

Filtration Dictionary

Universal Silencer products have been used to protect, quiet, and optimize the performance of industrial equipment for 40 years. Our corporate headquarters are located in Stoughton, Wisconsin, just southeast of Madison, the state capital. We maintain three fully equipped manufacturing facilities and a testing facility to qualify filters and silencers. This dictionary was developed by filtration experts at our parent company, Fleetguard/Nelson, in support of our air filtration products.

ABSOLUTE FILTER

A filter located downstream of the test filter whose efficiency is substantially greater than the efficiency of the tested filter. Absolute filters are made of membranes, or fine or ultra-fine fibers.

ABSORPTION

The taking up of bulk material by other matter. Absorbent material extracts one or more substances for which it has an affinity, and is altered physically or chemically throughout the process. During absorption one substance penetrates into another.

ADHESION

The tendency due to intermolecular, electrostatic, and surface tension forces for dust particles to cling to the filter media.

ADSORPTION

The surface retention of solid, liquid, or gas molecules, atoms, or ions by a solid or liquid, as opposed to absorption, the penetration of

substances into the bulk or liquid. The adsorbate is the solid, liquid, or gas that is adsorbed as molecules, atoms, or ions. The adsorbent is the solid or liquid which adsorbs.

AERODYNAMIC DIAMETER

The physical diameter of a unit density (1 g/cm³) sphere that settles through the air with a velocity equal to the dust particles. Inertial impaction and gravitational sedimentation are closely related to the aerodynamic diameter. Aerodynamic diameter is expressed as $D_a = [(\rho / (\rho_0 * \chi))]^{1/2} * D_g$, where D_a = aerodynamic diameter, D_g = geometric diameter, ρ = density of test dust particle (g/cm³), ρ_0 = unit density (1 g/cm³), and χ = dynamic shape factor of the test dust particle.

AEROSOL

A quasi-stable dispersion of small solid or liquid particles in air.

AGGLOMERATE

A cluster of dust particles fixed firmly to one

another as by sintering or growing together.

AGGREGATE

A large dust particle composed of separate fine dust particles. The small particles remain in an aggregate due to adhesive forces.

AIR CLEANER

A device designed to prevent dust particles and other air contaminants from entering the combustion chamber of an engine or gas turbine and to attenuate engine or gas turbine noise.

AIR FILTER

An air cleaner that removes air contaminants by means of filter media.

AIR (DUST) SEPARATOR

An air cleaner employing a separation process, such as a centrifugal force field, to remove solid or liquid particles from the air. A cyclone, centrifuge, and elutriator are examples of air separators.

AIR FLOW RATE

A measure of the quantity of volume of air passing



UNIVERSAL SILENCER

A FLEETGUARD/NELSON COMPANY

Noise Control and Air Filtration

through a test duct per unit time. Flow rate is expressed in actual cubic meters per hour (m³/h).

ANEMOMETER

A variable-area, constant-head instrument for measuring volumetric flow rate of fluids (for instance: air, water, oil, fuel). The fluid flows upward through a tapered tube, lifting a shaped weight to a position where upward fluid hydrodynamic force just balances its weight.

ARIZONA (SAE, ISO) TEST DUST

Standardized air cleaner test dusts classified from natural Arizona dust and generally referred to as SAE or ISO test dusts (old A.C. fine and A.C. coarse test dusts).

BUBBLE POINT

The differential gas pressure at which, under specified conditions, the first gas (usually air) bubble (maximum pore size) or steady stream of gas bubbles (mean pore diameter) appears on a test filter medium or filter element immersed in a liquid.

BURST STRENGTH

A measure of the ability of a filter medium to withstand pressure without rupture. Usually determined as air pressure required to rupture a circular sample of a filter medium.

CANISTER

A device containing an absorber or adsorber and, frequently, a particulate filter. It is used for the removal of specific air contaminants such as fuel vapor, odor, and toxic gas.

COAGULATION

A separation or precipitation from a dispersed state of fine suspensoid particles resulting from their growth.

COALESCENCE

Merging of liquid particles, for example, oil, fuel, or water, into a single larger drop. Fibrous and porous coalescers are used in the automotive industry to remove water from fuel.

CONTAMINATION

All solid, liquid, and gaseous substances present in the air that cause engine wear.

CUMULATIVE SIZE DISTRIBUTION

Fraction of dust particles of either greater or less than the stated size. Usually presented as a cumulative percentage undersize.

CYCLONE

Any cone-shaped or cylindrical air-cleaning apparatus operated by centrifugal separation that is used in collecting dust.

