Dust Collection Technical Handbook

Index

The following pages were prepared as a reference for designing industrial dust collection and ventilation systems. This is not a complete application and sizing manual.

Glossary

A

Abrasion-Flex – Where cloth has abraded in a creased area by excessive bending.

Abrasion Surface – Localized area where the cloth's surface has been abraded uniformly.

Absolute Temperature – In degrees Rankine, where absolute 0°R = -459.7°F.

°R = °F + 460°.

ρ = *Density of air*

$$\rho(\text{actual}) = \rho(\text{std at } 70°\text{F}) \times \left[\frac{70°\text{F} + 460°}{\text{Actual } °\text{F} + 460°}\right]$$

Absorber – A kind of scrubber utilizing the absorption principle.

Absorption – The penetration of a substance into or through another; distinct from adsorption.

Acceleration Loss – The velocity pressure required to accelerate the air from rest to the duct velocity or slot velocity, whichever is higher.

ACFM – Actual Cubic Feet per Minute of gas volume at the actual condition temperature, pressure, moisture, elevation and gas composition. See gas flow rate.

ACGIH – The American Conference Governmental Industrial Hygienists is a Professional Society devoted to the development of administrative and technical aspects of worker health protection. Membership is limited to professional personnel in governmental agencies or educational institutions engaged in occupational safety and health programs. The ACGIH issues guidelines and recommendations in the form of Threshold Limit Values (TLV's) which are published annually.

Acid Deposition – (Acid Rain) A complex chemical and atmospheric phenomenon that occurs when emissions of sulfur and nitrogen compounds and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on earth in either a wet or dry form. The wet forms, popularly called "acid rain", can fall as rain, snow or fog. The dry forms are acidic gases or particulates.

Acrylic – A synthetic polymerized fiber which contains at least 85% acrylonitrile.

Acrylonitrile – A colorless, volatile, flammable liquid nitrile C_3H_3N used chiefly in organic synthesis and for polymerization.

Actuator – Mechanical device attached to a damper to move its blades. May be manual, electric, pneumatic, or hydraulic.

Adsorbent – In addition to the adjectival meaning, the term describes any of several substances that collect gaseous pollutants. Used both for measurement and control.

Adsorption – The adhesion of a substance to the surface of a solid or liquid.

Aerosol – Particle of solid or liquid matter that can remain suspended in the air because of its small size. Particulates under 1 micron in diameter are generally called aerosols.

AF – Fan wheel design with airfoil-shaped blades.

Air Changes Per Hour (ACH) – The movement of a volume of air in a given period of time; if a building has one air change per hour, it means that all of the air in the building will be replaced in a one-hour period.

Air Conditioning – Treating air to meet the requirements of a conditioned space by controlling its temperature, humidity, cleanliness, and distribution.

Air Contaminant – An impurity emitted to the outside air. It can be solid (dust, particulate matter), liquid (vapor/mist), or gas (carbon monoxide, sulfur dioxide).

Air Curtain – Mechanical air-moving device designed to limit the influx of unwanted air at a building opening.

Air Handling Unit – Factory-made encased assembly consisting of a fan or fans and other equipment to circulate, clean, heat, cool, humidify, dehumidify, or mix air.

Air Horsepower – The theoretical horsepower required to drive a fan if there are no losses in the fan, that is, if its efficiency is 100%.

Air Leakage – Unwanted air intruding into an exhaust system (holes in ducts, missing and ineffective seals, etc.).

Airlock – Term generally applied to a rotary vane valve that keeps air from entering a dust collector, yet allows a collected particulate to continuously discharge from the device.

Air Monitoring – The continuous sampling for and measuring of pollutants present in the atmosphere.

Air Quality Criteria – As the Federal government uses the term, the varying amounts of pollution and lengths of exposure at which specific adverse effects to health and welfare take place.

Air Quality Standards – The approximate concentration level of a selected pollutant that is permitted in the atmosphere to minimize detrimental effects.

Air Pollution – The presence in the atmosphere of gases, fumes, or particulate matter alone or in combination with each other, in sufficient concentration to disturb the ecological balance; cause objectionable effects, especially sensory offenses; cause transient or chronic illnesses; or impair or destroy property.

Air, Standard – Dry air at 70°F and 29.92 inches (Hg) barometer. This is substantially equivalent to 0.075 lb/ ft^3.

Air-to-Cloth Ratio – See air to media ratio.

Air-to-Media Ratio – The ratio of air volume (ACFM) to square feet of effective filter media area. Also referred to as the apparent or face velocity through the media (FPM). Typically 3 to 12 fpm for bag medias and 0.5 to 6 for pleated type medias.

Air Toxics – Any air pollutant for which a national ambient air quality standard (NAAQS) does not exist (i.e., excluding ozone, carbon monoxide, PM-10, sulfur dioxide, nitrogen oxides) that may reasonably be anticipated to cause cancer, developmental effects, reproductive dysfunctions, neurological disorders, heritable gene mutations or other serious or irreversible chronic or acute health effects in humans.

Air Velocity – Rate of speed of an airstream, expressed in FPM.

Altitude – The height above sea level of a given location. Density corrections for altitude are made using the following formula where Z is the feet above seal level.

$$Density\ (Alt) = Density\ (Std)\ x\ [1-(6.73x10^{-6})Z]^{5.258}$$

Ambient – Immediate surroundings or vicinity.

AMCA – Air Movement and Control Association.

Anemometer – A device which reads air velocity such as a wind vane. In fan applications, it is usually a spinning-vane-type instrument used at read low velocities at registers and grills.

Anneal – The process of relieving stress and brittleness in metals by heating.

Anodize – An electrolytic action of affixing a protective coating or film, usually applied to aluminum.

ANSI – American National Standards Institute.

APC – Air Pollution Control.

API – American Petroleum Institute.

Appurtenances – Accessories added to a fan for the purposes of control, isolation, safety, static pressure regain, wear, etc.

ARI – Air Conditioning and Refrigeration Institute.

Area Source – Any small source of non-natural air pollution which is not large enough to be classified as a major source or point source.

Aromatics – A type of hydrocarbon, such as benzene or toluene, added to gasoline in order to increase octane. Some aromatics are toxic.

ASHRAE – American Society of Heating, Refrigeration, and Air Conditioning Engineers.

ASME – American Society of Mechanical Engineers.

Aspect Ratio – The ratio of the width to the length.
AR=W/L

ASTM – American Society of Testing Materials.

Atmospheric Pressure – One atmosphere is approximately 14.7 PSI; 408" water gauge. Airflow is the result of a difference in pressure (above or below atmospheric) between two points.

Attainment Area – An area considered to have air quality as good as or better than the National Ambient Air Quality Standards as defined by the Clean Air Act. An area may be an attainment area for one pollutant and a non-attainment area for others.

Attenuation – Absorption of sound pressure. Attenuation reduces the amplitude only of a sound wave while leaving the frequency unchanged.

Attrition – Wearing or grinding down by friction. One of the 3 basic contributing processes of air pollution, the others being vaporization and combustion.

AVR (c) – Air Vent Round. MAC Equipment acronym for its round bottom bag removal pulse jet dust collectors. *(c) designates cartridges instead of bags.*

AVS *(c)* – Air Vent Square. MAC Equipment acronym for its square bottom bag removal pulse jet dust collectors, up to 64 bags. *(c) designates cartridges instead of bags.*

Axial Fan – Fan where the airflow through the impeller is predominantly parallel to the axis of rotation. The impeller is contained in a cylindrical housing.

Axial Flow – In-line air movement parallel to the fan or motor shaft.

B

Backdraft Damper – Damper used in a system to relieve air pressure in one direction and to prevent airflow in the opposite direction.

BACM (Best Available Control Measure) **–** A term used in the CAAA referring to the "best" measures (according to EPA guidance) for controlling emissions.

BACT (Best Available Control Technology) **–** An emission limitation based on the maximum degree of emission reduction achievable. Under Title 1 of the CAAA, EPA will establish BACT standards for serious, severe, and extreme non-attainment areas.

Bag – The customary form of filter element. Also known as tube, stocking, etc. Can be unsupported (dust on inside) or used on the outside of a grid (cage) support (dust on outside).

Baghouse – An air pollution abatement device that traps gas born particulates by forcing the gas through filter bags.

Balancing – (1) On a fan, the process of adding (or removing) weight on a rotor in order to move the center of gravity toward the axis of rotation. **(2)** In a ventilation system, it's the process of measuring or calculating the airflow at a branch and altering duct size or a valve to attain desired airflow at that branch.

Barometric Pressure – A measurement of the pressure of the atmospheric; standard is 29.92" Hg.

Bernoulli's Theorem – The principle that the total energy per unit of mass in the streamline flow of a moving fluid is constant, being the sum of the potential energy, the kinetic energy, and the energy due to pressure. In terms of air movement, the theorem states that the static pressure plus velocity pressure as measured at a point upstream in the direction of airflow is equal to the static pressure plus velocity pressure as measured at a point downstream in the direction of airflow plus the friction and dynamic losses between the points.

BI Fan – Centrifugal fan with backward inclined blades that move air more efficiently than straight blade fans. BI fans are usually on the clean side of a piece of control equipment as the blades are not very abrasion resistant.

Blade Liners – Pieces of material added over the wheel blades to reduce abrasion of the blades.

Blade-Pass Frequency – The tone generated by the blades passing a fixed object.

Blast Area – The fan outlet area less the projected area of the cut-off.

Bleed – Particles of dust or fumes that are able to leak through filter media.

Blind (Blinding) **–** The blockage of filtration media by dust, fume or liquid covering the filter media and not being discharged by the cleaning mechanism. Once enough material has built up, air flow is severely restricted and the elements have to be cleaned or replaced.

Blow-pipe – See manifold.

Blue Smoke – A descriptive term for the gaseous hydrocarbons that escape from hot asphalt and other sources of VOC.

Boiler Horsepower – The capability to evaporate 34.5 pounds of water per hour into dry steam at 212°F. at sea level; 33,500 BTU/hr.

Brake Horsepower – The horsepower actually required to drive a fan. This includes the energy losses in the fan and can be determined only by actual tests of the fan (this does not include the drive losses between motor and fan).

Breakdown Torque – Maximum torque a motor will produce without a sudden decrease in speed. Often referred to as pull-out torque or maximum torque.

Bridge – Material building across an opening (such as a screw conveyor) and blocking off that opening.

BTU – British Thermal Unit; heat required to raise the temperature of 1 pound of water by 1°F. The BTU/hr. required to raise the temperature of a volume of standard air a specific number of degrees is calculated by the formula:

$$Btu/hr = Temp.\ Rise \times CFM \times 1.085$$

Bulked Yarn – Filament yarn which has been processed by high pressure air passing through the yarn and relaxing it into gentle loops, bends, etc.

C

CAAA – Clean Air Act Amendments of 1990.

Title I:	Nonattainment: Ambient Air Quality
Title II:	Motor Vehicles
Title III:	Hazardous Air Pollutants
Title IV:	Acid Rain
Title V:	Permits
Title VI:	Stratospheric Ozone
Title VII:	Enforcement
Title VIII:	Miscellaneous

Caking – Material crusted on a bag that cannot be removed by the cleaning mechanism. Frequently caused by the dust on the bags getting wet.

Calendered Finish – An available smooth finish for felt bags. Felt is drawn between two hot oil-filled rolls, where heat and pressure press down “hairs” on the felt, imparting a smooth finish that improves dust release.

Calendering – The application of either hot or cold pressure to smooth or polish a fabric, thereby reducing the thickness of the cloth by spreading the warp and filling yarns into a ribbon shape.

Can Velocity – As related to baghouses, the gas velocity within the collector. Dividing the gas volume by the cross sectional area of the collector determines "can velocity". Also, see interstitial velocity.

$$\textbf{Can Vel} = \frac{CFM}{ABH}$$

CFM = Gas volume through baghouse
A_{BH} = Cross sectional area of baghouse

Capacitor Start Motor – Type of single-phase induction motor with a capacitor connected in series with the starting winding. High-starting and breakdown torque, medium starting current. Used in hard-starting applications; compressors, pumps, etc.

Capture Velocity – The air velocity at any point in front of a hood or at a hood opening necessary to overcome opposing air currents and to capture the contaminated air at the point by causing it to flow into the hood.

Carbon Monoxide – A colorless, odorless gas which is toxic because of its tendency to reduce the oxygen-carrying capacity of the blood.

Carrying Velocity – The gas velocity that is necessary to keep the dust airborne. Usually 3500 to 4599 ft/min in ductwork depending upon the nature of the dust.

Cartridge – See pleated filter elements.

Cartridge Filter – An air pollution control device that traps gas-borne particulates by forcing the gas through filter element cartridges. The cartridges are typically made with pleated cellulose paper media. Recently, 100% spun bonded media equipped filters have been placed in commerce.

CAS (Chemical Abstracts Service) **–** Registry Number is a numeric designation assigned by the American Chemical Society's Chemical Abstracts Service which uniquely identifies a specific chemical compound.

Cellplate – See tubesheet.

Cellulose – The chief part of fibrous products which are used to make the filter media for many cartridge filters. Also referred to as "paper" media.

Centrifugal Collector – Any of several mechanical systems using centrifugal force to remove particulate from a gas stream.

Celsius – A thermometric scale in which water boils at 100° and freezes at 0°, same as centigrade:

$$°C = .5556 \times [°F. - 32°]$$

CFCs (Chlorofluorocarbons) **–** A family of inert, non-toxic, and easily liquefied chemicals used in refrigeration, air conditioning, packaging insulation, or as solvents or aerosol propellants. because CFCs are not destroyed in the lower atmosphere they drift into the upper atmosphere where chlorine is released and destroys ozone.

CFC-12 – A chlorofluorocarbon with a trademark name of Freon, commonly used in refrigeration and automobile air conditioning.

CFM – Cubic Feet (of any gaseous matter) per Minute. See gas flow rate.

Clean Coal Technology – Any technology not in widespread use as of the date of enactment of the Clean Air Act Amendments which will achieve significant reductions.

Clean Fuel – Blends and/or substitutes for gasoline fuels. These include compressed natural gas, methanol, ethanol, and others.

Cloth – In general, a plant fabric; woven , knitted, felted or otherwise formed of any textile fiber, wire, or other suitable material. Usually understood to mean a woven felted or textile fabric.

Cloth Weight – Is usually expressed in ounces per square yard or ounces per square foot. However, cotton sateen is often specified as a certain number of linear yards per pound of a designated linear yards per pound in a 54" width.

Coefficient of Conductivity – The rate of heat transfer through a material, expressed in Btu transmitted per hour through one square foot of surface per degree difference in temperature across the material. Figures are usually expressed for basic materials, such as wood or insulation; per inch of thickness, and called by the symbol "K".

COH – Abbreviation for coefficient of haze, unit of measurement of visibility interference.

Coke Oven – An industrial process which converts coal into coke, which is one of the basic materials used in blast furnaces for the conversion of iron ore into iron.

Cold Spot – On an insulated baghouse, a point where metal goes through insulation, creating an uninsulated area where heat dissipates rapidly.

Cold Temperature – A standard for automobile emissions of carbon monoxide (CO) to be met at a low temperature (i.e., 20°F). Conventional catalytic converters are less efficient upon start-up at low temperatures.

Collecting Efficiency – The ability of a dust collector to remove particulate from the exhaust gas. The ratio of particles entering the collection device vs. particles leaving is expressed in percent.

$$\frac{\text{inlet loading} - \text{outlet loading}}{\text{inlet loading}} \times 100$$

Collector – Used interchangeably with "baghouse," "cartridge filter," or mechanical collector, as in "cyclone."

Combustion – The production of heat and light energy through a chemical process, usually oxidation. One of the 3 basic contributing processes of air pollution, the others being attrition and vaporization.

Combustion Air – Amount of air necessary to burn the available fuel.

Combustion Products – 1) Primarily gaseous matter such as carbon oxides, nitrogen, oxygen, and water vapor – resulting from the combustion of fossil fuels. 2) In the context of emission control – the gaseous products resulting from the burning of any kind of material containing carbon in a free or combined state. Also referred to as "combustion contaminants."

Compressibility – A factor used by fan manufacturers to correct performance ratings in higher pressure ranges to account for the fact that air is a compressible gas that does not follow the perfect gas laws.

