periods. The compacted condition is related to “head” or consolidation pressure over a specific time period. A highly compressible material may compact as it is charged into a storage vessel due to the impact of the falling particles.

On particles where the compressibility factor is above 35% and extended shutdown periods are experienced, a closed loop recycling system should be incorporated in the storage discharge conveying system to prevent flow problems and/or material alterations.

The compressibility value indirectly references:
A) Uniformity in particle size
B) Deformability / Friability
C) Surface Area
D) Cohesion
E) Moisture Content.

PARTICLE SIZE

Material particle size is a measured property pertaining to the entire mass of particles.

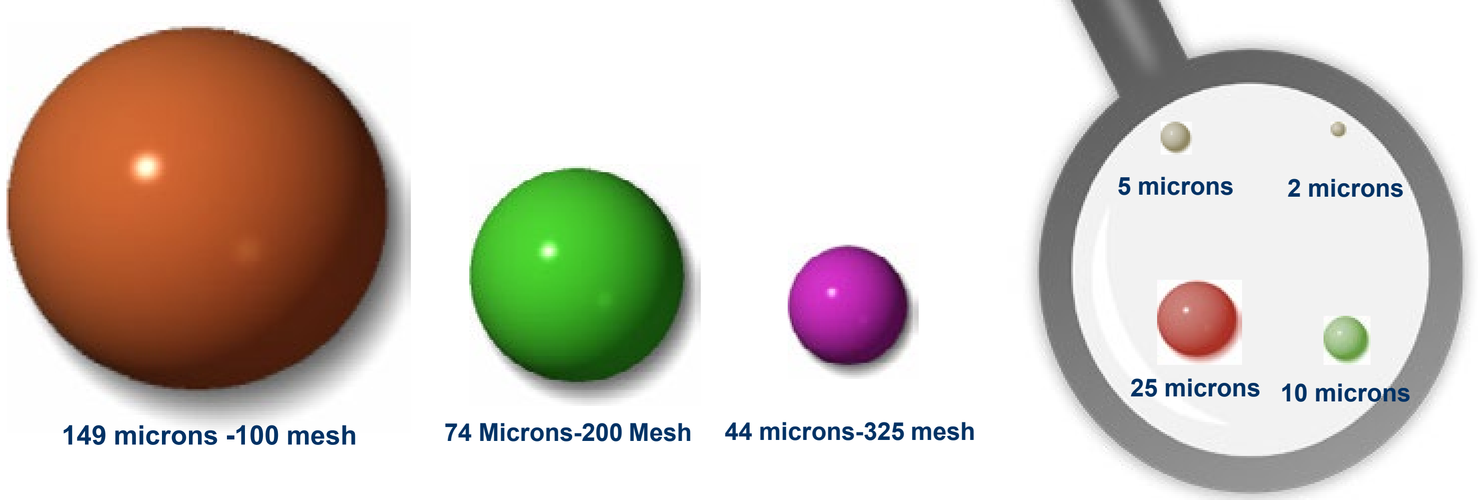
A representative sample of the bulk density is subjected to a standard shaking action with a series of U.S. test screens. The particles retained on a specific screen are recorded and a tabulation of the percent represented in each size range recorded.

A screen analysis and visual inspection (sometimes microscopic) of the material will indicate what the particle size amount of each size and shape of the individual particle exists, and how they vary within a specific material. It is highly unlikely that any natural material would be composed of 100% identically sized particles. A particle size distribution curve gives a visual picture of the screen analysis and size consistency of a sample. Particle size distribution will indicate how readily the material will segregate in the various components of the system.

Particle size will impact on feeder selection and vessel design. For example static hoppers, bin discharge outlets, feeder nozzles, etc. should be at least 6-8 particle diameters in size, when dealing with large lumpy particles

PARTICLE SIZE cont...

