Physical principle of pneumatic transport.

A particle in a flowing medium will undergo a force, depending on the relative direction and the relative velocity of the flow.
On the front side the flowing medium will be forced aside of the particle, while on the backside of the particle the medium closes again.
On the front side of the particle the pressure will increase and on the backside of the particle the pressure will decrease.
The created pressures along the surface of the particle cause a resulting force on the particle. The magnitude of this force is given by the general flow resistance-formulae :

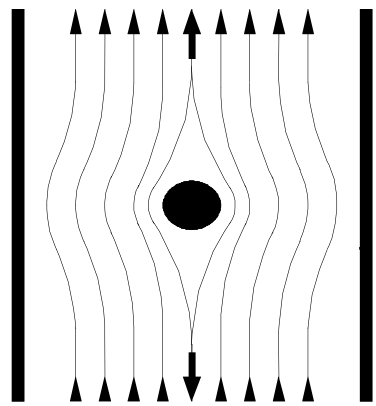

FIG.1

F = 1/2 * cw * rho(m) * v(r)^2 * A

Air (p,T)

in which :

cw	=	resistance-factor
rho(m)	=	specific mass of flowing medium
v(r)	=	relative velocity to the particle of flowing medium
A	=	projected area of the particle perpendicular to the flow of the medium.

For a symmetric particle , the direction of the force will coincide with the direction of the flow.

Floating velocity

In case of a ball-shaped particle in a vertical flow, the following motion- and equilibrium equations will exist.
(See FIG.2).

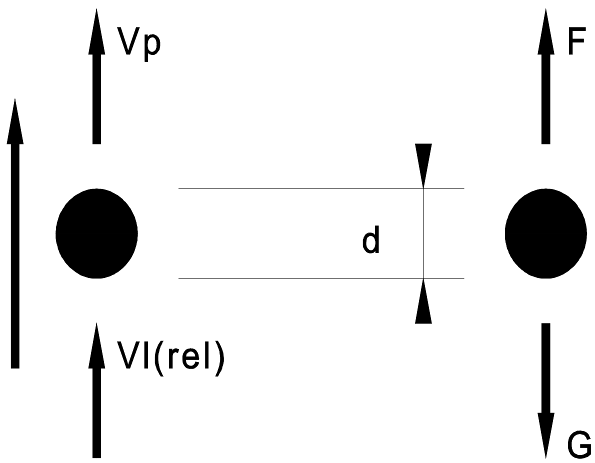

FIG.2

A = pi/4 * d^2

vl(r) = vl - vp

F = 1/2 * cw * rho(l) * vl(r)^2 * A

F = 1/2 * cw * rho(l) * (vl - vp)^2 * pi/4 * d^2

Volume= pi/6 * d^3

Weight= G = pi/6 * d^3 * rho(p)

in which :

d	= diameter ball
vl(r)	= relative velocity of medium (air) to ball
vp	= velocity of ball (product)
vl	= velocity of air
rho(l)	= specific weight of air
rho(p)	= specific weight of product

In the specific case that the ball is floating, (not moving upwards nor downwards) the corresponding air-velocity is called the **"FLOATING VELOCITY"** or the **"SUSPENSION VELOCITY"** of the ball (product).

In this case is : F = G vp = 0 and vl = vz
in which : vz = floating velocity of ball (product).

Then the following equation is valid :

$$1/2 * cw * rho(l) * vz^2 * pi/4 * d^2 = pi/6 * d^3 * rho(p)$$

Or :

$$vz = \sqrt{4/3 * (d * rho(p))/(cw * rho(l))}$$

$$cw = 4/3 * (d * rho(p))/(vz^2 * rho(l))$$

In order to have the ball transported by the airflow (to be lifted), the following compliance must be valid :

$$F > G$$

$$1/2*cw*rho(l)*(vl - vp)^2*pi/4*d^2 > pi/6 * d^3 * rho(p)$$

or :

$$(vl - vp) > \sqrt{4/3 * (d * rho(p))/(cw * rho(l))}$$

Hence the condition under which vertical pneumatic transport is possible is :

(vl - vp) > vz

In case the relative velocity (vl - vp) < vz, the particle will be accelerated and therefore move downwards.

In case the relative velocity (vl - vp) = vz , the particle will not be accelerated and stays in suspension (floating) or if the particle has an initial velocity it will maintain this velocity.

In case the relative velocity (vl - vp) > vz and is in the upwards direction, the particle will be accelerated and accordingly will be transported upwards.

The floating velocity of a particle, defined at normal standard air conditions

(T=0 deg C and p(amb)=1 bara is given as :

$$vz = \sqrt{\frac{4 * d * rho(p)}{3 * cw * 1.293}}$$

and

$$cw = \frac{4 * d * rho(p)}{vz^2 * 1.293}$$