Compression – A phenomenon related to positive pressure. When air is forced into a system it is compressed and becomes more dense. Depending on the volume or weight of air required down stream in the positive pressure portion of the system, the volume of air at the inlet of a fan may have to be adjusted by the ratio of absolute pressure at the entrance of the fan versus the design requirements in the system.

Concentration – The amount of dust in gas. Usually expressed in terms of grains per ft^3, lbs per 1000 lbs of gas, parts per million, or milligrams per cubic meter.

Conduction – The transfer of heat by physical contact between substances.

Conversion Factors – See pages 87 through 106.

Convection – The transfer of heat through a liquid or gas by the actual movement of the molecules.

Conveying Velocity – The air velocity required in a duct system to maintain entrainment of a specific material.

Corrosion – The deterioration of a material by chemical or electrochemical reaction resulting from exposure to weathering, moisture, chemical, or other agents in the environment in which it is placed.

Cotton Number – Staple yarns are generally sized on the cotton system. Example: an 18 singles yarn is of such a size that 18 hanks weighs one pound (each hank contains 840 yards).

Cotton System – A system of yarn manufacturing for spinning cotton fiber yarn whereby the individual fibers are aligned parallel.

CRP – Certified Ratings Program.

CRST (Cellulose Fibers, Resin Impregnated, Silicone Treated) **–** A type of filter media used in high quality cartridges. The treatments enhance filter life and moisture resistance.

CSA – Canadian Standards Association. Sets safety standards for motors and other electrical equipment used in Canada.

CTG (Control Techniques Guideline) **–** Guidance documents issued by EPA which define Reasonably Available Control Technology (RACT) to be applied to existing facilities that emit certain threshold quantities of air pollutants; they contain information both on the economic and technological feasibility of available techniques.

Curve, Fan Performance – A graphic representation of static or total presence and fan BHP requirements over an airflow volume range at a stated inlet density and fan speed.

Curve, System – A graphic representation of the pressure versus flow characteristics of a given system and density.

Cyclone Collector – A kind of centrifugal collector equipment.

D

Damper – Change in pressure, or pressure drop that occurs across a piece of control equipment.

dbA – Sound-pressure level corrected to the "A" weighing network.

Decibel – The logarithmic ratio between some known reference and some quantity of electrical or acoustic signal power.

Delta P (Δ^P) – Change in pressure, or pressure drop that occurs across a piece of control equipment.

Denier – The weight in grams that 9000 meters of a fiber weighs.

Density – The measure of unit mass equal to its weight divided by its volume (lbs/ft³); standard air is .075 lbs./ft³.

Density Factor – Ratio of actual air density of standard air. The product of the density factor and the density of standard air (0.075 lbs/ft³) will give the actual air density in pounds per cubic foot.

Dew Point – The temperature at which the equilibrium vapor pressure of a liquid is equal to the existing partial pressure of the respective vapor. (For air containing water vapor, it is the temperature at which liquid water begins to condense for a given state of humidity and pressure as the temperature is reduced. For flue gas containing water vapor and SO_3, it is the set of conditions at which liquid sulphuric acid begins to condense as the temperature is reduced.)

DFT – Dry-film thickness usually expressed in thousandths of an inch (mils).

Diaphragm Valve – A compressed air operated valve that opens to allow a pulse to go the filter bags or cartridges.

Diffusion – Takes place on particles so small that their direction and velocity are influenced by molecular collisions. These particles do not follow the air stream, but behave more like gases than particulate. They move across the direction of air flow in a random fashion. When a particle does strike a fiber, it is retained by the van der Waals forces existing between the particle and the fiber.

Dilution Ventilating – The mixing of contaminated air with uncontaminated supply air for the purpose of attaining acceptable working or living conditions.

Dimensional Stability – Ability of the fabric to retain its size in hot or moist atmosphere.

DNAPLS – Dense non-aqueous phased liquids.

DOP – Acronym for dioctylphthalate, a chemical, used in aerosol form, to non-destructively test high efficiency particulate air (HEPA) filters.

Double Bag – Features a conventional bag on a cage and an inner bag that filters from inside, out, with the bottom open for dirty air entrance. Puts more, but not necessarily effective, cloth area in a given size baghouse.

Dry Bulb Temperature – The actual temperature of a gas, taken with a conventional thermometer.

Dry Collector – Dust collectors which use mechanical means (centrifugal force, impingement, filtration) to remove particulate matter from exhaust gas. Such as: expansion chambers, knockout boxes, centrifugal collectors, cartridge filters and baghouses. Devices not using H_2O.

DSCFM – Dry Standard Cubic Feet per Minute. See gas flow rate.

Dust – A dispersion aerosol formed by the grinding or atomizing of a solid, or the transfer of a powder into a state of suspension through the action of air currents or by vibration.

Dust Collector – An air-cleaning device used to remove heavy-particulate loadings from exhaust systems prior to discharge.

Dust Collector, Cyclone – A mechanical device that utilizes the centrifugal force of the inlet gas to remove large particulate matter suspended in the gas.

Dust Collector Efficiency – See collecting efficiency.

Dust Permeability – Defined as the mass of dust (grains) per square foot of media divided by the resistance (pressure drop) in inches of water gauge (WG) per unit of filtering velocity, feet per minute (fpm). Not to be compared with cloth permeability.

DWDI – Double-width, double-inlet fans, Arrangement 3.

Dynamic Balance – The mechanical balancing of a rotating part of assembly in motion.

Dynamic Insertion Loss – A reduction of airborne noise levels affected by the installation of an acoustical silencer.

DYNE – A unit of force equal to that which would accelerate one gram by one centimeter per second.

E

Early Reduction/Early Compliance – A provision in the CAAA which provides incentives to a company for complying with new standards before they are required to by Law.

Effective Stack Height – The height at which a plume becomes essentially level. It is the actual stack height plus the plume rise.

Efficiency, Mechanical Total – The ratio of fan output to the power applied to the fan. Can be helpful in selecting fan size, type, or manufacturer for the same application:

$$ME = \frac{TP \times CFM}{6356 \times BHP}$$

Efficiency, Static – The ratio of fan output less the kinetic energy [outlet-velocity pressure] leaving the fan to the power applied to the fan:

$$SE = \frac{SP \times CFM}{6356 \times BHP}$$

Effluent – A discharge or emission of a fluid (liquid or gaseous).

Electrostatic Attraction – Mutual attraction, caused by static electricity, by which particles tend to draw together or adhere.

Electrostatic Precipitator – A kind of precipitator that first charges particulate (ESD), allowing electrostatic forces to attract particles to a collection point.

Elevation – The distance of the subject site above or below sea level.

EMD Airlock – Environmental Multi Duty airlock. MAC Equipment's airlock to place under a dust collector when a pneumatic convey system will be utilized beneath the airlock.

Emission – Release of pollutants into the air from a source.

Emission Control Diagnostics – Computerized devices placed on vehicles to detect malfunction of emissions controls and notify the owner of the need for repair.

Emission Control Equipment – Machinery used to remove air contaminants from the discharge of industrial exhaust streams.

Emission Factor – The statistical average of the amount of a specific pollutant emitted from each type of polluting source in relation to a unit quantity of material handled, processed or burned. E.g. the emission factor of oxides in nitrogen in fuel oil combustion is 119 lbs. per 1,000 gallons of fuel oil used. By using the emission factor of a pollutant and specific data regarding quantities of material used by a given source, it is possible to compute emissions for that source – information necessary for an emission inventory.

Emission Inventory – A list of primary air pollutants emitted into a given community's atmosphere, in amounts (commonly tons) per day, by type of source. The emission inventory is basic to the establishment of emission standards. Also see emission factor.

Emission Standard – The maximum amount of a pollutant that is permitted to be discharged from a single polluting source; e.g., the number of pounds of fly ash per cubic foot of gas that may be emitted from a coal-fired boiler. Rule or measurement established to regulate or control the amount of a given pollutant that may be discharged to the outdoor atmosphere from its source.

End – See warp thread.

End Count – See warp count.

End Reflection – A known value of sound radiated back into duct or opening.

Enhanced I&M (Enhanced Inspection & Maintenance) **–** An improved automobile inspection and maintenance program that includes, as a minimum, increases in coverage of vehicle types and model years, tighter stringency of inspections and improved management practices to ensure more effectiveness. This may also include annual, computerized, or centralized inspections, under-the-hood inspections to detect tampering with pollution control equipment; and increased repair waiver cost. The purpose of Enhanced I&M is to reduce automobile emissions by assuring that cars are running properly.

Enthalpy – The heat content per unit mass of a substance.

Entry Loss – The loss in pressure caused by air flowing into a system; normally expressed in fractions of velocity pressure.

EPA – Environmental Protection Agency.

Equivalent Duct Diameter – For rectangular duct with sides a and b is:

$$D = (4ab/\pi)^{0.5}$$

Evaporation – The physical transformation of a liquid to a gas at any temperature below its boiling point.

Evase – A diffuser at the fan outlet which gradually increases in area to decrease velocity and to convert kinetic energy to static pressure [regain].

Excess Air – Air in excess of the amount necessary to combust all the available fuel.

Exhaust Gas – The gases emitting from an industrial process, generally a combustion process.

Exhaust Stack Temperature – The temperature of the exhaust gas, measured in the discharge stack.

Exhaust Volume – The amount of exhaust gas (air, products of combustion and water vapor) leaving the exhaust stack usually measured in ACFM.

F

Fabric – A collective term applied to cloth no matter how constructed, regardless of the kind of fiber used.

Fahrenheit – A thermometric scale in which water boils at 212° and freezes at 32°.

$$°F = (1.8 \times °C) + 32°$$

Fan – A power-driven machine which moves a continuous volume of air by converting rotational mechanical energy to an increase in the total pressure of the moving air.

Fan Capacity – Performance requirement for which a fan is selected to meet specific system calculations given in terms of ACFM at the fan inlet.

Fan Class – Operating limits at which a fan must be physically capable of operating safely.

Fan Laws – Theoretical constant relationships between CFM, RPM, SP, and BHP for a given fan used in a given fixed system:

$$CFM \text{ varies as } RPM$$
$$SP \text{ varies as } (RPM)^2$$
$$BHP \text{ varies as } (RPM)^3$$

FC – Fan wheel design using forward-curved blades.

Federal Implementation Plan (FIP) – Under current law, a Federally implemented plan to achieve attainment of an air quality standard, used when a State is unable to develop an adequate plan. Under the Senate bill, a plan containing control measures developed and promulgated by EPA in order to fill gaps in a State Implementation Plan (SIP).

Felted Fabric – Type bag used on most all pulse jet dust collectors. Features a heavy, thick cloth of short fibers on a woven backing.

Fiber – The fundamental unit comprising a textile raw material such as cotton, wool, etc.

Filament – Mono – One continuous strand of fiber to indefinite length.

Filament – Multi – More than one mono-filament strand grouped together of definite length.

Fill – Crosswise threads woven by loom.

Fill Count – Number of threads per inch of cloth.

Filter Cake – The accumulation of dust on a bag before cleaning. This cake assists in the filtering of dust.

Filter Collector – A mechanical filtration system for removing particulate matter from a gas stream, for measurement, analysis, or control. Also called bag collector. Filters are designed in a variety of sizes and materials for specific purposes. Also called bag collector or cartridge.

Fines – Fine particulate, aerosol.

Flashing – Sheet metal strip placed at the junction of intersecting exterior building surfaces to make the joint water-tight.

Flexing – Bending, or contracting and expanding.

Fly Ash – The particulate impurities resulting from the burning of coal and other material.

Fog – The condensation of water vapor in air. Also see Smog.

Foot-Pound (Ft.-Lb.) – Torque rating or requirement; equivalent to the force required to move a one-pound weight one foot in distance, equal to 12 in-lb.

Forced Draft – How air is provided in a process such as a combustion process; when air is blown or forced into a process, it is known as a "forced draft" system. Also see induced draft.

Forced Draft Burner – A burner which has its secondary air supplied under pressure. This is normally done by surrounding the dryer opening by a plenum or windbox and supplying the air with a low pressure fan.

Fossil Fuels – Coal, oil, and natural gas; so-called because they are the remains of ancient plant and animal life.

FPM – Feet per minute, commonly defines air velocity (to determine velocity pressure or suitability for material conveying), shaft/bearing speeds (used to determine lubrication requirements) and wheel tip speeds.

Frame Size – A set of physical dimensions of motors as established by National Electrical Manufacturers Association (NEMA) for interchangeability between manufacturers. Dimensions include: shaft diameter, shaft height, and motor mounting footprint.

Free Field – The surroundings of a specific equipment location in which no obstructions or reverberant surfaces exist to distort or amplify sound waves.

Frequency – Any cyclic event whether vibration, alternating current, or rotational speed. Usually expressed in cycles per second (cps) or just "cycles".

Friction Loss – Resistance to air flow through any duct or fitting, given in terms of static pressure.

FRP – Abbreviation for fiberglass-reinforced-plastic.

Fugitive Emissions – Emissions not caught by a capture system.

Full-Load Speed – The speed at which the rated horsepower is developed. This speed is less than synchronous speed and varies with the motor type and manufacturer.

Full-Load Torque – The torque required to produce the rated horsepower at full-load speed.

Fume – Solid particulates generated by condensation from the gaseous state, generally after volatilization from molten metal, and often accompanied by a chemical reaction, such as oxidation. Fumes flocculate and sometimes coalesce.

G

Garbadine Weave – A regular or "steep" twill with higher warp than fill count.

GACT – (Generally Available Control Technology) Methods, practices, and techniques which are commercially available and appropriate considering economic impacts and the technical capabilities of the firms to operate and maintain the emissions control systems. Under Title III of the CAAA, EPA will establish either GACT or MACT standards for each source of HAPs.

Gases – Normally, formless fluids which occupy the space of its enclosure and which can be changed to a Liquid or solid state only by the combined effect of increased pressure and decreased temperature. Gases diffuse.

Gas Flow Rate, Cubic Feet per Minute (CFM) **–** The volume of process gas at any point of the plant exhaust system measured in terms of minutes. There are several units of measurement:

ACFM – The actual gas flow measured (Actual Cubic Feet per Minute).

SCFM – The gas flow volume reduced to 70°F (standard temperature) and standard pressure (latm) by calculation (Standard Cubic Feet per Minute).

DSCFM – The gas flow reduced to 70°F (standard temperature) and standard pressure (latm) and without volume of steam or water vapor contained in the exhaust gas (Dry Standard Cubic Feet per Minute).

Gasoline Volatility – The property of gasoline whereby it evaporates into a vapor. Gasoline volatility is measured in pounds per square inch (psi), with a higher number reflecting more gasoline evaporation. Gasoline vapor is a VOC (Volatile Organic Compound).

Gauge (gage) – Metal manufacturers' standard measure of thickness for sheer stock; some examples for steel are:

Gauge	*Thickness (Inches)*	*Weight of Steel (Lbs/Ft.²)*
7	.1793	7.50
10	.1345	5.625
12	.1046	4.375
14	.0747	3.125
16	.0598	2.50

Gauge Pressure – The pressure differential between atmospheric and that measured in the system.

Grain – A dust weight unit commonly used in air pollution control. Equal to one seven thousandth of a pound.

$$\text{One grain} = \frac{1\ \text{LB}}{7000}$$

Grain Loading – The rate at which particles are emitted from a pollution source. Measurement is made by the number of grains per cubic foot of gas emitted.

Griege (Griege goods) **–** Same as grey or unfinished goods. Does not imply a grey (gray) color.

Ground Motor – A short circuit between any point in the motor's electrical circuit and its connection to the ground.

H

Halons – A family of compounds containing bromine, fluorine, iodine, and chlorine used in fighting fires, that break down in the atmosphere depleting stratospheric ozone.

HAPs (Hazardous Air Pollutants) **–** Any of the 189 chemicals listed under Title III of the CAAA. All HAP sources will have to comply with GACT or MACT standards. (See page 33 for a complete listing).

H Cyclone – MAC Equipment's medium efficiency cyclone dust collector.

HCFC's – Chlorofluorocarbons that have been chemically altered by the addition of hydrogen, and which are significantly less damaging to stratospheric ozone than other CFC's.

HD Airlock – Heavy Duty airlock. MAC Equipment's all purpose, lowest priced cast iron airlock.