Magnification 500X



U.S. Sieve No.	Opening in inches	Opening in Microns
50	0.0117	297
60	0.009	238
70	0.0003	210
100	0.0059	149
140	0.0041	105
200	0.0029	74
270	0.0021	53
325	0.0017	44
paper	0.00039	10
paper	0.0019	2

Substance	Micron	Inch
Grain of Table Salt	100	0.004
Human Hair	70	0.0027
Lower Limit of Visability	40	0.00158
White Blood Cells	25	0.001
Talcum Powder	10	0.004
Red Blood Cells	8	0.0003
Bacteria (average)	2	0.00008
Smoke	.5	0.000025

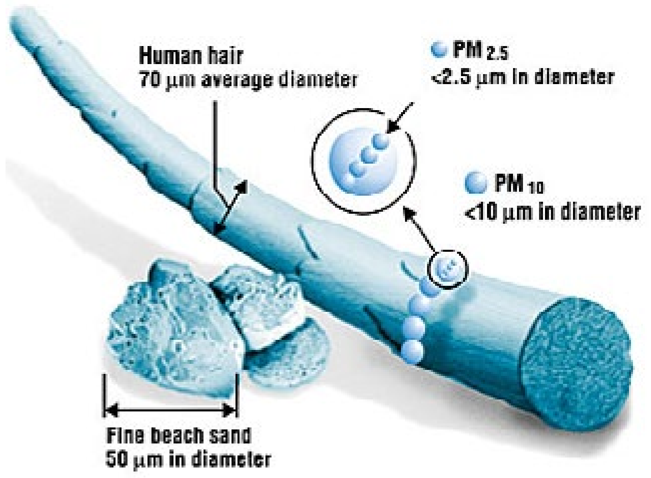


Image courtesy of EPA Office of Research and Development

ANGLE OF REPOSE

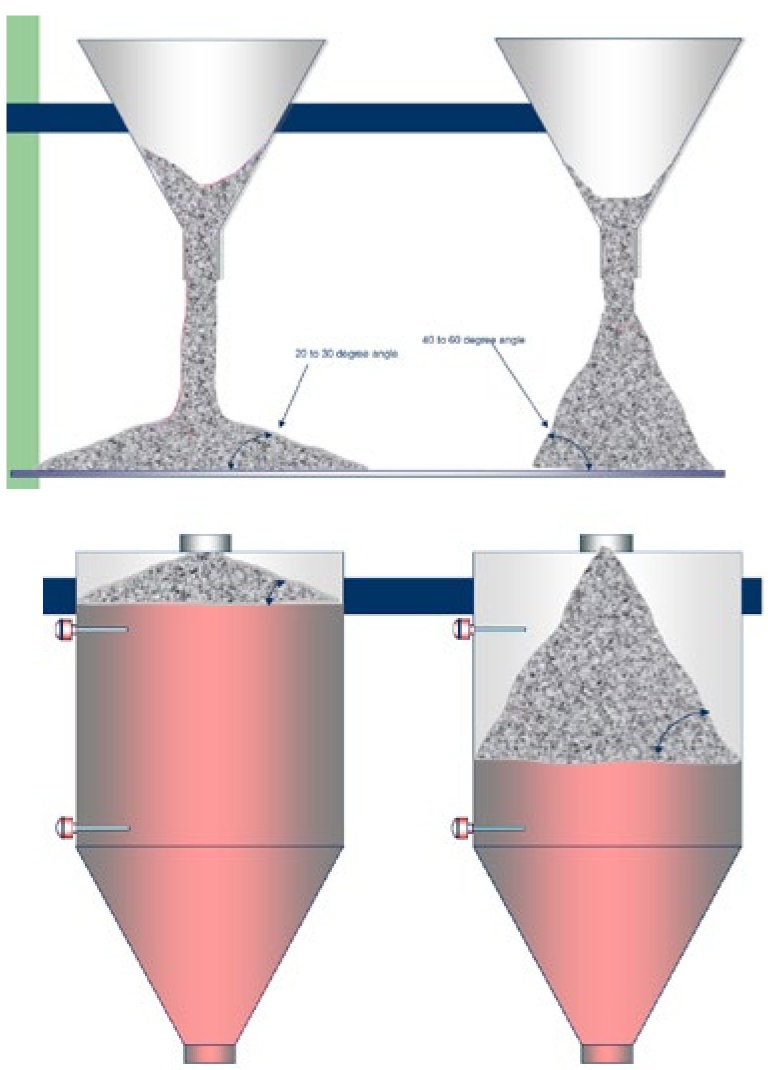
The angle of repose is defined as the angle from horizontal, that the material assumes when at rest, from the top of the pile to its base. The angle is determined between the horizontal and sloping surface of a “heap” of material which has been allowed to form naturally without and conditioning, usually by gravity flow from a funnel or other similar device. The angle of repose is useful for determining working vessel volume calculation of vessel loads, location of high/low level sensors, bed configuration as applied to belt feeders and also gives an indication of the materials flowability.