DARCY'S LAW

Describes viscous flow through a porous substance. If horizontal linear flow of an incompressible fluid is established through a porous material of thickness H in the flow direction and cross-sectional area A , then the permeability K of the porous material is defined as: $K = (Q \cdot \mu \cdot H) / (\Delta p \cdot A)$. Here, Q is the volumetric flow rate, μ is the fluid dynamic viscosity and Δp is the applied pressure difference across the porous material.

DECIBEL

A logarithmic unit used to express the magnitude of a change in level of sound intensity. A decibel (dB) is 1/10 bel. The level of a sound of intensity I in decibels relative to a reference intensity I_R is given by $10 \log_{10} I/I_R$. Because sound intensity is proportional to the square of sound pressure P , the level in decibels is given by $10 \log_{10} P^2/P_R^2 = 20 \log_{10} P/P_R$. P_R is usually equal to 2/10000 dyne per cm², or 20 μ pascals.

DENIER

The mass of a fiber in grams that is 9000 meters long. For cylindrical fibers, deniers can be converted to micrometers by the equation: $d_f = 11.9(d_n/\rho)^{0.5}$. Here d_f is the fiber diameter in micrometers, d_n is the fiber diameter in deniers and ρ is the fiber material in g/cm³.

DIFFUSIONAL DEPOSITION OF DUST PARTICLES

The filtration mechanism involving Brownian motion of fine dust particles at low flow velocity.

D.O.P. TEST

The dioctyl phthalate standard test is used in the U.S.A. for evaluation of high-efficiency air filters. Filter efficiency is determined using a liquid aerosol of mean diameter 0.3 μ m. Its upstream and downstream concentrations are measured using a light scattering technique.

DRAG

Resistance caused by friction in the direction opposite to the flow direction of a body being in motion or relative motion to the fluid.

DUST CAPACITY

The total weight gain of a test contaminant, in grams, of an air cleaner at the terminating restriction or pressure drop.

DUST CONCENTRATION

EFFECTIVE AREA

Total area of a filter medium exposed to the aerosol flow and usable for contaminant deposition.

EFFICIENCY

The ability of an air cleaner to remove contaminant. It is generally calculated as a mass of dust removed by the filter to the mass of dust fed to the filter. Fractional (grade) efficiency is defined as a fraction of dust in a narrow size range collected in the filter to the quantity of dust presented to the filter in the same size range.

ELUTRIATION

A separation process of the fine dust particles according to their settling rate against an upward fluid flow. An elutriator is a particle classifier.

ENTRAINMENT

Creation of air-borne dusts from deposits by an air (or gas) stream.

EXPANDED METAL

A perforate medium manufactured from rigid metal or plastic sheet material by slitting and expanding by means of tensile load. This product is usually used as a filter medium support.

EXTRUDED MESH

A flat or tubular mesh made by extruding and fusing together a system of plastic rods. In a flat form, mesh is used as a filter media support. The tubular mesh form is applied as a filter element center tube.

FILTER MEDIUM

Any permeable porous or fibrous material used in filtration and upon which or within which the removed contaminants are collected.

FILTER PAPER

A permeable web of randomly oriented fibers, generally cellulose, synthetic, or glass fibers, formed on a fine-wire screen from a dilute water suspension, and bonded together as the water is removed and the web is dried. Most papers are impregnated with resins that give the paper the required strength to withstand processing into a filter element and the conditions of end use.

FILTRATION

A process of separating particulate matter from a fluid, such as air, fuel, or oil, by means of fibrous or porous filter media.

FRACTIONAL EFFICIENCY, E_{Fi} %

The ability of an air filter to remove particles of a specified size, expressed as a percentage. Fractional efficiency is expressed as $E_{Fi} = [(C_{i1} - C_{i2})/C_{i1}] * 100$, where C_{i1} = the number of particles of the specified size i in the influent stream and C_{i2} = the number of particles of the specified size i in the effluent stream.

FRACTIONAL PENETRATION, P_{Fi} %

A ratio of the concentration of particles of a specified size exiting the filter to the concentration of particles of specified size entering the filter, expressed as a percentage, $P_{Fi} = 1 - E_{Fi}$.

GEOMETRIC (VOLUME EQUIVALENT) DIAMETER, D_{Gi}

The diameter of a sphere with the same volume as the particle being measured. For a spherical particle, it is the diameter of the particle.

GRAVIMETRIC EFFICIENCY

The ability of an air filter to remove contaminant. It is the cumulative mass efficiency during the life of a filter from the initially clean filter to the specified maximum filter pressure drop as it is loaded with a test dust. This is expressed by the following equation: *Gravimetric efficiency, % = (increase of weight of the air filter under test) / (increase of weight of the air filter under test + increase of weight of an absolute filter) * 100.*

GRAVIMETRIC METHOD

A method of measuring the filter efficiency in which a known mass of dust captured by the test filter is divided by a known mass of dust fed to the filter.