Header – As applied to pulse-jet baghouses, the pressurized pipe that contains the compressed air supply for pulsing. If it is undersized, insufficient cleaning air will flow through the valve.

Heat Exchanger – A device such as a coil or radiator which is used to transfer heat between two physically separate fluids.

HE Cyclone – MAC Equipment's High Efficiency cyclone dust collector.

HEPA Filter (High Efficiency Particulate Air Filter) – Capable of removing at least 99.97% by count of a standard 0.3 micron challenge particulate (DOP test).

Hertz – Frequency measured in cycles per second.

Hg – Symbol for mercury. Pressure is often measured in inches of mercury. (1" Hg = 13.64" WG)

High Pressure Cleaning Air – Air at 80-100 PSIG used for cleaning air in baghouses and cartridge filters.

Hi-Volume Sampler – Also called a Hi-Vol. A device used in the measurement and analysis of suspended particulate pollution.

HON – Hazardous Organic NESHAPS.

Horsepower – (As applied to motors) is an index of the amount of work the machine can perform in a period of time. 1HP equals 33,000 ft. lbs. of work per minute, also equal to 0.746 kilowatts. Horsepower can be calculated by:

$$HP = \frac{\text{Torque (ft.lbs.)} \times \text{RPM}}{5250}$$

Humidity, Absolute – The weight of water vapor per unit volume, pounds per cubic foot or grams per cubic centimeter.

Humidity, Relative – The ratio of the actual partial pressure of water vapor in a space to the saturated pressure of pure water vapor in a space to the saturated pressure of pure water at the same temperature.

HVAC – Heating, ventilating, and air conditioning.

Hydrocarbon – Any of the vast family of compounds containing carbon and hydrogen in various combinations; found especially in fossil fuels. Some of the hydrocarbon compounds are major air pollutants; they may be carcinogenic or active participants in the photochemical smog process.

Hydrophobic Fibers – Those fibers or materials not readily water absorbent.

Hygroscopic – Materials having an affinity for water.

I

Impeller – Another term for fan "wheel". The rotating portion of the fan designed to increase the energy level of the gas stream.

Impeller Diameter – The maximum diameter measured over the impeller blades.

Impingement – When air flows through a filter, it changes direction as it passes around each fiber. Larger dust particles, however cannot follow the abrupt changes in direction because of their inertia. As a result, they do not follow the air stream and collide with a fiber.

Inch of Water – A unit of pressure equal to the pressure exerted by a column of water one inch high at a standard temperature. (407" WC = 14.7 PSI)

Inches WG (Inches of Water Gauge) **–** See inch of water.

Incinerator – A device which burns household, industrial, pathological, or hazardous solid, liquid or gaseous wastes under controlled conditions.

Inclined Manometer – A testing instrument using a liquid column, set at an incline to increase reading accuracy, to measure pressure. Normally used to read velocity pressure.

Induced Draft – How air is provided in a process, such as a combustion process, where air is drawn or pulled through a process. Also see forced draft.

Induction – The production of an electric current in a conductor in a changing magnetic field.

Inertia – Tendency of an object to remain in the state it is in; see WR^2.

Inertial Separators – Air pollution control equipment that uses the principle of inertia to remove particulate matter from a stream of air or gas. See mechanical and cyclone collectors.

Inlet-Vane Damper – Round multiblade damper mounted to the inlet of a fan to vary the airflow.

Inspection & Maintenance (I&M) **–** A program providing for periodic inspections of motor vehicles to ensure that emissions of specified pollutants are not exceeding established limitations.

Instability – The point of operation at which a fan or system will "hunt" or pulse; common in FC fans and some other fan types where the point of operation is left of the peak of the static-pressure curve.

Insulation – Any method which will retard the flow of heat through a wall. In baghouses, it is commonly a lightweight fiberglass mat.

Interception – A special case of impingement where a particle is small enough to move with the air stream, but, because its size is very small in relation to the fiber, makes contact with a fiber while following the tortuous air flow path of the filter. The contact is not dependent on inertia and the particle is retained on the fiber because of the inherent adhesive forces that exist between the particle and fiber. These forces, called van der Waals forces, enable a fiber to trap a particle without the use of inertia.

Interstices – The openings between the interlacings of the warp and filling yarns; i.e., the voids.

Inversion – An atmospheric condition caused by a layer of warm air preventing the rise of cooling air trapped beneath it. This prevents the rise of pollutants that might otherwise be dispersed and results in a concentration of the air pollution.

Interstitial Velocity – The apparent velocity of a gas as it passes by a filter bag matrix. It is found by dividing the collector gas volume by its cross sectional area, after the cross sectional of the bags have been subtracted from the collector cross sectional area.

K

Kelvin – Absolute Temperature in the SI system scale.

Kilopascal – Kpa; metric pressure unit; one inch water gauge is 0.24836 Kpa.

Kilowatt – Kw; measure of power equal to 1.34 horsepower.

Knockout Box – See primary collector.

L

L-10 Bearing Life – The theoretical number of hours after which 90% of the bearings subjected to a given set of conditions will still be in operation; also known as B-10.

LAER (Lowest Achievable Emission Rate) **–** The rate of emissions which reflects either the most stringent emission limit contained in the implementation plan of any state (unless it is proved that such limitations are not achievable), or the most stringent emission limit achieved in practice, whichever is most stringent.

Laminar Flow – Gas or fluid in parallel layers with some sliding motion between the layers.

Leno – A weave in which the adjacent warp yarns are twisted on either side of the interlacing filling yarn.

Liquide Flowrate – The amount of water or "scrubbing liquid" introduced into a wet collector.

Louver – A device comprised of multiple blades which, when mounted in an opening, permits the flow of air but inhibits the entrance of undesirable elements.

Low Nox Burners – One of several combustion technologies used to reduce emission of Nox.

Low Pressure Cleaning Air – Air at less than 30" WC used for cleaning baghouses.

Lower Explosive Limit – The lower limit of flammability or explosibility of a gas or vapor at ordinary ambient temperature expressed in percent of a gas or a vapor in air by volume.

LST (*c*) – Large Square Top removal. MAC Equipment acronym for its square top bag removal pulse jet dust collectors from 64 to 144 bags. **(*c*)** *designates cartridges instead of bags.*

LVS (*c*) – Large Air Vent Square. MAC Equipment acronym for its square bottom bag removal pulse jet dust collectors from 64 to 144 bags. **(*c*)** *designates cartridges instead of bags.*

M

Mach Number – A fraction of the speed of sound; used in fan engineering where air moving at a mach of 0.9, or 9/10 the speed of sound, begins to deviate from the fan laws.

MACT (Maximum Achievable Control Technology) **–** The standard to which sources of HAPs will have to comply; the CAAA defines MACT as "the maximum degree of reduction in emissions...achievable for new or existing sources...taking into account the cost of achieving such reductions." MACT standards for existing sources must be at least as stringent as the average level of control achieved at the best controlled 12 percent of facilities, and MACT for new sources will have to be even stricter.

Mactiflo – MAC Equipment's trademark name for its down flow cartridge filter.

Major Source – A stationary source which emits a large amount of pollution. In non-attainment areas, under Title I of the CAAA, a major source is one which emits more than 100, 50, 25, or 10 tons per year depending on whether the area is classified as Marginal or Moderate, Serious, Severe, or Extreme, respectively. For hazardous air pollutants, under Title III of the CAAA, a major source is one which can emit more than 10 TPY of any one HAP or 25 TPY of total HAPs.

Make-up Air – A ventilating term which refers to the replacement of air lost because of exhaust air requirements.

Manifold – As used in conjunction with pulse jet baghouses, the pipe that extends over the bags with a hole over each bag. It distributes the compressed pulse to the bags. Sometimes called a blow-pipe.

Manometer – A u-shaped device for measuring the static pressure at a point relative to some other point, the pressure difference causes water to rise or fall. The difference in the level of the water columns is equivalent to the pressure differential.

Maximum Continuous Rating – The point at which the fan is expected to operate.

MCF (*c*) – Medium Pressure Controlled Fire. MAC Equipment acronym for its dust collector that utilizes 7 psi air to clean the bags through a rotating mechanism that is timed to release the air precisely over the bags. This patented dust collector is available from 22 to 1652 bags. **(*c*)** *designates cartridges instead of bags.*

Mechanical Collector – Devices that are functionally dependent on the laws of mechanics governing the motion of bodies in space. Can be operated dry or wet. When operated wet, devices are generally called scrubbers. Examples of mechanical collectors are cyclones, settling chambers, and various types of impingement collectors.

Medium Pressure Cleaning Air – Air at 5-10 PSIG used for cleaning baghouses.

Mega – A prefix meaning 1 million.

MIASMACT – MAC Equipments trademark name for its Automatic Cleaning HEPA filter. MIASMACT is an overlay of the words Miasma and MIACT. Miasma is a word meaning toxic materials in the air, and MACT is Maximum Achievable Control Technology.

Micro – A prefix meaning 1/1,000,000 abbreviated by the Greek letter μ.

Microbar – A unit of pressure equal to one-millionth of an atmospheric pressure, 0.0000146 PSI.

Micrometer – See micron.

Micron – Symbol μ, a unit of length equal to one millionth of a meter. An average human hair is 70 microns in diameter. In general, particles down to 10 microns can be seen without the aid of magnification.

MIL – A unit of measure equal to 25 microns or one thousandth of an inch.

Mildew Resistant Finish – An organic or inorganic finish to repel the growth of fungi on natural fibers.

Milli – A prefix meaning 1/1,000.

Mist – Suspended liquid droplets generated by condensation from the gaseous to the liquid state or by breaking up a liquid into a dispersed state, such as by splashing, foaming and atomizing.

Modacrylic – A synthetic fiber which contains less than 85% acrylonitrile.

Modeling – An investigate technique using computer mathematical, or physical representation of a system that accounts for all or some of its known properties.

Molecular Weight – The weight of a molecule expressed on a scale in which the carbon isotope weighs exactly 12.0; represents the sum of the weights of all the atoms in a molecule. As air is a gas mixture, it does not have a true molecular weight, but an apparent molecular weight determined by the percentages of the molecular weights of each gas in a composition.

Montreal Protocol – An international environmental agreement to control chemicals that deplete the ozone layer. The protocol, which was renegotiated in June 1990, calls for phase-out of CFCs, halons, and carbon tetrachloride by the year 2000, a phase-out of chloroform by 2005, and provides financial assistance to help developing countries make the transition from ozone-depleting substances.

MSDS (Material Safety Data Sheet) **–** Compilation of data and information on individual hazardous chemicals produced by the manufacturers and importers of that chemical, as required by OSHA's Hazard Communication Standard, 29 CFR 1910.1200.

Mullen Burst – The pressure necessary to rupture a secured cloth specimen, usually expressed in pounds per square inch.

Multi-Filament (Multi-fill) **–** A yarn composed of a number of filaments.

N

NACE – National Association of Corrosion Engineers.

Napped – The rupturing of the filling yarns to produce a fleecy surface on woven fabrics.

Natural Frequency – The frequency at which a component or system resonates.

NEC – National Electrical Code.

Needled Felt – A felt made by the placement of loose fiber in systematic alignment with barbed needles. The needles move up and down, pushing and pulling fibers to form an interlocking of adjacent fibers. It is the most commonly used construction method since it is stronger than pressed felt.

NEDS – National Emission Data System.

NEMA – The National Electrical Manufacturers Association; the trade association establishing standards of dimensions, ratings enclosures, insulation, and other design criteria for electric motors.

NESHAP – National Emissions Standards for Hazardous Air Pollutants.

New Source – A stationary source, the construction or reconstruction of which is commenced after the proposal date of the standard. Also NSPS (New Source Performance Standard).

NIOSH (National Institute for Occupational Safety and Health) **–** Created by the Occupational Safety and Health Act of 1970. NIOSH is part of the Centers for Disease Control under the Department of Health and Human Services. Its mandate includes conducting research in developing criteria and/or recommendations to be used in setting occupational exposure standards, identifying and evaluating workplace hazards, measurement techniques, and control technologies, and providing professional education as well as health and safety information.

Noise Criteria – A way for an architect to specify the maximum permissible sound-power level in each of the eight octave bands. NC curves give, in a graphical form, maximum permissible intensity per octave band.

Non-Attainment – An area which has not achieved air quality as good as the National Ambient Air Quality Standards as defined by the CAAA.

Non-Woven Felt – A felt made by either needling, matting of fibers or compressed with a bonding agent for permanency.

Nox (Nitrogen Oxides) **–** Chemical compounds containing nitrogen and oxygen; reacts with volatile organic compounds, in the presence of heat and sunlight to term ozone. It is also a major precursor to acid rain. Nationwide, approximately 45% of Nox emissions come from mobile sources, 35% from electric utilities, and 15% from industrial fuel combustion.

O

OCIS (OSHA Computerized Information System) **–** A comprehensive database that contains information and data on standards interpretation, chemical information, hazardous waste activity 5(a)(1) citations, a health hazard evaluation index, training materials, and other information compiled by OSHA on subjects related to occupational safety and health.

Octave Bands – Ranges of frequencies. These octave bands are identified by their center frequencies (63, 125, 250, etc.).

Ohm – A measure of electrical resistance. A wire in which one volt produces a current of one ampere has a resistance of one Ohm.

Onboard Controls – Devices placed on vehicles to capture gasoline vapor during refueling.

Capacity – Refers to the amount of light that can pass through; normally refers to the degree of visibility of an exhaust plume, Normal measurement technique used by EPA method 9.

Opposed-Blade Damper – A type of damper where the blades rotate in the opposite direction.

OSHA – Occupational Safety and Health Administration.

OSI – Ounces per square inch; a unit of pressure equal to one-sixteenth PSI or 1.733 inches of water.

Oxygenated Fuels – Gasoline which has been blended with alcohols or ethers that contain oxygen in order to reduce carbon monoxide and other emissions.

Ozone – A compound consisting of three oxygen atoms, that is the primary constituent of smog. It is formed through chemical reactions in the atmosphere involving volatile organic compounds, nitrogen oxides, and sunlight. Ozones can initiate damage to the lungs as well as damage to trees, crops, and materials. There is a natural layer of ozone in the upper atmosphere which shields the earth from harmful ultraviolet radiation.

P

Parallel-Blade Damper – A type of damper where the blades rotate in the same direction.

Parallel Fans – Two or more fans which draw air from a common source and exhaust into a common duct or plenum. A parallel fan arrangement is generally used to meet volume requirements beyond that of single fans. Two identical fans in parallel will effectively deliver twice the rated flow of any one of the fans at the same static pressure.

Particulate – A particle of solid or liquid matter.

Particulate Matter – Any solid or liquid material in the atmosphere.

PEL (Permissible Exposure Limits) **–** Limits developed by OSHA to indicate the maximum airborne concentration of a contaminant to which an employee may be exposed.

Permanent Split Capacitor Motor – Very low starting torque. Performance and applications similar to shaded pole but more efficient, with lower line current and higher horsepower capabilities.

Permeability, Fabric – Measured on Frazier porosity meter or Gurley permeometer, etc. Not to be confused with dust permeability. The ability of air to pass through the fabric, expressed in cubic feet of air per minute per square foot of fabric with 0.5 H_2O pressure differential.

Permit – An authorization, license, or equivalent control document issued by EPA or an approved state agency to implement the requirements of an environmental regulation; e.g., a permit to operate a facility that may generate harmful emissions.

pH – A symbol as part of a logarithmic designation to indicate acidity or alkalinity on a scale from 0 to 14; pH7 is taken as neutral, 6 to 0 increasingly acid, 8 to 14 increasingly alkaline.

Photochemical Process – The chemical changes brought about by the radiant energy of the sun acting upon various polluting substances. The products are known as photochemical smog.

Pick – See fill.

Piezometer Ring – A device consisting of a number of pressure taps connected to a common manifold to measure pressure.

Pilot Valve – The small solenoid valve that is electrically operated to relieve pressure on one side of the diaphragm and cause the operation of a larger diaphragm valve.

Pitch Diameter – The mean diameter or point at which V-belts ride within a sheave. This dimension is necessary for accurate drive calculations.

Pilot Tube – A metering device consisting of a double-walled tube with a short right-angle bend; the periphery of the tube has several holes through which static pressure is measured; the bend end of the tube has a hole through which total pressure is measured when pointed upstream in a moving gas stream.