The lower the angle of repose of a dry material, the more flowable a material will be, and the more floodable a fluidizable material will be. Angle of repose is a direct indication of the potential flowability of a material. It indirectly measures properties affecting flow such as:

A) Particle shape and size
B) Porosity
C) Cohesion
D) Fluidity
E) Surface area and bulk

Repose angles will vary, subjected to particle size, uniformity, particle shape, moisture and temperature variations.

Flow Property	Angle of Repose (degrees)
Excellent	25-30
Good	31-35
Fair-aid not needed	36-40
passable-may hang up	41-55
Poor- must agitate, vibrate	46-55
Very Poor	56-65
Very, very poor	≥ 65

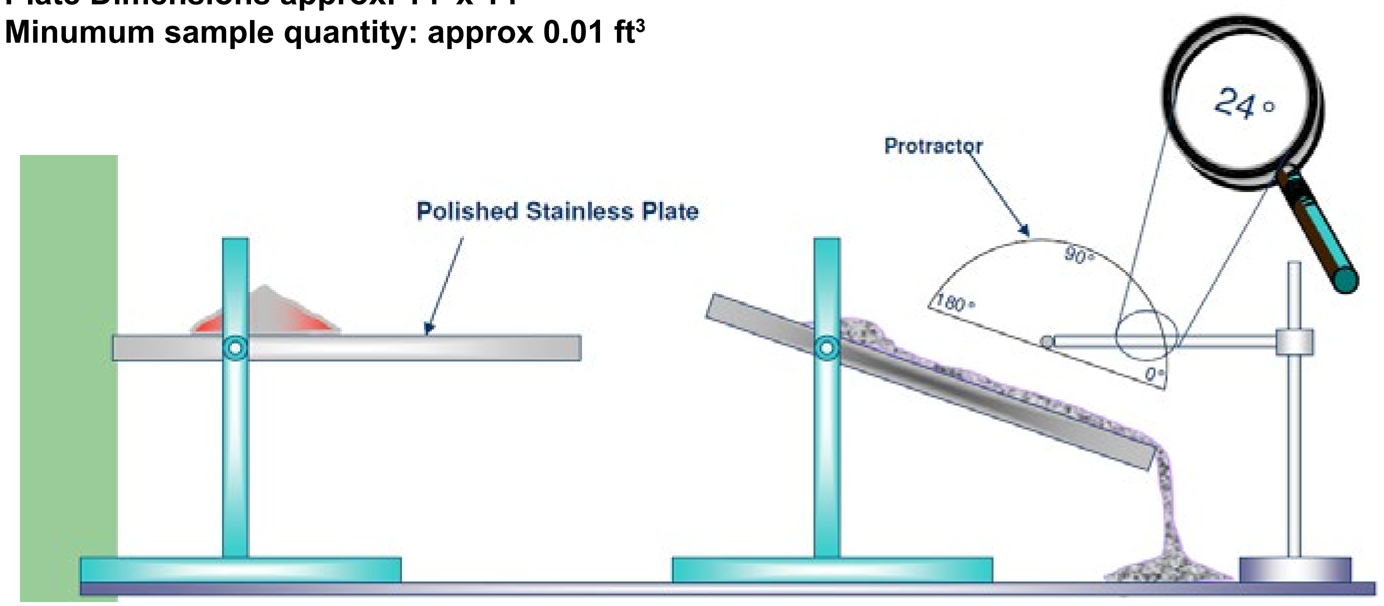


ANGLE OF SLIDE

The angle of slide of a material is the angle, to the horizontal, of an inclined flat surface on which a given quantity of material will begin to slide downward by its own weight. The angle of slide will vary with moisture content, particle size and shape, any type of surface the material is coming in contact with. For consistency, a polished stainless steel plate, with a number 4 polish is used.
Powders and some granular material are measured in this manner. Slide angles are used in the design of vessels, chutes, conveyors inclination and other angled surfaces. In Mass Flow calculations, the tangent of the slide angle is generally referred to as the coefficient of friction (dimensionless number).

For some class 5 materials , it is possible to have shallow slide angles, while having large repose ANGLES, PRIMARILY DUE TO MECHANICAL INTERLOCKING OF PARTICLES FOR REPOSE, AND LOW FRICTIONAL COEFFICIENT BETWEEN PARTICLES AND STEEL.

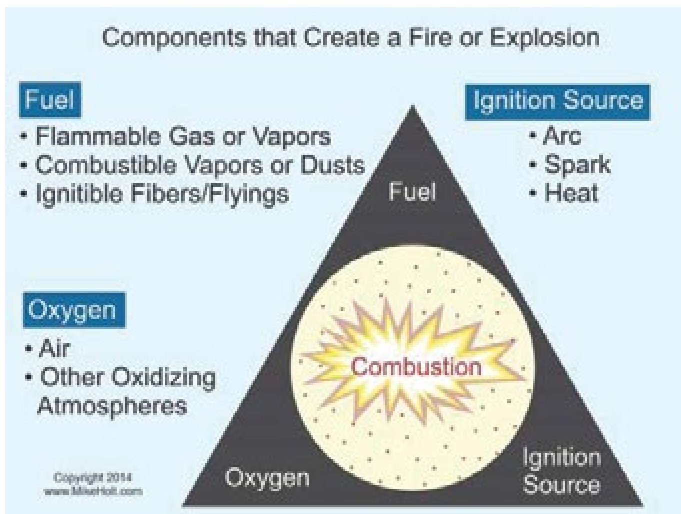
Plate Dimensions approx. 14”x 14”