HARMONIC WAVES

A transverse waveform obtained by mapping onto a time base the periodic up and down excursions of simple harmonic motion.

HEPA (HIGH EFFICIENCY PARTICULATE AIR) FILTER

High efficiency normally refers to air filters that will remove more than 99% of the airborne particles that are in the size range of 0.1 - 0.3 μ m in diameter. These particles are known as the most penetrating contaminants. HEPA filters are sometimes described as HESPA (High Efficiency Submicron Particulate Air) filters. HEPA filters with an efficiency greater than 99.997% are termed as ULPA (Ultra Efficiency Particulate Air) or UHESPA (Ultra High Efficiency Submicrometer Particulate Air) filters.

HYDRAULIC DIAMETER, D_h

An equivalent diameter used to characterize non-round ducts calculated as $D_h = 4 * (\text{area of flow cross-section} / \text{duct perimeter})$.

HYDRAULIC RADIUS

The ratio of four cross-sectional areas of a conduit in which a fluid is flowing to the inner perimeter of the conduit.

HYDROPHILIC

Having an affinity for, or attracting, adsorbing, or absorbing water.

HYDROPHOBIC

Lacking an affinity for, repelling, or failing to absorb or adsorb water.

INITIAL FRACTIONAL EFFICIENCY

Fractional efficiency before the collected particles have any measurable effect on the efficiency of the filter under test. NOTE: The collected particles can affect the measured filter efficiency before enough aerosol is collected to have any measurable effect on the filter pressure loss.

INERTIAL IMPACTION (IMPINGEMENT)

Dust particle deposition on a fiber or other collecting surface due to the size of the particles. This filtration mechanism is characterized by the Stokes number.

INTERCEPTION

Dust particle deposition on a fiber or other collecting surface due to the size of the particles. This filtration mechanism is characterized by a dimensionless parameter: particle size/fiber diameter.

INTERFERENCE EFFECT

The resulting influence of neighboring fibers on dust particle deposition process in a fibrous filter.

ISOKINETIC SAMPLING

Any technique for collecting airborne particulate matter in which the velocity of the airstream entering the sampling probe is equal to that of the air passing around and outside the sampling probe.

KNUDSEN NUMBER

It indicates the type of flow around a fiber or dust particle. The number is given by $K_n = \lambda/r$ where λ =

the mean free path of air molecules ($\lambda = 0.0653 \mu\text{m}$ under standard conditions and is inversely proportional to the pressure) and $r =$ fiber or particle radius.

LAMINAR FLOW

Streamline flow of incompressible, viscous Newtonian fluid in which all fluid particles move in distinct and separate lines.

MEMBRANE FILTER

A thin filter medium with controlled pore size, number, and shape. Membrane filters are made of animal tissue, ceramics, glass, metals, alloys, porcelain, polyvinylchloride, nylon, and other materials. The most widely used material for MF preparation is a collodion, generally, nitrocellulose solution in acetic acid or nitrocellulose solution in an alcohol-ether mixture. Membranes can be used to separate particles smaller than $0.1 \mu\text{m}$.

MESH

A size of screen or of particles passed by it in terms of the number of openings occurring per linear inch. Any metal or synthetic fabric, knitted or woven, with an open, fine, or coarse texture.

METHYLENE BLUE TEST

An older British test method used to evaluate high-efficiency air filters, but now replaced by the sodium flame test. An aerosol of methylene blue generated from a 1% water solution is passing the filter under test; upstream and downstream samples are collected on esparto filter paper. The dye particles deposited on the paper are exposed to the steam, which dissolves them, resulting in the blue color. The filter efficiency is determined by comparing the intensities of the stains on the paper.

MONODISPERSE AEROSOL

A gaseous disperse system in which all particles are essentially the same size. Also applied when the relative standard deviation of the particle size distribution has a value below 0.1.

NEEDLE FELT

Filter media constructed by needling a web or batt by means of barbed needles. Synthetic and natural fibers may be used in this process.

NEWTONIAN FLUID

A simple fluid in which the state of stress in any point is proportional to the time rate of strain at that point. The proportionality factor is known as the viscosity coefficient.

NOISE LEVEL

The intensity of unwanted sound averaged over a specified frequency range and time interval, and weighted with frequency in a specified manner; usually expressed in decibels relative to a specified reference.