Pleated Filter Element – Filter elements made from any pleated filter media; but primarily applying those equipped with 100% synthetic fabric.

Plenum – Pressure equalizing chamber.

Plenum Pulse – Type of pulsing collector where entire sections of the clean air plenum are isolated and pulsed with either compressed air or air from a high pressure blower.

Ply – Two or more yams joined together by twisting.

PM $_{10}$ – A new standard for measuring the amount of solid or liquid matter suspended in the atmosphere ("particulate matter"). Refers to the amount of particulate matter under 10 micrometers in diameter. The smaller PM_{10} particles penetrate to the deeper portions of the lung, affecting sensitive population groups such as children and people with respiratory diseases.

Point of Operation – The intersection of a fan's static pressure curve and the system curve to which the fan is being applied; may be designated as velocity pressure divided by static pressure or by a given CFM and SP.

Point Source – A stationary location or facility from which pollutants are emitted. Also, any single identifiable source of pollution.

POLIPLEET – MAC Equipment's trademark for its line of pleated spun bond 100% polyester cartridges. The POLIPLEET can be used in MAC Equipment's entire product line of dust collectors.

Polymerized – A chemical reaction in which two or more small molecules combine to form larger molecules that contain repeating structural units of the original molecules.

Porosity – Sometimes erroneously used as a synonym for permeability. Originally a designation for the amount of air in a fabric, i.e. blankets.

Pounds Per 100 Pounds of Gas – A common quantitative definition of air pollution concentration.

PPM (Parts Per Million) **–** The number of parts of a given pollutant in a million parts of air. Units are expressed by weight or volume.

Precipitators – Any number of devices using mechanical, electrical, or chemical means to collect particulates. Used for measurement, analysis or control. See electrostatic precipitator.

Pre-Coating – The application of a relatively coarse, dry dust to a bag or cartilage before start-up to provide an initial filter cake to enhance immediate high efficiency.

Pressed Felt – A type of felt manufactured by pressing fibers into the skrim.

Pressure, Atmospheric – The pressure due to the weight of the atmosphere. It is the pressure indicated by a barometer; standard atmospheric pressure is 29.92 inches of mercury.

Pressure Drop – The differential pressure between two points in a system. The resistance to flow between the two points.

Pressure, Static – The potential pressure exerted in all directions by fluid at rest. For a fluid in motion it is measured in a direction normal (90°) to the direction of now. Usually expressed in inches water gauge when dealing with air.

Pressure, Velocity – The kinetic pressure in the directional flow necessary to cause a fluid at rest to flow at a given velocity. Usually expressed in inches water gauge.

Prevention of Significant Deterioration (PSD) **–** EPA program in which state and/or federal permits are required that are intended to restrict emissions for new or modified sources in places where air quality is already better than required to meet primary and secondary ambient air quality standards.

Primary Collector – A dry or wet collector which is followed by a secondary collector with greater filtering efficiency.

Process Weight – The weight per hour that is run through the process. Commonly used in APC codes to determine the maximum allowance pollution exhausted.

Promulgate – To make a new law known and put it into effect. The EPA promulgates a rule when it issues the final version in the Federal Register.

PSI (Pounds per square inch) **–** A measure of pressure. 1 psi equals 27.7" water gauge.

PSIA (Pounds per Square Inch Absolute) **–** The absolute pressure without reference to another point. Atmospheric pressure is 14.7 PSIA.

PSIG (Pounds per Square Inch Gauge) – The pressure relative to atmosphere. For instance, 10 PSIG equals 24.7 PSIA. This is the more common pressure term.

Psychromatic Chart – A graphic depiction of the relationship between pressure, density, humidity, temperature, and enthalpy for any gas-vapor mixture, used extensively in comfort ventilation.

Pulse Cycle – As used in conjunction with pulse jet baghouses; the interval of time between pulsing a row of bags and that row being pulsed again.

Pulse Duration – The length of time a pulse lasts. Generally described as the length of time the electrical signal the pilot valve open (20-40 milliseconds), however would more correctly be the description of the length of time the manifold is pressurized (120-180) milliseconds.

Pulse Interval – The time between pulsing one row of bags and pulsing the next row.

Pulse Jet – Generic name given to all pulsing collectors.

Pulse Jet Cleaning – A cleaning method where a momentary burst of compressed air is introduced through tube or nozzle to the top cap of a bag. A bubble of air flows down the bag, causing bag walls to collapse behind it. Generic name given to all pulsing collectors.

R

RACM (Reasonably Available Control Measures) **–** A broadly defined term referring to technologies and other measures that can be used to control pollution; includes Reasonably Available Control Technology and other measures. In the case of PM_{10}, it refers to approaches for controlling small or dispersed source categories such as road dust, woodstoves, and open burning.

RACT (Reasonably Available Control Technology) **–** An emission limitation on existing sources in non-attainment areas, defined by EPA in a Control Techniques Guideline (CTG) and adopted and implemented by states. Under Title I of the CAAA, EPA will establish RACT standards for marginal, moderate, and serious non-attainment areas.

Radial Blade – Fan wheel design, with blades positioned in straight radial direction from the hub.

Radionuclide – Radioactive element which can be man made or naturally occurring. They can have a long life as pollutants, and are believed to have potentially mutagenic effects on the human body.

Radon – A colorless, naturally occurring, radioactive, inert gaseous element formed by radioactive decay of radium atoms in soil or rocks.

Random Noise – A sound that has an average amplitude and constantly changing frequency.

Rankine – See Absolute Temperature.

Rarefication – A phenomenon related to negative pressure. When air is drawn put through resistance into a fain inlet, the air is stretched out, or rarefied, and becomes less dense than at the entry to the system. While negligible at low pressure and volumes, high pressure fan selection must be based on rarefied inlet density.

Ravel Strip Tensile – The tension strength, in pounds per inch of a 6" long textile sample cut, cut just over one inch wide, (with yarns peeled off each side down to exactly one inch wide) pulled in two lengthwise between jaws set 3" apart and pulled at a constant specified speed. The type of test always used unless specified. ASTM specs are available at technical libraries.

Re-entrainment – The phenomenon whereby dust is collected from the air stream and then is returned to the air stream. Occurs when dust is pulsed from a bag and then caught up by an upward moving air stream.

REL (Recommended Exposure Limits) **–** Issued by NIOSH to aid in controlling hazards in the workplace. These limits are generally expressed as 8 or 10 hour TWAs for a 40-hour work week and/or calling levels with time limits ranging from instantaneous to 120 minutes.

Relative Humidity – The ratio of existing water vapor to that of saturated air at the same dry-bulb temperature.

Repeat – The number of threads in a weave before the weave repeats or starts over again. The number of ends and picks in the repeat may be equal or unequal but in every case the repeat must be in a rectangular form.

Repressuring Baghouse – Baghouse using bags that are cleaned by flowing air backwards through the cloth. Same as reverse air baghouse.

Repowering – The replacement of an existing coal-fired boiler with one or more clean coal technologies, in order to achieve significantly greater emission reduction relative to the performance of technology in widespread use as of the enactment of the Clean Air Act Amendments.

Residual Risk – The quantity of health risk remaining after application of the MACT (Maximum Achievable Control Technology).

Resistance – In air flow, it is caused by friction of the air against any surface, or by changing the momentum of the gas.

Reverse Air Baghouse – Baghouse using bags that are cleaned by flowing air backwards through the cloth, to cause dust cake release.

Reverse Jet – See pulse jet.

Reynolds Number – A mathematical factor used to express the relation between velocity, viscosity, density, and dimensions in a system of flow, used to define fan proportionality.

Ringelman – A measure of the opacity caused by pollution from a stack. Grades opacity from 0 to 5, where 0 is an invisible discharge and 5 is totally opaque.

Ringelman Chart – Actually, a series of charts, numbered from 0 to 5, that simulate various smoke densities, by presenting different percentages of black. A Ringelman No. 1 is equivalent to 20 percent black; a Ringelman No. 5, to 100 percent. They are used for measuring the opacity of smoke rising from stacks and other sources, by matching with the actual effluent, the various numbers, or densities, indicated by the charts. Ringelman numbers were sometimes used in setting emission standards.

Rotor – The rotating part of most AC motors.

RPM – Revolutions per minute.

RPT *(c)* – Rectangular Pulse Top removal. MAC equipment acronym for its large rectangular, top bag removal pulse jets that start at 196 bags and go up as high as needed. *(c) designates cartridges instead of bags.*

RT *(c)* – Round top removal. MAC Equipment acronym for its round top bag removal pulse jet dust collectors. *(C) designates cartridges instead of bags.*

RTECS (Registry of Toxic Effects of Chemical Substances) – A database that lists an identification number, synonyms, Department of Transportation (DOT) hazard label information, EPA Toxic Substances Control Ad (TSCA) Information, OSHA and Mine Safety and Health Administration (MSHA) air exposure limits, and animal and human toxicologic data.

S

Sanctions – Actions taken against a State or local government for failure to plan or to implement a SIP, e.g., a ban on construction of new sources.

Sateen – Cotton cloth made with a satin weave, expressed as warp sateen or filling sateen.

Satin Weave – A form of twill except that the points of intersection are separated from one another in a consistent or inconsistent manner.

Saturated Air – Air containing the maximum amount of water vapor for a given temperature and pressure.

SB Fan – MAC Equipment's Strait Blade fan. This all purpose fan can be placed on the clean air or dirty air side of the dust collector in most cases.

SCFM (Standard Cubic Feet per Minute) **–** The volume that a gas would occupy at standard temperature and pressure conditions (70°F and 14.7 PSIA). See gas flow rate.

Scour – A soap and water wash to "off loom" fabric.

Scroll – The general shape of a centrifugal fan housing; the formed piece to which housing sides are welded.

Scrubber – A device that uses a liquid spray to remove aerosol and gaseous pollutants from an air stream. The gases are removed either by absorption or chemical reaction. Solid and liquid particulates are removed through contact with the spray. Scrubbers are used for both the measurement and control of pollution.

Scrubber, Gas – Any device in which a contaminant, solid or gaseous, is removed from a gas stream by liquid droplets. (Types include spray towers, packed towers, cyclone scrubbers, jet scrubbers, orifice scrubbers, venturi scrubbers, impingement scrubbers, and mechanical scrubbers).

Secondary Collector – A dust collector which is preceded by primary collector(s). The secondary filter normally has a higher filtering efficiency.

Seeding – The application of a relatively coarse, dry dust to a bag or cartridge before start-up to provide an initial filter cake for immediate high efficiency and to protect bags from blinding. Also, in crystallizing, seeding is used to start the crystallization process.

Sensible Heat – Any portion of heat which affects a change in a substance's temperature but does not alter that substance's state.

Series Fans – A combination of fans connected such that the outlet of one fan exhausts into the inlet of another. Fans connected in this manner are capable of higher pressures than a single fan and are used to meet pressure requirements greater that single fans.

Service Factor – The number by which the horsepower rating is multiplied to determine the maximum safe load that a motor may be expected to carry continuously.

Settling Chamber – A dry collection device which removes particulate matter from the gas stream by slowing down the exhaust gas velocity.

Shaded-Pole Motor – A special type of single-phase induction motor. Low starting torque, low cost. Usually used on direct-drive fans.

Shaft Seal – A device to limit gas leakage between the shaft and fan housing.

Shaker Baghouse – A baghouse using woven cloth bags; cleaning occurs by shaking bags from the top.

SI Units – Systeme International d'Unites, International System of Units, any one of the units of measure in the international meter-kilogram-second system.

Silicone Finish – A treatment of felted bags with silicone to provide a slick finish for improved dust release. Most commonly used on Dacron polyester and fiberglass bags.

Singed Finish – A felted bag finish that is designed to provide a finish similar to calendering. The "hairs" are burned off to provide a smoother finish.

Singeing – The burning off of the protruding fibers from the warp and filling yarns of the fabric.

Singles – The term used to imply only one yarn.

SIP (State Implementation Plan) **–** Documents prepared by states, and submitted to EPA for approval, which identifies actions and programs to be undertaken by the State and its subdivisions to implement their responsibilities under the Clean Air Act.

Sizing – A protective coating applied to yarn to ensure safe handling, e.g., abrasion-free during weaving.

Skrim – A woven fabric that felt is needled onto.

Slip – The percentage difference between synchronous and operating speeds.

Slippage – The movement of yarns in a fabric due to insufficient interlacings.

Smog – The irritating haze resulting from the sun's effect on certain pollutants in the air, notably those from automobile exhaust; see photochemical process. Also a mixture of fog and smoke.

Smoke – Carbon or soot particles, less than 0.1 micrometers in size which result from the incomplete combustion of carbonaceous materials such as coal, oil, tar and tobacco.

SO_2 – Sulfur dioxide is an invisible, non-flammable acidic gas, formed during combustion of fuel containing sulfur.

SO_3 – Sulfur trioxide oxidized from SO_2 combines with atmospheric moisture to form sulfuric acid mist (H_2SO_4).

Soot – Very finely divided carbon particles clustered together in long chains.

Second-Power Level – Acoustic power radiating from a sound source. Expressed in watts or decibels.

Sound-Pressure Level – The acoustic pressure at a point in space where the microphone or listener's ear is situated. Expressed in units or pressure or in decibels.

Source – Any place or object from which pollutants are released.

SP – Static pressure; pressure as measured in all directions within an air-handling system, not including the force or pressure of air movement.

Specific Gravity – The ratio of the weight or mass of a given volume of any substance to that of an equal volume of some other substance taken as a standard. The ratio of the density of andy gas to the density of dry air at the same temperature and pressure is the specific gravity of the gas.

Specific Heat – The ratio of the quantity of heat required to raise a certain volume one degree to that required to raise an equal volume of water one degree.

SPI – Society of the Plastics Industry.

Split-Phase Motor – The most common type of single-phase induction motor. moderate starting torque, high starting current, high breakdown torque, used on easy-starting equipment, such as belt-drive fans.

Spun Fabric – Fabric woven from staple spun fabric.

Squirrel-Cage Winding – A permanently short-circuited winding , usually uninsulated and chiefly used in induction motors, having its conductors uniformly distributed around the periphery of the machine and joined by continuous end rings.

SRC – Spark-Resistant Construction; AMCA standard of guidelines for general methods of fan construction when handling potentially explosive or flammable particles, fumes, or vapors.

SSPC – Steel Structure Painting Council

ST *(c)* – Square Top removal. MAC acronym for its square top bag removal pulse jet dust collectors up to 64 bags. *(c) designates cartridges instead of bags.*

Stack – A smokestack, a vertical pipe or flue designed to exhaust gases.

Stage II Controls – Systems placed on service station gasoline pumps to control and capture gasoline vapors during an automobile refueling.

Standard Air Density – 0.0750 lbs./ft³, corresponds approximately to dry air at 70°F. and 29.92 in. Hg.

Starting Torque – The torque produced by a motor as it begins to turn from a standstill and accelerate. Sometimes called locked rotor torque.

Static Balance – The mechanical balance of a rotating part or assembly by adding weights to counter-balance gravitational rotating of the part without power driving it.

Static Pressure (Cold) **–** The pressure caused by the resistance to air flow through the system if the gas were at standard conditions or colder, if this is a possibility.

Static Pressure (Fan) **–** The static pressure for which a fan is to be selected based on system calculations;

fan SP = SP outlet-Sp inlet-VP inlet.

Static Pressure (Hot) **–** The pressure caused by the resistance to air flow through the system at actual conditions. Measured in inches of water (WG).

Stator – The stationary parts of a magnetic circuit with associated windings.

Streamline Flow – Fluid flow in which the velocity pressure and fluid density of a given particle remains constant with time.

STEL (Short Term Exposure Limit) **–** The employee's 15 minute time weighted average exposure which cannot be exceeded at any time. STEL is set by OSHA for each pollutant and expressed in terms of ppm or mg/m³.

Stoichlometric Air – The exact quantity of air required to combine with the given fuel so that the ensuing combustion reaction is perfect and no free oxygen or unburned constituents remain. In reality, air in excess of the stoichlometric ratio is usually provided to encourage complete combustion of the fuel.

Sulfur Dioxide (SO_2) – A heavy, pungent, colorless air pollutant formed primarily by the combustion of fossil fuels. It is a respiratory irritant, especially for asthmatics and is the major precursor to the formation of acid rain.