Minumum sample quantity: approx 0.01 ft³



EXPLOSIVENESS

In certain conditions, fine organic particles with large surface areas may readily explode in the presence of air, when in the proper ratios. When storing combustible powders, the potential for explosion is present whenever these materials are moved into and out of the storage vessel or major component within the system.
In order for an explosion to occur, the dust must be combustible, have a source of ignition, and be mixed with oxygen in a proper ratio.

Most dry processing operations generate dust.
Generation points include:
dumping, filling, drying, feeding or weighing, mixing/blending, screening/classifying, size reduction, pneumatic conveying, emptying of bags, etc.



NEC CLASSIFICATIONS

LOCATION CLASSIFICATION

•Class

I	VAPOR
II	DUST
III	FIBER

• Division

1	Always Present
2	Present Under Fault Conditions

•Group

A	Acetylene
B	Hydrogen
C	Ethylene
D	Propane
E	Metal Dust
F	Carbon Dust
G	Grain Dust

TEMPERATURE

Most bulk materials are handled at ambient temperature conditions. However, process and ambient temperature may affect a material if the temperature involved induces a physical change or initiates a chemical reaction.
Elevated temperature can effect both material condition and equipment. Temperature changes can result in condensation forming within conveying lines, hoppers, metering devices, etc.

Pelletized material containing latent heat, when collected and stored, can result in a resolidification of all particles into a single mass or masses, of considerably larger size, that will not readily flow. Also, heat generated from the processing equipment (screw, bearings, etc.) should not initiate endothermic chemical reactions.