NON-WOVEN FILTER MEDIA

Any filter media made directly from a web or batt of synthetic or natural or other fibers without the yarn preparation.

OPEN AREA

The pore surfaces area of a filter, often given as a percentage of the total surface area.

OPTICAL (EQUIVALENT) DIAMETER, D_{op}

The diameter of a particle of the type used to calibrate an optical sizing instrument that scatters the same amount of light as the particle being measured. Optical diameter depends on the instrument, the type of particle used to calibrate the instrument (usually polystyrene latex spheres), the optical properties of the particle being measured, and the size of the particle.

PAPER (SEE FILTER PAPER)

PANEL FILTER

A filter, usually of cellulose paper of non-woven fibrous material, in a form of flat sheet or pleats.

PARTICLE SIZE

The magnitude of some physical dimension of the particle. Unless the particle is a sphere it is not possible to give its size uniquely by a unit of length. For non-spherical particles the method of measurement must be stated.

PARTICLE SIZE DISTRIBUTION

The presentation, in the form of a table of numbers, or a graph giving the frequency of the occurrence of particles within a chosen size range. The experimental results used must be qualified by quoting the method or apparatus by which they were obtained and thus specifying the "diameter" involved. Statistical methods are especially applicable to such systems and presentations.

PECTLET NUMBER (Symbol N_{pe} or Pe .)

A dimensionless ratio of significance in the analysis of the deposition of a diffusing aerosol within a fibrous filter medium.

PENETRATION

A term used in connection with high-efficiency air and gas filters to denote the transmitted fraction of the applied contaminants. The mass fraction or percentage (or number when aerosol is monodisperse) of the performance of vapor filters. In liquid filtration, the extent to which slides from the filter feed pass beyond the surface of a precoat.

PERMEABILITY

The ease with which a porous mass permits the passage of a fluid.

PERMEABILITY COEFFICIENT

The volume of an incompressible fluid that will flow through a unit cube of porous material across which unit pressure differential is maintained.

POLYURETHANES

Synthetic plastics formed by action of diisocyanates on dihydric alcohols, polyesters, or polyethers.

PORE

A hole or cavity in a body. If the pore communicates with the surface, it is an open pore. If the pore is internal, it is a closed pore. For permeable media, however, the "open" pores on inlet and outlet surfaces must also communicate.

PORE SIZE DISTRIBUTION

This is almost certainly exclusive to permeable media and describes the number of pores in various groups of sizes.

POROSITY

The ratio of voids to the total volume of material, for example, the ratio of void volume to total cake volume. Also given by the ratio of the apparent to the true density and expressed as a percentage.

PRESSURE DROP

The difference in static pressure measured immediately upstream and downstream of an air cleaner (Pascals, Pa at standard conditions).

PRESSURE LOSS

Permanent pressure reduction resulting from a decrease in the flow energy (velocity head) caused by the filter (Pa at standard conditions of 23°C and 101.3 kPa barometric pressure).

RE-ENTRAINMENT

The process of rendering particles airborne again after they have been deposited from an airstream. For example, particles captured in a filter may be re-entrained if the velocity through the filter is increased slightly or if the filter is subjected to increased vibration.

RESIN IMPREGNATION

Usually applied to filter papers used to construct pleated paper cartridges in order to give high mechanical strength. Typically 30% by weight of phenol formaldehyde, polyurethane, or epoxide resins are added.

RESISTANCE (VENTILATION FILTER)

The pressure drop across a filter at a stated flow and under given conditions; generally expressed in millimeters water gauge or, in SI units, as N/m^2 or Pascals.

RESPIRATOR

A device in which the inhaled air passes through a filter to remove contaminants, thus enabling the wearer to breathe in an otherwise toxic or unpleasant atmosphere. A dust respirator is for use against dust only and contains a particulate filter

that provides protection against harmful dusts. A chemical respirator removes specific gases and vapors by chemical action. Activated charcoal, a nonpolar substance, is commonly used in both industrial and military respirators for the removal of organic molecules by adsorption.

RETENTION

The ability of a filter medium to retain particles of a given size.

REYNOLDS NUMBER Symbol

(N_{re} or Re).

A dimensionless group of considerable significance in the study of fluid flow, representing the ratio of inertial forces to viscous forces.

SEDIMENTATION

Gravitational settling of solid particles suspended in a liquid. Two extensive, rather imprecise, classes are recognized in practice, namely (a) sedimentation of "sands" or coarse particles that may settle at a comparatively rapid rate to produce a sediment and a substantially clear supernatant liquid and (b) the much slower process associated with the removal of "slimes" and resulting in the production of a "thickened" sludge. The term implies also the associated operations of chemical treatment, pumping, filtration, and rate of removal of the bulk of the more or less clarified liquor or water.