Sulfur Oxides – Pungent, colorless gases formed primarily by the combustion of fossil fuels; considered major air pollutants; sulfur oxides may damage the respiratory tract as well as vegetation.

Surge Limit – That point near the peak of the pressure curve which corresponds to the minimum flow at which the fan can be operated without instability.

SWSI – Single-Width Single-Inlet Centrifugal Fans.

Synchronous Speed – Rated motor speed expressed in RPM. Synchronous speed = 120 x frequency divided by number of poles.

System – A series of ducts, conduits, elbows, filters, diffusers, etc., designed to guide the flow of air, gas, or vapor to and from one or more locations. A fan provides the energy necessary to overcome the system's resistance to flow and causes air or gas to flow through the system.

System Curve – Graphic presentation of the pressure versus volume flow rate characteristics of a particular system.

System Effect – The effect on the performance of a fan resulting from the difference between the fan inlet and outlet connections to the actual system, and the standardized connections used in laboratory tests to obtain fan-performance ratings.

System gas Volume – All gases flowing through the exhaust gas system (including excess air, scavenger air, leakage air).

T

Tachometer – an instrument which measures the speed of rotation, usually in RPM.

Tape Sampler – A device used in the measurement of both gases particulates. It allows air sampling to be made automatically at predetermined times.

Tensile Strength – The maximum stress a material can withstand before it breaks; expressed in pounds per square inch.

Test Block – An operating point above and beyond the maximum specified continuous rating demonstrating the fan margin to the customer.

Textile – That which is or may be woven. Comes from the Latin "Texere" to weave. Hence any kind of fabric.

Thread Count – The number of warp and filling yarns in a fabric commonly expressed in square inch.

Threshold Limit Values (TLV) **–** Represents the air concentrations of chemical substances to which it is believed that workers may be exposed daily without adverse effect.

Tip Speed – Fan wheel velocity at a point corresponding to the outside diameter of the wheel blades; normally expressed in feet per minute (circumference times RPM).

TLV®(Threshold Limit Value) **–** A registered trademark for an exposure limit developed by the American Conference of Governmental Industrial Hygienists (ACGIH). A listing of TLVs may be found in the ACGIH's "Documentation of the Threshold Limit Values and Biological Exposure Indices for 1988-1989."

Torque – A force which produces, or lends to produce, rotation; commonly measured in ft.-lbs. or in.-lbs. A force of one pound applied to the handle of a crank, the center of which is displaced one foot from the center of the shaft, produces a torque of one ft.-lb. on the shaft if the force is provided perpendicular to, not along the crank. Torque can be calculated by:

$$\text{Torque (Ft.-lbs.)} = \frac{\text{HP x 5250}}{\text{RPM}}$$

Toxic Release Inventory (TRI) **–** A listing of pollutants and emissions Levels from each major source.

TP – Total pressure; the sum of velocity pressure plus static pressure.

TPI – Twist Per Inch.

TPY – Tons per year.

Transportation Control Measures (TCM's) **–** Steps taken by a locality to adjust traffic patterns (e.g. lanes, right turn on red) or reduce vehicle use (ridesharing, high-occupancy vehicle Lanes) to reduce vehicular emissions of air pollutants.

Traverse – A method of sampling points in a duct where pressure readings will be taken to determine velocity. A traverse divides the duct into equal, evenly distributed areas that are each tested, compensating for errors caused by uneven gas flow in the duct.

TSCA (Toxic Substances Control Act) **–** Administered by the Environmental Protection Agency (EPA), was passed by Congress to protect human health and the environment by requiring testing and necessary use restrictions to regulate the commerce of certain chemical substances.

TSD (Facility) **–** Treatment, Storage, and Disposal.

Tubeaxial Fan – Axial fan without guide vanes.

Tubesheet – The steel plate that bags and cages are suspended from. Separates the clean air and dirty air sections of the baghouse. Sometimes called cellplate, a term usually used for inside collector baghouses.

Tubular Centrifugal Fan – Fan with a centrifugal impeller within a cylindrical housing discharging the gas in an axial direction.

Turbulent Flow – Airflow in which true velocities at a given point vary erratically in speed and direction.

Turning Vanes – Baffles put in a duct to straighten out the air flow.

TWA (Time Weighted Average) **–** Employee's average airborne exposure which can not be exceeded in any 8 hour work shift. TWA is set by OSHA and expressed in mg/m^3.

Twist – The number of complete spiral turns in a yarn, in a right or left direction, e.g., "Z" or "S" respectively.

U

Unbalance – The condition of a rotor in which its rotation results in centrifugal force being applied to the rotor's supporting bearings.

Uniform Flow – Airflow in which velocities between any two given points remain fairly constant.

V

Valve – In baghouses, frequently the pilot valve and the diaphragm valve pulse are considered as one, simply called "valve."

van der Waals – Adhesive forces that exist between the particle and fiber.

Vaneaxial Fan – Axial fan with either inlet or discharge guide vanes or both. Includes fixed-pitch, adjustable-pitch, and variable-pitch impellers.

Vaporization – The change of a substance from the liquid to a gaseous state. One of the 3 basic contributing processes of air pollution, the others being attrition and combustion.

Vapors – The gaseous form of substances which are normally in the solid or liquid state and which can be changed to these states, either by increasing the pressure or decreasing the temperature alone. Vapors diffuse.

Variance – Permission granted for a limited time, under stated conditions, for a person or company to operate outside the limits prescribed in a regulation. Usually granted to allow time for engineering and fabrication of abatement equipment to bring the operation into compliance.

Velometer – A simple instrument for determining the velocity of gas in a duct, its operation is similar to an inclined manometer, except that it automatically converts the reading to velocity.

Vena Contracta – The smallest flow area for flow through a sharp-edged orifice.

Ventilation – Supplying and removing air by natural or mechanical means to and from any space.

Venturi – Device used to theoretically increase the efficiency of a compressed air pulse. Designed with converging circular sides to a throat and then diverging sides. Designed such that when a pulse is introduced at the top, a negative pressure zone is created outside the top, and secondary air is induced into the venturi, increasing cleaning energy.

Venturi Scrubber – A wet type dust collector that can obtain very high efficiency, but requires large horsepower to do so. The gas and dust particles are accelerated in a venturi throat, where finely atomized water is introduced and water/dust take place.

Vibration – Alternating mechanical motion of an elastic system, components of which are amplitude, frequency, and phase.

Viscosity – The characteristic of all fluids to resist flow.

VOC's (Volatile Organic Compounds) **–** A group of chemicals that react in the atmosphere with nitrogen oxides in the presence of heat and sunlight to form ozone; does not include methane and other compounds determined by EPA to have negligible photochemical re-activity. Examples of VOC's include gasoline fumes and oil-based paints.

Volt – A unit of electrical potential or pressure. 110 or 220 volts are normally found in the U.S.

VP – Velocity pressure; the kinetic energy pressure of air in motion. VP is used to get the velocity of a gas stream.

$$Velocity\ (SFPM) = 4005\sqrt{VP}$$

$$Velocity\ (AFPM) = 1096\sqrt{VP/\rho}$$

ρ = Actual density of the air (lb/ft^3)
VP = inches of water column

VP/SP – Velocity pressure divided by static pressure; a single number reference used to define a fan's point of operation. Each system curve has a unique VP/SP value.

W

Warp Count – Number of warp threads per inch width.

Warp Sateen – The face of the cloth having the warp yarns floating over the filling yarns and being greater in number than the filling yarns.

Warp Thread – Yarn or threads in a fabric running lengthwise.

Warp Yarns – Yarn in a fabric running lengthwise.

Water Gauge – Inches water is a pressure term defined as a pressure equal to that exerted by a column of water of the same height. 27.7" WG equals 1 PSI.

Watt – A unit of power in electrical terms, the product of voltage and amperage. 746 watts are equal to one horsepower.

Weave – The pattern of weaving, e.g., plain twill, satin, etc.

Weft – See fill.

Wet-Bulb Depression – The difference between the dry-bulb and wet-bulb temperature at the same location.

Wet-Bulb Temperature – The temperature of a gas stream taken with a wetted thermometer. It is approximately equal to the adiabatic saturation temperature of the gas.

Wet Collector – Dust collector which uses water to remove particulate matter from the exhaust gas (wet washers, venturis, wet fans).

WG – Water gauge, see inch of Water.

Wizard – MAC Equipment trademark for its intelligent dust collector controller. The MAC Baghouse Wizard controls the pulse cleaning of a dust collector and monitors emissions, airflow, pressure drop, temperature, and hopper level and displays it in a user friendly graphical interface.

Woof – See fill.

Woolen System – A system of yarn manufacturing suited for the shorter wools, various wastes, reclaimed wools, etc.

Worsted System – A system of yarn manufacturing suited for medium and longer wools. Includes additional processing steps resulting in the most uniform yarn. The resulting yarn is compact and level.

Woven Cloth Bag – A bag made of woven material, similar to normal cloth. Used in re-pressuring and shaker baghouses.

WR^2 -- The unit designation of fan wheel rotational inertia in lb.-ft^2, also known as WK^2.

Wrapper – Used in electrostatic precipitators, the light gauge steel or aluminum covering put over insulation.

Y

Yarn – A term for an assemblage of fibers or filaments forming a strand (thread) which can be otherwise formed into a textile material.

Yarn Size – A relative measure of fineness or coarseness of yarn. The smaller the number in spun yarns, the coarser the yarn.

Yield Strength – Maximum stress to which a ductile material can be subjected before it physically distorts.

Z

Z-Twist – The yarn spirals conform in slop to the center portion of the letter "Z."

Filter Media / Fibers

Definitions

Every industry has unique buzz words, terms and acronyms. Fabric filtration is especially blessed with a full vocabulary. Jargon associated with fabrics, can be nearly as arcane as any found in the Military's or Silicon Valley's lexicon. This section has been prepared to give you a basic understanding of the different filtration medias in the dust collection marketplace.

Nonwoven – Nonwovens are defined by what they are not. Nonwoven is a generic term used to describe fabric that is produced differently from a fabric made by weaving or, more broadly, a fabric that is different from traditional woven or knitted fabrics. Like all fabrics, nonwovens are planar structures that are relatively flat, flexible, and porous. Unlike traditional fabrics that re made by mechanically interlacing (weaving) or interlooping (knitting) yarns composed of fibers of filaments, nonwovens are fabrics that are made by:

(a) mechanically, chemically, or thermally interlocking layers of networks or fibers or filaments or yarns,
(b) interlocking fibers or filaments concurrent with their extrusion,
(c) perforating films, or
(d) forming porous films concurrent with their extrusion.

The American Society for Testing and Materials (ASTM D 1117-80) defines a nonwoven fabric as: "A textile structure produced by bonding or interlocking of fibers, or both, accomplished by mechanical chemical, or solvent means and combinations thereof."

How nonwoven fabrics are made – A basic concept used in making a nonwoven is to transform fiber-based materials into flat, flexible, porous, sheet structures with fabric characteristics. In practice, this is accomplished several ways, depending on the fiber material used and/or the fabric characteristics desired. Technologies used in three primary manufacturing industries: textile, paper, and extrusion and various combinations of established processes from one or more of these industries, form the basis of the processes for manufacturing nonwovens. Accordingly, process for manufacturing nonwoven fabric can be grouped into four general technology bases: textile, paper, extrusion, or hybrid (combination).

The textile technology base includes garneting, carding and aerodynamic forming of textile fibers into preferentially-oriented webs. Fabrics produced by these systems are referred to as dry laid nonwovens and carry terms such as "garneted", "carded", and "air laid." These fabrics, or fiber-network structures, are manufactured with machinery associated with staple fibers bonded by stitching filaments or yarns. Needle-felt fabric is produced by textile-based technology.

Paper technology base includes dry laid pulp and modified wet laid paper systems designed to accommodate fibers longer than wood pulps. Fabric produced by these systems are referred to as "dry laid pulp" and "wet laid" nonwovens. These fabrics are manufactured with machinery associated with pulp fiberizing (i.e. hammer mills) and paper forming (i.e. slurry pumping onto continuous screens) designed to manipulate short fibers suspended in a fluid.

Most cartridge filter media is produced by the wet laid systems. All wet laid cartridge paper contains high percentages of cellulose, reducing its resistance to moisture. HEPA media is also produced on specialized, wet laid equipment.

The extrusion technology base includes spunbound, meltblown, and porous film systems. Fabrics produced by these systems are referred to individually as "spun bounded", "meltblown", and "textured" or "apertured film" nonwovens; or, generically, as "polymer laid" nonwovens. The fabrics are produced with machinery associated with polymer extrusion (i.e. manufactured fiber spinning, film casting, extrusion coating). In polymer laid systems, fiber structures are simultaneously formed and manipulated.

The hybrid base combine elements of the first three technologies. An example of a hybrid product, is the **MIASMACT™** HEPA media, wet laid media is laminated with spun bounded support sheets, to form a combination media.

Characteristics of Selected Fibers

Acrylic Fibers – Acrylic fibers are man made fibers, in which the fiber forming substance is any long chain polymer composed of at least 85% acrylonitrile units, and the remainder a copolymer. Acrylic is non-thermoplastic.

Orlon® (Dupont), Acilian® (Monsanto), Creslan® (American Cyanimid), Crylor® (Crylor SA), Zefran® (BASF), and Draylon-T® (Bayer) are trade names used by various producers of acrylic fibers.

Draylon-T® (or equivalents), a homopolymer (100% acrylonitrile), is a widely used acrylic, for high-pressure cleaned needled felts. For MAC Equipment applications, only acrylic homopolymer fabric should be used. Fiber cross sections are dumbbell-shaped, and surfaces are striated. Diameters are typically 15 to 35 microns. Where polyesters are not suitable, because of potential hydrolysis, acrylics offer a combination of abrasion resistance and resistance to wet heat degradation, particularly under acid conditions. Homopolymer felt is a candidate for hot gas applications of less than 284 degrees F. Temperature resistance of copolymers is less, 250°F degrees.

Acrylic felts are used in drying raw flour, coal, gold and copper ores, galvanizing, and low temperature flue gas applications. Polyester is superior for most dry heat applications.

Aromatic polymide (Nomex®) – Nomex® nylon was a proprietary (patent has expired) aromatic-polymide (aramide) linked structure, developed by E.I. duPont de Nemours, for applications requiring dimensional stability and high heat resistance. Nomex® is a non-thermoplastic so it does not melt, but at temperatures above 700 degrees F, degradation sets in rapidly. In dry heat up to and including 375 degrees F, this fabric may be used satisfactorily as long as there is no acid dew point problem.

Nomex® is unaffected by small amounts of water vapor and high temperatures. When exposed to saturated steam at high temperatures, Nomex® will progressively lose strength. However, it withstands these conditions better than many other fibers.

Nomex® withstands the attack by mild minerals and inorganic acids, mild alkali, and most hydrocarbons. It is unaffected by florines and gases from metallurgical and rock processing operations. However, high active oxidizing agents, such as sulphur oxides, will rapidly degrade Nomex®.

The single biggest use for Nomex®, needled felt, is asphalt batch plant dryers and drum-mix plants. Other uses include raw and finish mill grinding on cement plants, carbon bake, clinker coolers, and many other hot gas processes.

Polyester – a manufactured fiber in which the fiber forming substance is any long chain synthetic polymer composed of at least 85% by weight of an ester of a dihydric alcohol and terephtalic acid. This material is a thermoplastic.

Fiber is available under various trade names: Dacron® (duPont), Enka Polyester® (American Enka), Fortrel® (Fiber Industries/Celanese), and Kodel® (Eastman Chemical). Polyester is the most widely used needled felt for pulse jet applications.

Polyester (PE) is superior to most synthetics in dry heat installations but it is not comparable to Teflon® nor Nomex®. Recommended operating temperature is 275 degrees F maximum.

Under moist, near-saturation, heat conditions, polyester is inferior to other synthetics. In the presence of a saturated vapor, the fibers will hydrolyze, weakening the fabric.

PE provides good resistance to most oxidizing agents, mineral acids, and most organic solvents except high concentrations of sulfuric, carbolic and nitric acids. It resists weak alkalis. However, strong alkalis, at high temperatures, will dissolve the fabric.

Polyester fiber makes an excellent filter fabric, with efficient filtration and good energy absorption characteristics.