For example, a dry powdery mixture of material that flows readily from a container may become a “pasty” mass in pneumatic conveying lines due to an increase in the conveying air pressure, caused by the heat of compression in the air supply blower. Added heat also causes chemical reactions to occur, thus, seriously altering the material being handled. Therefore, the temperature at which a bulk material changes it’s characteristics should be identified.

This is an often overlooked material characteristic that can be troublesome.
Materials will begin to soften as the critical melting point is approached. Heat can be generated by a feed screw or by a pneumatic conveying system.

Good examples of this powdered wax (melting point around 125 degrees F), plastic materials, sugars, etc

This material has reached its melting point in the feeder tube.
Tube temperature 98°, screw rpm 28.

MOISTURE

Moisture content is divided into three areas: inherent (water of hydration), surface moisture (free moisture) and bound moisture.(FeCL3.6H2O)

Inherent moisture content refers to water molecules contained in a material particle as part of its chemical composition (i.e. FeCL3.6H2O) This is also called "chemically bound water".

This "water of hydration" is sometimes difficult to remove. Often high temperature processing is required in order to "drive off" the inherent water molecules, and when removed, very often alters the material's flow characteristics.

Surface moisture, as the name implies, is water that is contained on the surface (or "pores of the material). This absorbed water is water "mechanically" held in place. Surface moisture is removed through various drying processes. This moisture may also be contained "interstitial", that is, in the air gap between adjourning particles. This water is held in place by physical chemical forces. The amount of moisture caught in the interstitial air between crystals is in direct relation to the temperature of the air and the condition of the material crystal.

Bound moisture is very similar to surface moisture. Bound moisture is moisture trapped on the surface of particles, which have been coated with finer particles which are somewhat difficult to remove. Bound moisture migration has long been known to be a cause caking and flowability problems with many materials. (i.e. sugar) moisture migration is caused by movement from the warm interstitial air to the cooler exterior surfaces.

Moisture content is further defined as "the ratio of the weight of water to the dry solids in a given quantity of material". In a simple lab test, samples are prepared and weighed, dried at elevated temperatures (around 110 degrees C), and re-weighed to determine water loss. Samples are placed in a desiccant drying vessel while awaiting weighing. A very simple and common means for performing a moisture check is by means of an Infrared Moisture Balance.

Moisture content effects solid materials in many different ways. An increase in surface moisture may result in a material becoming free-flowing; such as in the case of mason sand or coke breeze, and many other granular Class 1 materials. The water acts as a "lubricant", reducing the frictional effects one particle has upon the other; thus, increasing the flowability of the material.

Some materials, however, such as color concentrates, class 4, bauxite ore, clays, and many other finely divided powders with non-uniform particle shapes, became more difficult to convey and discharge from a storage tanks. In such cases, the surface water acts as a bonding agent between particles.

Some materials exhibit an increased difficulty in handling with an increase in moisture content. This occurs up to a "breakpoint". At the breakpoint level, flowability increases. A good example is bauxite ore (-1/4" and fines). Extreme handling problems are present in the 16-22% moisture content range; with compressibility increasing above 60%. However, above 22% and below the 16% surface moisture content, the material can be successfully handled.

Moisture content should not be confused with solvent, fat or oil content, which behaves somewhat differently, primarily due to differences in surface vapor pressure and it's ability to "air dry". A non-corrosive powder may become corrosive with added moisture or a free-flowing powder, cake, solidify a cease to flow. Moisture in a bulk material is presumed to be solely water which can be evaporated by conventional drying methods.

COHESIVNESS

Cohesiveness is defined as the extent individual particles tend to cling together or form an inter-particle bond. The cohesiveness of a bulk solid material can be caused by any number of factors. These include tribo-electrification (electrostatic attraction), surface tension effects, and particle interlocking of certain non-uniform shapes.