SETTLING

That aspect of particle mechanics concerned with the action of a particle, or group of particles, allowed to sink in a homogeneous fluid under controlled conditions. Free settling is observed where the distances between adjacent particles are large by comparison with the size of the particles in suspension. This phenomenon occurs when the concentration of solids is low and mutual interference between them is negligible. Settling velocity is the rate at which particles fall under a given force, usually gravity. It is sometimes used as an alternative for terminal velocity.

SPECIFIC SURFACE AREA

The actual surface area of a quantity of particles or a porous material per unit weight. It is sometimes used to relate surface to unit volume, but in all cases it is essential to state the conditions under which the surface was determined; gas adsorption techniques can give much greater values due to penetration into smaller pores than liquid techniques based on flow measurements.

STOKES LAW

A mathematical statement of the condition that when a particle is allowed to fall freely through a homogeneous fluid, infinite in extent compared with the size of the particle, the velocity of fall increases to a terminal value that remains constant and is of such a low value that viscous forces only affect the motion. The essential requirement is the determination of the terminal velocity (u_t) which is given by the Stokes equation for a smooth, spherical particle. The conditions pertaining are known as the Laminar or Stokes Region of the fall, known to persist up to a value of the modified Reynolds number.

STREAMLINE FLOW

A term synonymous with laminar flow and viscous flow. Also a flow regime in which the flow characteristics are governed mainly by the viscosity of the fluid.

SURFACE FILTER

A filter material that retains particles wholly on its surface.

SURFACTANT

A surface active agent; when added to a liquid it reduces surface tension. Surfactants can interfere with the action of some types of filters and coalescers.

TERMINAL VELOCITY

The steady velocity achieved by a falling particle when gravitational forces are balanced by viscous forces.

TEST CONTAMINANTS

Materials used to challenge a filter under controlled

conditions. The precise composition of a test dust is normally included in the test specification.

TORTUOSITY

The flow of a fluid through a bed of unconsolidated media, consisting of discrete, granular particles that have come into contact through natural settlement under the action of gravity; it is essentially viscous in form. The path of a streamline through the pore space created in the formation of the bed would be tortuous and its length may be designated L_1 . The actual depth of the bed is termed L . The value of L_1 is greater than that of L and, again, L_1 may be regarded as the average length of the capillaries through which the flow takes place. The ratio (L_1/L) has been termed tortuosity and serves as a factor in discussions on permeability relationships of all types.

VAN DER WAALS FORCES

Weak attractive forces between molecules represented by a constant in the equation of state, first applied to gases, distinguishing real gases from

an ideal gas. They vary inversely as the seventh power of the interatomic distance and are due to momentary dipoles caused by fluctuations in the electronic configuration of the molecules.

VELOCITY HEAD

Velocity pressure or kinetic pressure is half the product of the fluid density and the square of the velocity in fluid flow. The difference between total and static pressure in incompressible flow.

VORTEX CLEANER

A name sometimes given to the "straight-through cyclone."

ZEOLITE

A complex silicate having a lattice structure within which water is contained. In general, the water may be driven off by quite moderate heating, giving the appearance of a boiling liquid. On exposure to moist air, water is again taken up, in a manner similar to that associated with silica gel. Naturally occurring zeolites have been used as desiccants.

BIBLIOGRAPHY

- ISO 5011—*Inlet Air Cleaning Equipment for Internal Combustion Engines and Compressors—Performance Testing.*
- ISO Tr 11155-1 *Road Vehicles—Air Filters for Passenger Compartments, Part 1: Test for Particle Filtration.*
- Parker, Sybil P., ed. *McGraw-Hill Dictionary of Scientific and Technical Terms*, 4th ed. (New York: McGraw-Hill, 1989).
- SAE J726. *Air Cleaner Test Code*, June 1993.
- SAE J1669, *Passenger Compartment Air Filter Test Code*, 1994.
- SAE J1669, *Passenger Compartment Air Filter Test Code*, (Recommended Practice), December 1994.
- Stockman, J. D., and Fochtman, E. G., *Particle Size Analysis* (Ann Arbor, MI: Ann Arbor Science Publishers, Inc., 1979).

*Keeping
industrial equipment
clean and quiet.*



UNIVERSAL SILENCER

A FLEETGUARD/NELSON COMPANY
P. O. Box 411, Stoughton, Wisconsin 53589
608-873-4272 Fax 608-873-4298

■ US@universal-silencer.com ■ www.universal-silencer.com