The fabric is widely used in many of the industries served by MAC Equipment. It is used in agricultural, woodworking, chemical and other applications where chemical and mechanical characteristics are compatible. As needled felt, it is available in 12, 16, and 18 oz./yd² versions. The use of 12 oz./yd² should be reserved for non-critical applications, handling large particulate. Spunbonded POLIPLEET™ media is available in plain, water/oil resistant (TR), metalized-antistatic (ME), and with a laminated PTFE membrane.

Polypropylene – (polyolefin) is a manufactured fiber in which the fiber forming substance is any long chain synthetic polymer, composed of at least 85% by weight of olefin units.

Herculon® (Hercules) and Reevon® (Phillips) are trade names used by various producers of polypropylene (PP) fibers.

The fibers combine excellent resistance to most acids and alkalis, plus high strength. It has one of the lowest specific gravities of any synthetic fiber, and is one of the most economical synthetics, (about the same price as polyester). PP is a good choice for replacement of cotton in low temperature applications.

PP absorbs no moisture and provides excellent cake discharge and resistance to blinding. Filtration efficiency is not quite as good as polyester.

Polypropylene has very low heat resistance, even less than cotton, and should not be exposed to prolonged temperatures of over 165 degrees F. Since it does not absorb moisture, its degradation characteristics in dry heat and moist heat are virtually the same.

Within its limited temperature range, polypropylene provides good resistance to mineral and organic acids. It resists alkalis, reducing agents and organic solvents. It is, however, soluble at 160 degrees F in chlorinated hydrocarbons.

P84 (Polyimide) – P84 is a proprietary fiber produced by Lenzing in Austria. P84 is a non-thermoplastic, and in 100% form may be used for temperatures of 500 degrees F. Its fiber is highly convoluted, having a high surface area-to-diameter ratio.

Extensive testing has shown that P84 fabric approaches Gortex® in efficiency, but has all of the advantages of a needled felt. It may be layered on top of lower cost fibers, to provide the benefits of the base fiber, but at lower costs than a 100% version of the P84 felt. Composites generally have a 4 oz.yd² P84 fiber layer, needled to a 12 oz.yd² carrier base. 100% P84 is readily available in 14 oz. weight, but other weights are available.

P84 needled felt, and composites, are used in many industrial applications where high efficiency is required. Examples are: gold and copper ore processing, incinerators, boilers, and various chemical processes.

Teflon® - is a proprietary fluorocarbon fiber, manufactured by E.I. duPont. It is composed of long chain carbon molecules in which all of the available bonds are completely saturated with fluorine. These strong carbon-to-fluorine bonds create fibers that are exceptionally stable to both heat and chemicals. Teflon® is the most chemically resistant fiber used in conventional dust filtration.

Teflon® is not affected by any known solvents except some prefluorinated organic liquids at temperatures above 570 degrees F. Exposure to temperatures above 550 degrees F. will cause some decomposition, although it is slow to develop. Teflon® bags shrink when exposed to high temperatures, especially in length.

The low friction properties of Teflon® fibers provide excellent cake discharge. In addition, Teflon® fibers' chemical inertness and resistance to dry and moist heat degradation makes it ideal for use under severe conditions.

Teflon® needled felt is extremely expensive. Recently a lower cost version, Tefaire®, has been introduced. This felt is a blend of 85% Teflon® and 15% fiberglass fibers. Commercial uses are limited to extreme chemical environments where the advantages of Teflon fibers' great chemical resistance outweighs cost disadvantages.

Some boilers, carbon black plants, soil remediation systems, and incinerators have been equipped with Teflon® products.

Glass – Glass fiber is a product of fusion, a non-crystalline silicate analogous to other fiber polymeric materials. Selected silica sands, limestone, soda ash, and borax or other ingredients are melted at about 2500 degrees F. and the mixture is extruded through spinnarets. The resulting filaments may be drawn while still molten and later twisted and plied into filament yarn.

Or, as the extruded glass may be drawn and broken by jets of compressed air into staple of lengths 8 to 15 inches. The fibers are then treated with a lubricant which is of great importance in the durability of the eventual fabric. Following drying, the fibers are process much like the more conventional fibers.

Woven fiberglass and felted fiberglass medias are available for high energy cleaned fabric filters. These are specialty products and are used for very specific applications; involving high (up to 500 degrees F.) temperatures, usually in the presence of oxidizing agents.

Some common trade names for woven fiberglass are GL65 Tri-Loft™ (BHA), and FL57 Hi-Loft™ (BHA); other companies have similar products. Available weights are 16 to 22 oz./yard². Huyglas® (Air Purator Corporation) felted fiberglass medias are available in a variety of weights, form 14 to 27 oz./yd². Bag/cage fit & support is very critical – check with the vendors involved for specific recommendations.

Woven fiberglass, in particular, is very easy to damage, and is not as efficient as other medias. Felted fiberglass tends to be heavy and difficult to handle. Suitable applications for this material are limited. Consult MAC Equipment engineering before using these products for any application.

HEPA – High Efficiency Particulate Air filter is the maximum efficiency available in particulate filtration. Rated for temperatures up to 275°F. Usually offered as a static after filter following a dust collector; however, a pulse cleaned version is available. MAC Equipment's style FG134/2 cleanable HEPA media, is a borosilicate microfiber glass, supported by polyester webbing on each side. Refer to MAC Equipment for more application information.

Ryton® (Polyphenylene Sulfide) – Ryton® (Phillips) is a long chain synthetic polysulfide, with at least 85% of the sulfide linkages attached directly to two aromatic rings. Standard fiber is 3-denier. The resin was developed by Phillips Petroleum, in 1973.

Ryton® is resistant to sulphur oxides, and is used for high temperature gas streams, up to 360 degrees F. Gas stream oxygen content should not exceed 15%. Ryton® does not hydrolyze and has flame retarding characteristics.

Typical applications are industrial/municipal solid waste incinerators and coal-fired boilers.

Other fibers and medias are available for very special temperature, chemical, pressure drop, or efficiency requirements. Consult MAC Equipment for more details.

Properties of Filtration Fabrics

Temp. °F	Polypropylene 170	Polyester 275	Acrylic 275	Fiberglass® 500	Nomex® 375	Ryton® 375	P-84™ 500	Teflon® 500
Abrasion	Excellent	Excellent	Good	Fair	Good	Good	Good	Excellent
Energy Absorption	Good	Excellent	Good	Fair	Good	Good	Good	Good
Filtration Properties	Good	Excellent	Good	Fair	Excellent	Very Good	Excellent	Fair
Moist Heat Hydrolysis	Excellent	Poor	Excellent	Excellent	Good	Excellent	Good	Excellent
Alkalines	Excellent	Good	Fair	Fair	Good	Excellent	Fair	Excellent
Mineral Acids	Excellent	Fair	Good	Poor**	Poor	Excellent	Good	Excellent
Oxygen (15%+)	Excellent	Excellent	Excellent	Excellent	Excellent	Poor	Excellent	Excellent
Relative Cost	X	X	XX	XXX	XXXX	XXXXX	XXXXXX	XXXXXXX

* Sensitive bag-to-cage fit

** Fair with acid resistant finishes

Note: Combinations of variables alter the resistance of the fiber to the specified performance ratings, i.e., time, temperature and gas stream chemistry.

Chemical Compatibility of Fabrics with Common Chemicals

Salts **A=Excellent Suitability B=Limited Suitability C=Not Recommended**

Max. Operating Temperature °F	Dralon T® (Poly Acrylic) 275	Acrylic (Poly Acrylic) 275	Nomex® 375	Polyester 275	Polypropylene 170	Teflon® 500	Glass 500	P84 500
Calcium Chloride ($Ca\ Cl_2$)	A	A	B	A	A	A	B	B
Ferrous Chloride ($Fe\ Cl_2\ 4H_2O$)	A	A	B	A	A	A	C	B
Sodium Acetate ($C_2\ H_4\ Na\ O_2$)	A	A	B	A	A	A	B	B
Sodium pyrosulfite ($Na_2\ O_5\ S_2$) (metan sulfite)	C	A	B	A	A	A	A	B
Sodium Bromide (Na Br)	A	A	A	A	A	A	C	C
Sodium Perchbrate ($Cl\ Na\ O_4$)	A	A	A	A	A	A	-	B
Sodium Cyanide (Na Cn)	A	A	B	A	A	A	B	B
Sodium Nitrate ($Na\ NO_3$) (Chile Saltpeter)	A	A	B	A	A	A	B	B
Sodium Sulfate ($Na_2\ SO_4$) (Glaubers Salt)	A	A	A	A	A	A	B	B
Sodium Sulfide ($Na_2\ S$)	A	A	A	A	A	A	B	B

Chemical Compatibility of Fabrics with Common Chemicals

Oxidizing Agents **A=Excellent Suitability B=Limited Suitability C=Not Recommended**

Max. Operating Temperature °F	Dralon T® (Poly Acrylic) 275	Acrylic (Poly Acrylic) 275	Nomex® 375	Polyester 275	Polypropylene 170	Teflon® 500	Glass 500	P84 500
Bromine Calcium (Br)	B	B	-	B	A	A	A	B
Calcium Hypochlorite ($Ca(OCL)_2$)	A	A	-	A	A	A	A	B
Carbon (C) (Graphite/Diamond)	B	B	-	B	A	A	A	B
Fluorine (F)	B	B	-	B	A	A	C	B
Hydrogen Peroxide (H_2O_2)	A	A	-	B	A	A	A	B
Iod	A	A	-	A	A	A	A	B
Ozone (O_3)	A	A	-	-	B	A	A	B
Potassium Chloride (K Cl) (Sylvine)	A	A	B	A	A	A	A	B
Sodium Chlorate ($Na\ Cl\ O_3$)	-	A	-	-	A	A	A	B
Sodium Hypochlorite (Na Ocl) (Eau-de-Labarraque)	B	A	-	B	B	A	A	B

Chemical Compatibility of Fabrics with Common Chemicals

Mineral Acids **A=Excellent Suitability B=Limited Suitability C=Not Recommended**

Max. Operating Temperature °F	Dralon T® (Poly Acrylic) 275	Acrylic (Poly Acrylic) 275	Nomex® 375	Polyester 275	Polypropylene 170	Teflon® 500	Glass 500	P84 500
Chromium Trioxide ($Cr O_3$) (Chromic Acid Anhydride)	A	A	C	A	B	A	A	B
Hydrogen Chloride (H Cl) (Hydrochloric Acid) (Muriatic Acid)	A	A	C	A	A	A	A	B
Hydrofluoric Acid (HF)	A	A	C	B	A	A	C	B
Nitric Acid ($HN O_3$)	A	A	B	A	B	A	A	B
Tripotic Acid $(HO)_3$ P(O)	A	B	A	A	A	A	A	B
Sulphuric Acid ($H_2 SO_4$) (Sulphuric Acid) (Vitrol)	B	B	B	B	A	A	A	B

Chemical Compatibility of Fabrics with Common Chemicals

Organic Acids **A=Excellent Suitability B=Limited Suitability C=Not Recommended**

Max. Operating Temperature °F	Dralon T® (Poly Acrylic) 275	Acrylic (Poly Acrylic) 275	Nomex® 375	Polyester 275	Polypropylene 170	Teflon® 500	Glass 500	P84 500
Acetic Acid ($C_2 H_4 O_2$)	A	A	A	A	A	A	A	B
Benzoic Acid ($C_7 H_6 O_2$)	A	A	B	A	A	A	A	B
Phenol ($C_6 H_6 O$) (Carbolic Acid)	A	A	C	B	A	A	C	B
Formic Acid ($CH_2 O_2$)	A	A	B	A	A	A	A	C
Lactic Acid ($C_3 H_6 O_3$)	A	A	B	A	A	A	B	B
Oxalic Acid ($C_2 H_2 O_4$) (Acid of Sugar)	A	A	C	A	A	A	A	B
Salicylic Acid ($C_7 H_8 O_3$)	A	A	B	A	A	A	C	B

Chemical Compatibility of Fabrics with Common Chemicals

Bases **A=Excellent Suitability B=Limited Suitability C=Not Recommended**

Max. Operating Temperature °F	Dralon T® (Poly Acrylic) 275	Acrylic (Poly Acrylic) 275	Nomex® 375	Polyester 275	Polypropylene 170	Teflon® 500	Glass 500	P84 500
Ammonia ($H_3 N$)	B	B	B	C	A	A	B	B
Calcium Hydroxide ($Ca (OH)_2$) (Hydrated Lime)	A	A	A	A	A	A	A	B
Potassium Hydroxide (KOH) (Caustic Potash)	B	C	B	B	B	A	C	B
Potassium Carbonate ($K_2 CO_3$) (Potash) (Salt of Tarter)	B	B	A	B	A	A	C	B
Sodium Hydroxide (Na OH) (Caustic Soda)	B	B	B	B	B	A	C	C
Sodium Carbonate (Na2 Co3) (Washing Soda)	A	A	A	A	A	A	C	B

Chemical Compatibility of Fabrics with Common Chemicals

Organic Solvents **A=Excellent Suitability B=Limited Suitability C=Not Recommended**

Max. Operating Temperature °F	Dralon T® (Poly Acrylic) 275	Acrylic (Poly Acrylic) 275	Nomex® 375	Polyester 275	Polypropylene 170	Teflon® 500	Glass 500	P84 500
Acetone (H_3 C-CO-CH_3)	A	A	A	A	B	A	A	C
($(CH_2)_4H_3$)	A	A	A	A	B	A	A	C
Benzene (C_6 H_6) (Benzol)	A	A	A	A	A	A	A	B
Carbon Disulfide (C S_2)	A	A	A	B	C	A	A	B
Carbon Tetrachloride (C Cl_3)	A	A	A	A	B	A	A	B
Chloroform (CH Cl_3)	A	A	A	A	B	A	A	B
Cyclohexane (C_6 H_{12})	A	A	A	A	B	A	A	B
Acetoin (C_2 H_6 O_2)	A	A	A	A	B	A	A	B
Ethylalcohol or Methane Ether (C_2 H_6 O) (Vanillin)	A	A	A	A	A	A	A	B
Butyl Alcohol or Ethyl Ether (C_4 H_{10} O)	A	A	A	A	A	A	A	C
Methanol (CH_4 O)	A	A	A	A	A	A	A	C
MEK	A	A	A	A	B	A	A	B
Nitrogen (N)	A	A	A	A	B	A	A	B
Ethylenes trichloro (C_2 H CL_3)	A	A	A	A	A	A	A	B
Methyl Benzene (C_6 H_5 CH_3) (Toluene)	A	A	A	A	B	A	A	C
O-Xylene (C_6 H_4 $(CH_3)_2$)	A	A	A	A	B	A	A	C

Chemical Compatibility of Fabrics with Common Chemicals

Miscellaneous **A=Excellent Suitability B=Limited Suitability C=Not Recommended**

Max. Operating Temperature °F	Dralon T® (Poly Acrylic) 275	Acrylic (Poly Acrylic) 275	Nomex® 375	Polyester 275	Polypropylene 170	Teflon® 500	Glass 500	P84 500
Acetaldehyde (H_3 C-CHO) (Aldehyde)	A	A	A	A	-	A	A	B
Vinyl Alcohol (H_2 C-CH_2 O) (Ethenolivinol)	A	A	A	A	B	A	A	B
Glycerol (C_3 H_8 O_3) Glycerin	A	A	A	A	A	A	A	B
Clycol (C_2 H_6 O_2)	A	A	A	C	A	A	A	B
Mineral Oil	A	A	A	A	A	A	A	B
Benzene, Nitro (C_6 H_5 NO_2) (Essence of Mirbane)	A	A	A	A	A	A	A	B

Gas / Air Tables

Temperature and Altitude Corrections

Temperature – Density* **Altitude – Density****

Temp. °F	Density factor	Wt. per cu. ft.	Elevation ft.	Air density lb./cu. ft.	Density factor
0	1.1.52	0.0864	0	0.075	1.0
70	1.000	0.0749	500	0.0736	0.982
100	0.946	0.0709	1,000	0.0723	0.964
150	0.869	0.0651	1,500	0.0710	0.947
200	0.803	0.0602	2,000	0.0697	0.930
250	0.747	0.0560	2,500	0.0684	0.913
300	0.697	0.0522	3,000	0.0672	0.896
350	0.654	0.0490	3,500	0.0659	0.880
400	0.616	0.0462	4,000	0.0647	0.864
450	0.582	0.0436	4,500	0.0635	0.848
500	0.552	0.0414	5,000	0.0623	0.832
550	0.525	0.0393	5,500	0.0612	0.817
600	0.500	0.0375	6,000	0.0600	0.801
650	0.477	0.0358	6,500	0.0589	0.786
700	0.457	0.0342	7,000	0.0578	0.772
750	0.438	0.0328	7,500	0.0567	0.757
800	0.421	0.0315	8,000	0.0557	0.743
850	0.404	0.0303	8,500	0.0546	0.729
900	0.390	0.0292	9,000	0.0536	0.715
950	0.376	0.0282	9,500	0.0525	0.701
1,000	0.363	0.0272	10,000	0.0515	0.688

*Table based on 29.92 in. Hq.
**Dry air at 70°F.