Cohesion is often referenced when dealing with powders having a very fine particle size or with materials on which effective cohesion force can be measured. Cohesion is consolidated granules or fine powder under pressure may be expressed in terms of shear force required to overcome the internal friction in the material to cause the material to yield. (as in a shear test cell). "uniformity" refers to granular and powdered granular materials on which an effective surface cohesion cannot be measured.

Cohesion is therefore, a force existing on a surface of fine particles that are composed of million of atoms or molecules. A material with cohesive properties will tend to bridge or dome in bins, hopper or feeder troughs. A powder has lesser flowability when it has a higher cohesion percentage. Cohesion percentage is a direct measurement of the amount of energy necessary to pull apart aggregates of cohesive particles in a specific time, as demonstrated in a shear cell test apparatus.

Fig.1. Two typical heap shapes. (a) Conical heap shape obtained with a non cohesive granular sugar. (b) Irregular heap of powdered sugar which is a cohesive granular material (1)

FLOODING TENDENCIES

Dry, very fine bulk solids (usually -200 mesh) can often be easily aerated. If so, they probably are "floodable". Extra care must be taken to minimize aeration as the flow pattern develops to maintain near uniform densities as the material flows from storage for reasonably accurate volumetric feeding. Or, to prevent the material from flushing through the feeding device below, totally uncontrolled.

To estimate the flooding tendencies of a bulk solid, take a handful of the material and make a squeeze fist very quickly. If the material squirts through your figures easily, floodable tendencies exist. For comparison, household flour has only moderate flooding tendencies; whereas, warm fly ash, hot stucco or carbon black are extremely floodable.

Hydrated lime, fly ash, kaolin clay, pesticides, virtually all the different "dusts" from dust collectors, acetylene black, carbon black, stucco, bentonite, talcum powder, diatomaceous earth, cement, ink dyes, powdered milk, dextrose, powdered sugar, or anything similar exemplify bulk solids that are floodable.

ADHESIVENESS

The tendency of the material to adhere or accumulate on dissimilar surfaces is its adhesiveness. This can also be called "external cohesiveness" Material build-up due to adhesion can cause "blinding off" of chutes, hoppers, plugging of conveying lines, vent ducts or screws, and output reduction of feeders. Some factors effecting adhesiveness include moisture, temperature, static forces, particle size and shape.

Electrostatic charges can cause agglomeration and adhesion, impairing flow, in addition to potential detonation. To avoid electrostatic charges, minimize the charge, minimize the discharging (mechanical); reutilize using ions. Equipment should be well grounded. Metal surfaces should be smooth, crevice free, in order to minimize the material adhesion. Super slick surfaces, (Teflon, UHMW materials, chrome plate, electro polishing) should be used. Material adhesion is a detriments in low output feeders.

FRIABILITY

The friability of a material is the ability to be readily broken crumbled or ground into smaller particles as a result of impact, agitation or attrition. Factors influencing friability are its hardness, particle size and shape, and chemical bond. Easily friable materials will change particle size distribution, noticeably changing bulk density. Some bulk materials will deteriorate or decompose due to aging, pressure, temperature, moisture absorption or release, chemical composition change, altering particle size as well.

Other words for fiable: crumbly, brittle, crisp, breakable, fragile, soft, powdery, loose.

Freeze Dried Fruits

Potato Chips

Oats

Coffee Beans

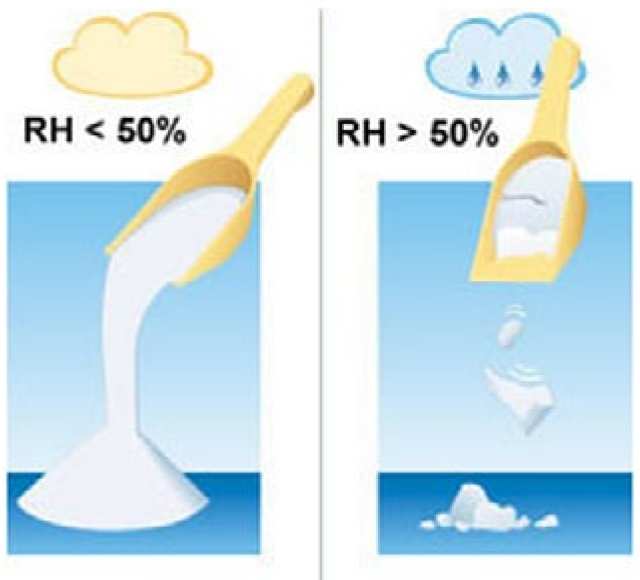
Pet Food

Tobacco

HYGROSCOPIC

A material is Hygroscopic if it has a tendency to “pick up” moisture from the surrounding atmosphere. Moisture may be absorbed from the surrounding ambient air (critical in high humidity environments) or from the conveying air in the transport system. Hygroscopic materials will tend to “cake up” causing hard agglomerates to form. Changes in particle size due to hygrosopicity can seriously alter the flow of materials. Materials can change from Class 1 to Class 4 due to hygroscopicity.

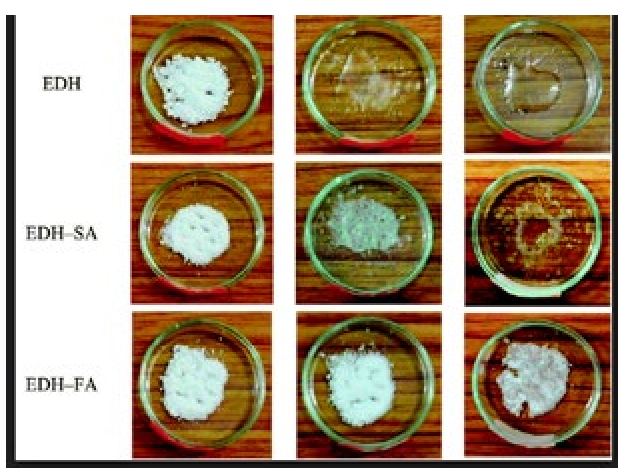
Example: Water treatment polymers are designed to be diluted in water. Water vapor from the mix tank and infiltrate into the feeder tube and be absorbed by the material. If the feeder is turned of for a long period of time the material can harden and seize the screw. more examples are calcium chloride, ferric chloride, magnesium chloride, zinc chloride, potassium carbonate, potassium hydroxide and sodium hydr



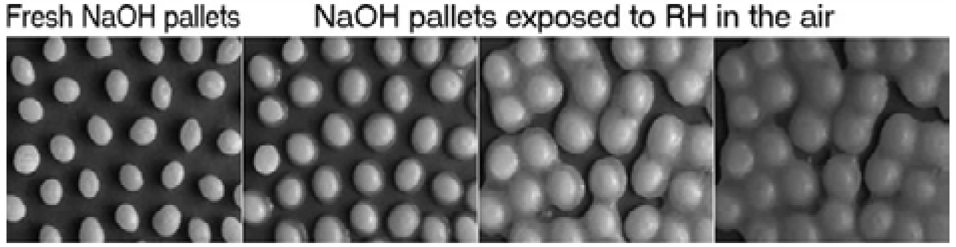
Freeze Dried Strawberries will obsorb moisture and go from crip when broken to limp and wet

DELIQUESCENTS

Deliquescent solids become liquids through the absorption of moisture from the air. This results in the material physically deteriorating when conveyed. This is primarily a result of additional moisture being added to a super saturated material.