Composition of Air

Component of Air	Symbol	Content - % Volume
Nitrogen	N_2	78.084 percent
Oxygen	O_2	20.947 percent
Argon	Ar	0.934 percent
Carbon dioxide	CO_2	0.033 percent
		>99.998%
Neon	Ne	18.2 parts/million
Helium	He	5.2 parts/million
Krypton	Kr	1.1 parts/million
Sulfur dioxide	SO_2	1.0 parts/million
Methane	CH_4	2.0 parts/million
Hydrogen	H_2	0.5 parts/millions
Nitrous oxide	N_2O	0.5 parts/million
Hydrogen	H_2	0.5 parts/million
Xenon	Xe	0.09 parts/million
Ozone	O_3	0.0 to 0.07 parts/million
Ozone – Winter	O_3	0.0 to 0.02 parts/million
Nitrogen dioxide	NO_2	0.02 parts/million
Iodine	I_2	0.01 parts/million
Carbon monoxide	CO	0.0 to trace
Ammonia	NH_3	0.0 to trace

The above table is an average for clean, dry air at sea level.
1 part/million = 0.0001 percent.

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Type 9 – Class II, Indoor hazardous locations.
May be classified Groups E, F, or G, depending on specific design as defined in the National Electrical Code.

Type 10 – Mining Enforcement Safety Administration.
Explosion proof. For use in mines with atmospheric containing methane or natural gas, with or without coal dust.

Type 11 – Corrosion Resistant & Drip-proof – oil immersed indoor.
Provide, by oil immersion, protection against the corrosive effects of liquids and gases.

Type 12 – Dust-tight and Drip-tight – Indoor.
Protects against dust, falling dirt and dripping non-corrosive liquids.

Type 12K – Same as Type 12 except enclosures have knockouts.

Type 13 – Oil tight and Dust-tight – Indoor.
Protects against dust, spraying of water, oil and non-corrosive coolant.

Horsepower Formulas

$$\text{Air Horsepower} = \frac{\text{CFM X TP}}{6356}$$

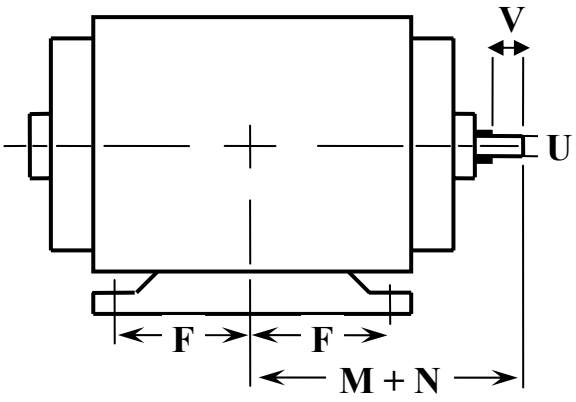
$$\text{Brake Horsepower} = \frac{\text{CFM X TP}}{6356 \text{ X } ME_{fan}}$$

Where ME_{fan} = Mechanical Efficiency of Fan

NEMA Electric Motor Frames

Motor Frame	NEMA Frame Dimension – Inches						
	D	**E**	**F**	**U**	**V**	**M + N**	**Keyway**
42	2-5/8	1-3/4	27/32	3/8	...	4-1/32	...
48	3	2-1/8	1-3/8	1/2	...	5-3/8	...
56	3-1/2	2-7/16	1-1/2	5/8	...	6-1/8	3/16x3/32
66	4-1/8	2-15/16	2-1/2	3/4	...	7-7/8	3/16x3/32
143T	3-1/2	2-3/4	2	7/8	2	6-1/2	3/16x3/32
145T	3-1/2	2-3/4	2-1/2	7/8	2	7	3/16x3/32
182	4-1/2	3-3/4	2-1/4	7/8	2	7-1/4	3/16x3/32
182	4-1/2	3-3/4	2-1/4	1-1/8	2-1/2	7-3/4	1/4x1/8
184	4-1/2	3-3/4	2-3/4	7/8	2	7-3/4	3/16x3/32
184T	4-1/2	3-3/4	2-3/4	1-1/8	2-1/2	6-1/4	1/4x1/8
213	5-1/4	4-1/4	2-3/4	1-1/8	2-3/4	9-1/4	1/4x1/8
213T	5-1/4	4-1/4	2-3/4	1-3/8	3-1/8	9-5/8	5/16x5/32
215	5-1/4	4-1/4	3-1/2	1-1/8	2-3/4	10	1/4x1/8
215T	5-1/4	4-1/4	3-1/2	1-3/8	3-1/8	10-3/8	5/16x5/32
254T	6-1/4	5	4-1/8	1-5/8	3-314	12-3/8	3/8x3/16
254U	6-1/4	5	4-1/8	1-3/8	3-1/2	12-1/8	5/16x5/32
256T	6-1/4	5	5	1-5/8	3-3/4	13-1/4	3/8x3/16
256U	6-1/4	5	5	1-3/8	3-1/2	13	5/16x5/32
284T	7	5-1/2	4-3/4	1-7/8	4-3/8	14-1/8	1/2x1/4
284TS	7	5-1/2	4-1/4	1-5/8	3	13-1/2	3/8x3/16
284U	7	5-1/2	4-3/4	1-5/8	4-518	14-2/8	3/8x3/16
286T	7	5-1/2	5-1/2	1-7/8	4-318	14-7/8	1/2x1/4
286U	7	5-1/2	5-1/2	1-5/8	4-5/8	15-1/8	3/8x3/16
324T	8	6-1/4	5-1/4	2-1/8	5	15-3/4	1/2x1/4
324U	8	6-1/4	5-1/4	1-7/8	5-3/8	16-1/8	1/2x1/4
326T	8	6-1/4	6	2-1/8	5	16-1/2	1/2x1/4
326TS	8	6-1/4	6	1-7/8	3-1/2	15	1/2x1/4
326U	8	8-1/4	6	1-7/8	5-3/8	16-7/8	1/2x1/4
364T	9	7	5-5/8	2-3/8	5-5/8	17-3/8	5/8x5/16
364U	9	7	5-5/8	2-1/8	6-1/8	17-7/8	1/2x1/4
365T	9	7	6-1/8	2-318	5-518	17-7/8	5/8x5/16
365U	9	7	6-1/8	2-1/8	6-1/8	1-3/8	1/2x1/4
404T	10	8	6-1/8	2-7/8	7	20	3/4x3/8
404U	10	8	6-1/8	2-3/8	6-7/8	19-7/8	5/8x5/16
405T	10	8	6-7/8	2-7/8	7	20-3/4	3/4x3/8
405U	10	8	6-7/8	2-3/8	6-7/8	20-5/8	5/8x5/16
444T	11	9	7-1/4	3-3/8	8-1/4	23-1/4	7/8x7/16
444U	11	9	7-1/4	2-7/8	8-3/8	23-3/8	3/4x3/8
445T	11	9	8-1/4	3-3/8	8-1/4	24-1/4	7/8x7/16
445U	11	9	8-1/4	2-7/8	8-3/8	24-318	3/4x3/8

The above standards were established by the *National Electrical Manufacturers Association* (NEMA)



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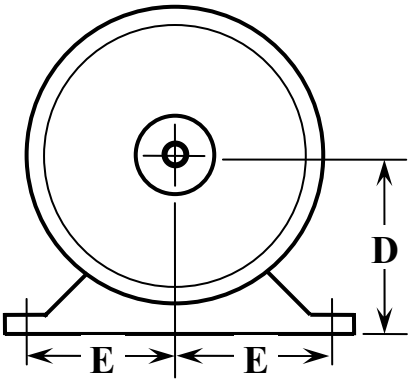
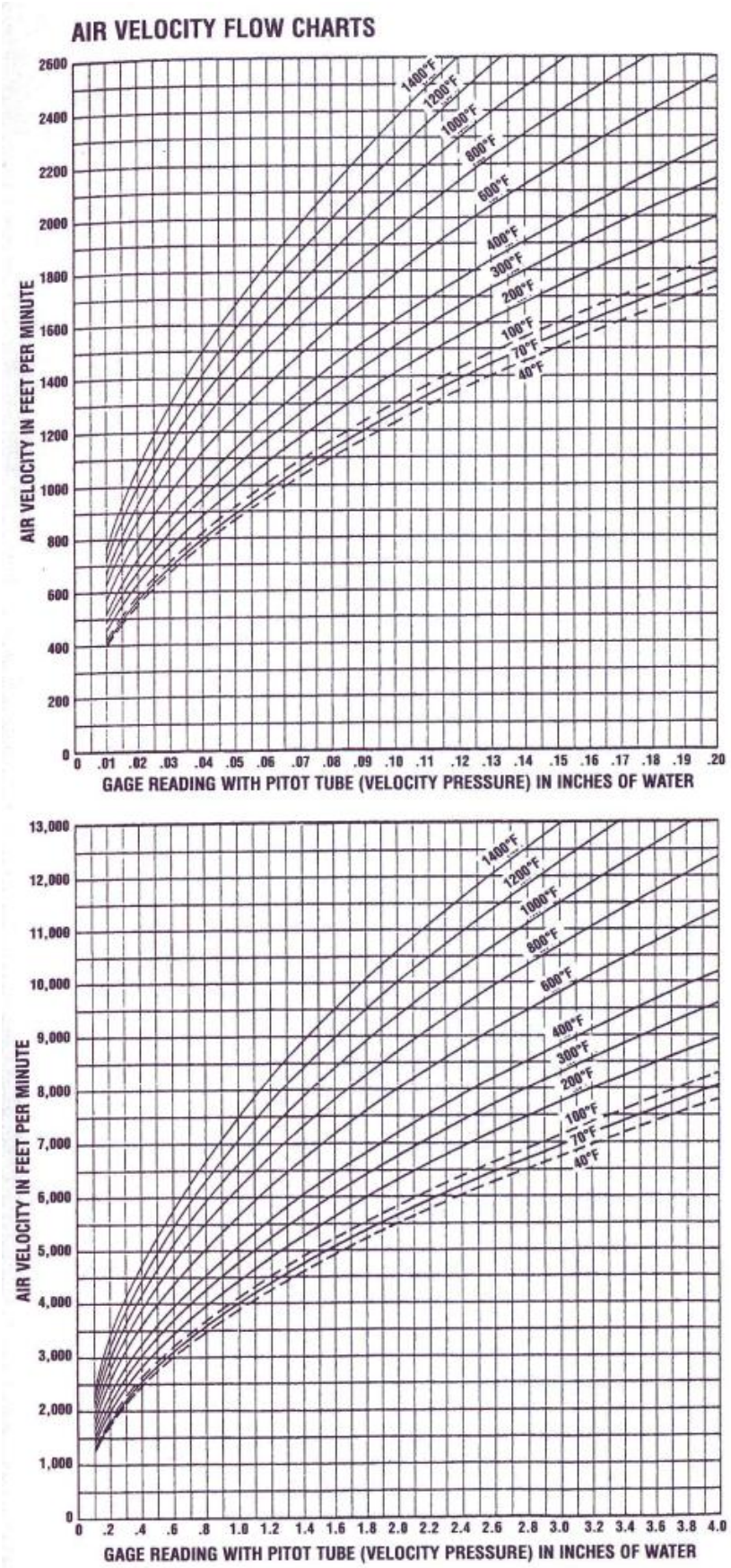



AIR VELOCITY FLOW CHARTS
AIR VELOCITY IN FEET PER MINUTE
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1400°F
1200°F
1000°F
800°F
600°F
400°F
300°F
200°F
100°F
70°F
40°F
0 .01 .02 .03 .04 .05 .06 .07 .08 .09 .10 .11 .12 .13 .14 .15 .16 .17 .18 .19 .20
GAGE READING WITH PITOT TUBE (VELOCITY PRESSURE) IN INCHES OF WATER
AIR VELOCITY IN FEET PER MINUTE
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1400°F
1200°F
1000°F
800°F
600°F
400°F
300°F
200°F
100°F
70°F
40°F
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
GAGE READING WITH PITOT TUBE (VELOCITY PRESSURE) IN INCHES OF WATER

Circular equivalents of rectangular ducts for equal friction

Sides	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	7	8	9	10	11	12	13	14	15	16	17
4	3.04	3.42	3.77	4.09	4.37	4.63	4.88	5.10												
5	3.37	3.81	4.18	4.55	4.88	5.18	5.45	5.73												
6	3.65	4.17	4.55	4.96	5.32	5.65	5.97	6.27	6.55											
7	3.90	4.43	4.91	5.34	5.72	6.08	6.42	6.75	7.07	7.63										
8	4.12	4.71	5.20	5.67	6.08	6.47	6.85	7.21	7.54	8.17	8.72									
9	4.34	4.97	5.48	5.96	6.42	6.84	7.25	7.62	8.00	8.66	9.25	9.81								
10	4.54	5.21	5.74	6.24	6.74	7.17	7.60	7.99	8.37	9.09	9.76	10.3	10.9							
11	4.72	5.40	5.98	6.51	7.02	7.49	7.93	8.34	8.74	9.50	10.2	10.8	11.4	12.0						
12	4.90	5.58	6.22	6.75	7.29	7.79	8.25	8.69	9.10	9.90	10.6	11.3	11.9	12.5	13.1					
13	5.06	5.76	6.42	6.98	7.56	8.08	8.56	9.02	9.46	10.3	11.0	11.8	12.4	13.0	13.6	14.2				
14	5.21	5.94	6.61	7.21	7.80	8.34	8.85	9.33	9.81	10.7	11.4	12.2	12.8	13.5	14.1	14.7	15.3			
15	5.36	6.11	6.80	7.43	8.02	8.58	9.11	9.62	10.1	11.0	11.8	12.6	13.3	14.0	14.6	15.2	15.8	16.4		
16	5.51	6.28	6.98	7.64	8.24	8.82	9.37	9.90	10.4	11.3	12.2	13.0	13.7	14.4	15.1	15.7	16.3	16.9	17.5	
17	5.64	6.44	7.16	7.83	8.46	9.06	9.62	10.1	10.7	11.6	12.5	13.3	14.1	14.8	15.5	16.2	16.8	17.4	18.0	18.6
18	5.76	6.58	7.33	8.03	8.68	9.30	9.85	10.4	10.9	11.9	12.8	13.7	14.5	15.2	15.9	16.6	17.3	17.9	18.5	19.1
20	6.01	6.86	7.65	8.38	9.06	9.70	10.3	10.9	11.5	12.5	13.5	14.4	15.2	16.0	16.7	17.5	18.2	18.9	19.5	20.2
22	6.25	7.12	7.95	8.71	9.44	10.1	10.9	11.4	12.0	13.0	14.0	15.0	15.9	16.7	17.5	18.3	19.0	19.7	20.4	21.1
24	6.44	7.38	8.25	9.04	9.77	10.5	11.1	11.8	12.4	13.5	14.6	15.6	16.5	17.4	18.3	19.1	19.8	20.5	21.3	22.0
26	6.66	7.63	8.53	9.33	10.1	10.9	11.5	12.2	12.8	14.0	15.1	16.1	17.1	18.1	18.9	19.8	20.6	21.3	22.1	22.8
28	6.86	7.87	8.79	9.63	10.4	11.2	11.9	12.6	13.2	14.4	15.6	16.7	17.7	18.7	19.6	20.5	21.3	22.1	22.9	23.6
30	7.04	8.07	9.03	9.87	10.7	11.5	12.2	13.0	13.6	14.9	16.0	17.2	18.3	19.3	20.2	21.1	22.0	22.8	23.6	24.4
32	7.22	8.27	9.25	10.2	11.0	11.8	12.5	13.3	14.0	15.3	16.4	17.7	18.7	19.8	20.8	21.7	22.6	23.5	24.3	25.2
34	7.40	8.47	9.46	10.4	11.2	12.1	12.8	13.6	14.4	15.7	16.9	18.2	19.2	20.3	21.4	22.3	23.2	24.1	25.0	25.9
36	7.58	8.66	9.67	10.6	11.5	12.3	13.1	13.9	14.7	16.1	17.4	18.6	19.7	20.8	21.9	22.9	23.8	24.7	25.7	26.7
38	7.75	8.85	9.88	10.9	11.7	12.6	13.4	14.2	15.0	16.5	17.8	19.0	20.2	21.3	22.5	23.5	24.4	25.3	26.3	27.3
40	7.89	9.04	10.1	11.1	12.0	12.9	13.7	14.5	15.3	16.8	18.1	19.4	20.6	21.8	23.0	24.0	25.0	25.8	26.9	27.9
42	8.03	9.22	10.3	11.3	12.3	13.2	14.0	14.8	15.6	17.1	18.5	19.8	21.0	22.3	23.5	24.5	25.5	26.5	27.5	28.5
44	8.17	9.39	10.5	11.5	12.5	13.4	14.3	15.1	15.9	17.4	18.6	20.2	21.4	22.7	24.0	25.0	26.0	27.0	28.0	29.0
46	8.31	9.55	10.7	11.7	12.7	13.7	14.5	15.4	16.2	17.8	19.2	20.6	21.8	23.1	24.4	25.5	26.4	27.7	28.6	29.6
48	8.45	9.72	10.8	11.9	12.9	13.9	14.8	15.7	16.5	18.1	19.5	21.0	22.2	23.5	24.8	26.0	26.8	28.3	29.2	30.2
50	8.59	9.86	11.0	12.1	13.1	14.1	15.0	16.0	16.8	18.4	19.9	21.3	22.6	23.9	25.2	26.4	27.2	28.9	29.8	30.8
52	8.73	10.0	11.2	12.3	13.3	14.3	15.3	16.2	17.1	18.7	20.2	21.6	23.0	24.3	25.6	26.8	27.7	29.5	30.4	31.2
54	8.87	10.2	11.4	12.5	13.5	14.5	15.5	16.5	17.3	19.0	20.5	22.0	23.4	27.7	26.0	27.3	28.2	29.9	30.9	31.8
56	8.99	10.3	11.6	12.7	13.7	14.7	15.7	16.7	17.6	19.3	20.8	22.3	23.8	25.1	26.4	27.7	28.7	30.2	31.3	32.3
58	9.10	10.5	11.8	12.9	13.9	14.9	15.9	16.9	17.8	19.5	21.1	22.6	24.1	25.5	26.8	28.1	29.3	30.5	31.7	32.8