Fresh NaOH pallets NaOH pallets exposed to RH in the air



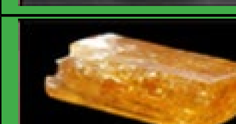
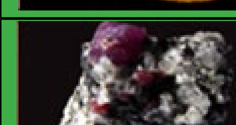
Deliquesent Vs. Hygroscopic

Deliquescent substances are solids that absorb moisture from the atmosphere until they dissolve in the absorbed water and form solutions	Hygroscopic substances are solids that can absorb or adsorb water from its surroundings
Can absorb a high amount of water vapor	Can either absorb or adsorb water vapor
Deliquescent substances are called desiccants	Hygroscopic substances are called humectants
Have a very high affinity for water	Have a less affinity for water
Form an aqueous solution by absorbing water vapor	Do not form a solution, but absorb water vapor

HARDNESS

This is a property of a solid material which contributes to its over abrasiveness (along with it's particle shape. The harder a material is, the greater the erosion will be at higher flow velocities. Hardness is a difficult factor to quantify, and is somewhat a qualitative judgment.

The MOH'S Scale of Hardness is used to describe a materials hardness, relative to a diamond (#10 on the scale from 1-10). The MOH'S scale was developed by MOH's around 1822, and was meant as a relative hardness scale.
Very hard material with irregular particle shapes can be extremely abrasive and will require special handling techniques. A very hard particle with smooth, spherical or uniform particles shape, however, may not be mush of a problem in standard equipment.

MOHS HARDNESS	MINERAL	
01	TALC	
02	GYPSUM	
03	CALCITE	
04	FLUORITE	
05	APATITE	
06	FELDSPAR	
07	QUARTZ	
08	TOPAZ	
09	CORUNDUM	
10	DIAMOND	

ABRASIVENESS

Abrasiveness of bulk solids, i.e., their ability to abrade or wear surfaces with which they come into contact, is considered a property closely related to the hardness of the material. The hardness of powders or granules is defined, in direct analogy with the definition of hardness of solid materials, as the degree of resistance of the surface of a particle to penetration by another body.

Hardness is often considered a relative rather than an absolute property and may be determined by using the Mohs' hardness scale. In this scale, the ten selected minerals are listed in order of increasing hardness, so that a material of a given Mohs' number cannot scratch any substance of a higher number, but will scratch those of lower numbers. In a qualitative manner, materials different from those included in the scale are referred to as having an equivalent number of hardness of the ten listed.

Likewise, the abrasiveness of powders can be assessed in different ways. It can be implied from the relative hardness of the particles and the surface with which they are in contact, using the Mohs' hardness scale. It can also be described by an abrasion index, which combines the effects of particle hardness, shape, size distribution, and bulk density into one factor, independent of the nature of the contacting surface. The best way to assess abrasiveness is to use the actual bulk material and the contact surfaces in question. There have been some developed tests proposed for specific materials.

For example, a test used for coke and coal, consisting of measuring the wear on a standard surface when it is brought into moving and intimate contact with the material under specific conditions, can be adapted to many different materials, including food powders. Abrasiveness and hardness are two major factors that govern the choice and design of different types of equipment, such as size reduction machines, air classifiers, mixers, dryers, screw conveyors etc.
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Mohs' scale of hardness.

Hardness number Material	Notes
1 Talc, graphite	Can mark paper powdered by finger
2 Gypsum rock salt	Can scratch lead
3 Calcite	Can scratch finger nail
4 Fluorospar	Can scratch copper coin
5 Apatite	
6 Feldspar	Can scratch window glass
7 Quartz	Can scratch a knife blade
8 Topaz	
9 Sapphire, corundum	
10 Diamond	

Keeping Dry Materials Moving

With a wealth of knowledge and experience in the use of controlled vibration to process dry bulk materials, Vibra Screw engineers have devised systems to handle most materials -- probably your material included.

As the leader in dry solids processing, our name is recognized and trusted worldwide in such diverse industries as:

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Flour, Soy, Meal, Sugar, Vitamin Supplements

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Pigments, Additives, Starch, Carbon Black

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Foundry Sand, Ores, Binders, Ferrous & Non-Ferrous Additives

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- Live Bin
- Live Bin Screw Feeder
- Pan & Tube feeder
- Portable Bin Unloader
- Screener
- Storage Pile Activator
- VersiFeeder
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If your Vibra Screw equipment doesn't perform in the service for which it was sold, we'll refund your money. Ask any other equipment manufacturer to put that in writing.

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