Velocity pressures for different velocities: standard air

Design procedure

Dry air at 70°F, 29.92" barometer, and less than 20" WC static pressure.

From: $V = 4{,}005\sqrt{VP}$ = Velocity FPM.
VP = Velocity pressure, inches of water

V	VP	V	VP	V	VP
400	0.01	2,157	0.29	3,024	0.57
566	0.02	2,193	0.30	3,050	0.58
694	0.03	2,230	0.31	3,076	0.59
601	0.04	2,261	0.32	3,102	0.60
896	0.05	2,301	0.33	3,127	0.61
981	0.06	2,335	0.34	3,153	0.62
1,060	0.07	2,369	0.35	3,179	0.63
1,133	0.08	2,403	0.36	3,204	0.64
1,201	0.09	2,436	0.37	3,229	0.65
1,266	0.10	2,469	0.38	3,254	0.66
1,328	0.11	2,501	0.39	3,279	0.67
1,387	0.12	2,533	0.40	3,303	0.68
1,444	0.13	2,563	0.41	3,327	0.69
1,498	0.14	2,595	0.42	3,351	0.70
1,551	0.15	2,626	0.43	3,375	0.71
1,602	0.16	2,656	0.44	3,398	0.72
1,651	0.17	2,687	0.45	3,422	0.73
1,699	0.18	2,716	0.46	3,445	0.74
1,746	0.19	2,746	0.47	3,468	0.75
1,791	0.20	2,775	0.48	3,491	0.76
1,835	0.21	2,804	0.49	3,514	0.77
1,879	0.22	2,832	0.50	3,537	0.78
1,921	0.23	2,860	0.51	3,560	0.79
1,962	0.24	2,888	0.52	3,582	0.80
2,003	0.25	2,916	0.53	3,604	0.81
2,042	0.26	2,943	0.54	3,625	0.82
2,081	0.27	2,970	0.55	3,657	0.83
2,119	0.28	2,997	0.56	3,669	0.84
3,690	0.85	4,423	1.22	5,050	1.59
3,709	0.86	4,442	1.23	5,066	1.60
3,729	0.87	4,460	1.24	5,082	1.61
3,758	0.88	4,478	1.25	5,098	1.62
3,779	0.89	4,495	1.26	5,114	1.63
3,800	0.90	4,513	1.27	5,129	1.64
3,821	0.91	4,531	1.28	5,144	1.65
3,842	0.92	4,549	1.29	5,160	1.66
3,863	0.93	4,566	1.30	5,175	1.67
3,884	0.94	4,583	1.31	5,191	1.68
3,904	0.95	4,601	1.32	5,206	1.69
3,924	0.96	4,619	1.33	5,222	1.70
3,945	0.97	4,636	1.34	5,237	1.71
3,965	0.98	4,653	1.35	5,253	1.72
3,985	0.99	4,671	1.36	5,268	1.73
4,005	1.00	4,688	1.37	5,283	1.74
4,025	1.01	4,705	1.38	5,298	1.75
4,045	1.02	4,722	1.39	5,313	1.76
4,064	1.03	4,739	1.40	5,328	1.77
4,081	1.04	4,756	1.41	5,343	1.78
4,103	1.05	4,773	1.42	5,359	1.79
4,123	1.06	4,790	1.43	5,374	1.80
4,142	1.07	4,806	1.44	5,388	1.81
4,162	1.08	4,823	1.45	5,403	1.82
4,181	1.09	4,840	1.46	5,418	1.83

V	VP	V	VP	V	VP
4,200	1.10	4,856	1.47	5,433	1.84
4,219	1.11	4,873	1.48	5,447	1.85
4,238	1.12	4,889	1.49	5,462	1.86
4,257	1.13	4,905	1.50	5,477	1.87
4,276	1.14	4,921	1.51	5,491	1.88
4,295	1.15	4,938	1.52	5,506	1.89
4,314	1.16	4,954	1.53	5,521	1.90
4,332	1.17	4,970	1.54	5,535	1.91
4,350	1.18	4,986	1.55	5,550	1.92
4,368	1.19	5,002	1.56	5,564	1.93
4,386	1.20	5,018	1.57	5,579	1.94
4,405	1.21	5,034	1.58	5,593	1.95
5,608	1.96	6,113	2.33	8,496	4.50
5,623	1.97	6,128	2.34	8,590	4.60
5,637	1.98	6,140	2.35	8,683	4.70
5,651	1.99	6,153	2.36	8,774	4.80
5,664	2.00	6,166	2.37	8,865	4.90
5,678	2.01	6,179	2.38	8,955	5.00
5,692	2.02	6,192	2.39	9,044	5.10
5,706	2.03	6,205	2.40	9,133	5.20
5,720	2.04	6,217	2.41	9,220	5.30
5,734	2.05	6,230	2.42	9,307	5.40
5,748	2.06	6,243	2.43	9,392	5.50
5,762	2.07	6,256	2.44	9,477	5.60
5,776	2.08	6,269	2.45	9,562	5.70
5,790	2.09	6,282	2.46	9,645	5.80
5,804	2.10	6,294	2.47	9,728	5.90
5,817	2.11	6,307	2.48	9,810	6.00
5,831	2.12	6,320	2.49	9,891	6.10
5,845	2.13	6,332	2.50	9,972	6.20
5,859	2.14	6,458	2.60	10,052	6.30
5,872	2.15	6,581	2.70	10,132	6.40
5,886	2.16	6,702	2.80	10,210	6.50
5,899	2.17	6,820	2.90	10,289	6.60
5,913	2.18	6,937	3.00	10,366	6.70
5,927	2.19	7,051	3.10	10,444	6.80
5,940	2.20	7,164	3.20	10,520	6.90
5,954	2.21	7,275	3.30	10,596	7.00
5,967	2.22	7,385	3.40	10,968	7.50
5,981	2.23	7,492	3.50	11,328	8.00
5,994	2.24	7,599	3.60	11,676	8.50
6,008	2.25	7,704	3.70	12,015	9.00
6,021	2.26	7,807	3.80	12,344	9.50
6,034	2.27	7,909	3.90	12,665	10.00
6,047	2.28	8,010	4.00	13,283	11.00
6,061	2.29	8,109	4.10	13,874	12.00
6,074	2.30	8,208	4.20	14,440	13.00
6,087	2.31	8,305	4.30	14,775	13.61
6,100	2.32	8,401	4.40	14,986	14.00

Weights of galvanized sheet metal ducts

Duct dia.	Straight runs								Elbow
	Weight per linear foot								Equiv. length in feet
	Gauge size								Two gauges heavier than duct
	26	**24**	**22**	**20**	**18**	**16**	**14**	**12**	
4	1.13	1.47	1.69	1.97	2.59	3.10	3.76	5.20	1.20
5	1.39	1.80	2.08	2.43	3.19	3.82	4.65	6.41	1.83
6	1.65	2.14	2.47	2.89	3.80	4.54	5.53	7.62	1.62
7	1.91	2.48	2.86	3.34	4.39	5.25	6.38	8.80	1.75
8	2.18	2.83	3.27	3.81	5.01	5.99	7.28	10.05	2.00
9	2.44	3.17	3.66	4.27	5.61	6.71	8.15	11.25	2.17
10	2.70	3.51	4.05	4.72	6.21	7.42	9.02	12.45	2.41
11	2.96	3.85	4.44	5.18	6.80	8.15	9.90	13.66	2.57
12	3.22	4.18	4.83	5.63	7.40	8.85	10.78	14.85	2.80
13	3.48	4.52	5.22	6.09	8.00	9.57	11.63	16.10	2.96
14	3.74	4.86	5.61	6.54	8.60	10.30	12.50	17.25	3.20
15	4.01	5.21	6.01	7.01	9.22	10.86	13.40	18.50	3.40
16	4.27	5.55	6.40	7.47	9.82	11.74	14.28	19.70	3.56
18	4.87	6.33	7.30	8.51	11.18	13.36	16.30	22.40	3.98
20	5.40	7.02	8.10	9.45	12.42	14.85	18.10	24.90	4.27
22	5.92	7.70	8.88	10.35	13.60	16.25	19.80	27.30	4.66
24	6.45	8.38	9.67	11.30	14.84	17.71	21.30	29.80	5.05
26	6.97	9.05	10.45	12.20	16.00	19.15	23.20	32.20	5.43
28	7.50	9.75	11.27	13.13	17.26	20.60	25.00	34.60	5.77
30	8.10	10.54	12.17	14.20	18.62	22.25	27.00	37.40	6.13
32	8.62	11.20	12.93	15.10	19.84	23.70	28.80	39.80	6.50
34	9.15	11.90	13.73	16.00	21.08	25.18	30.60	42.30	7.00
36	9.67	12.57	14.50	16.91	22.22	26.60	32.30	44.60	7.43
38	10.19	13.25	15.29	17.81	23.40	28.00	34.00	47.00	7.87
40	10.72	13.95	16.08	18.76	24.68	29.50	35.80	49.50	8.44
Lbs Sq. Ft.	0.90	1.30	1.50	1.75	2.30	2.70	3.28	4.53	

Duct Data Chart

Duct Dia Inches	Area		Cir In Ft.	CFM at			
	Sq. In.	Sq. Ft.		3500 FPM Vel.	4000 FPM Vel.	4500 FPM Vel.	5000 FPM Vel.
4	12.56	.087	1.05	304	348	391	435
5	19.63	.136	1.31	476	544	612	680
6	28.27	.196	1.57	686	784	882	980
7	38.48	.367	1.83	934	1066	1201	1335
8	50.26	.349	2.09	1221	1396	1570	1745
9	63.61	.442	2.35	1547	1768	1989	2210
10	78.54	.545	2.61	1910	2180	2450	2730
12	113.1	.785	3.41	2750	3140	3530	3920
14	153.9	1.06	3.66	3610	4240	4770	5300
16	201.1	1.39	4.19	4860	5560	6250	6950
18	245.5	1.76	4.70	6160	7040	7920	8800
20	314.2	2.18	5.23	7630	8720	9810	10900
22	380.1	2.64	5.75	9240	10560	11880	13200
24	452.4	3.14	6.28	10990	12560	14130	15700
26	530.9	3.68	6.80	12880	14720	16560	18400
28	615.8	4.27	7.33	14950	17080	19215	21350
30	706.9	4.91	7.85	17180	19640	22090	24550
32	804.2	5.58	8.38	19530	22320	25110	27900
34	907.9	6.30	8.90	22050	25200	28350	31500
36	1017.9	7.07	9.42	24740	28380	31810	35350
38	1134.1	7.88	9.95	27560	31500	35440	39380
40	1256.6	8.73	10.47	30545	34905	39270	43630
42	1385.4	9.62	11.00	33675	38485	43295	48105
44	1520.5	10.56	11.52	36960	42235	47515	52795
46	1661.9	11.54	12.04	40395	46165	51935	57705
48	1809.6	12.57	12.57	43980	50265	56550	62830
50	1963.5	13.64	13.09	47225	54540	61360	68175
52	2123.7	14.75	13.61	51620	58990	66365	73740
54	2290.2	15.90	14.14	55665	63620	71570	79520
56	2463.0	17.10	14.66	59865	68415	76970	85520
58	2642.1	18.35	15.18	64220	73390	82565	91740
60	2827.4	19.63	15.71	68720	78540	88360	98175

Material Properties

Weights and specific heats of material mean values

Material	Density lb. per. cu. ft.	Specific heat Btu per lb. per deg. F.
Air	.0749	0.24
Aluminum	165	0.22
Aluminum chips	48	
Antimony	414	0.05
Asbestos	153	0.20
Asbestos, loose	64	
Ashes, coal, dry	40	.20
Ashes, wood, dry	47	
Bakelite, laminated	86	0.35
wood filler	85	0.33
asbestos filler	118	0.38
crushed	43	
Baking powder	56	
Bauxite, dry, crushed	43	
Bone, dry, ground	75	
Borax	109	0.38
Borax, dry, crushed	75	
Brass	530	0.09
Brass chips	163	
Brick, masonry	118	0.22
Bronze	509	0.09
Bronze, phosphor	554	0.09
Calcium, carbonate	177	0.19
Calcium chloride	134	0.16
Calcium sulphate	185	0.17
Carbide, dry, crushed	50	
Carbonundum	195	0.16
Carbonundum, loose	140	
Caustic soda	88	
Celluloid	90	0.36
Cellulose	94	0.37
Cement, loose	94	0.20
Cereals, bulk barley, corn	37	
oats	26	
rye, wheat	48	
Chalk	142	0.21
Charcoal,		
hard-wood	34	0.20
softwood	23	0.20
broken	12	
Cinders	43	0.18

Weights and specific heats of material mean values (cont'd)

Material	Density lb. per. cu. ft.	Specific heat Btu per lb. per deg. F.
Clay, loose, dry	63	0.22
moist	110	0.55
Coal, anthracite	98	0.31
anthracite, piled	54	
bituminous	85	0.30
bituminous, piled	47	
Coffee	48	
Coke	75	0.20
Coke, piled	28	
Coke, dry, crushed	15	
Concrete, cinder	97	0.18
stone	142	0.19
Copper	556	0.09
Copper ore, crushed	190	
Copper oxide	190	
Cork	15	0.48
Corn meal	40	
Conundum, alundum	247	0.20
Cotton, baled	93	0.32
loose	30	0.32
Dolomite	181	
Duralumin	175	0.23
Earth, dry and loose	76	
Earth, moist and loose	78	0.44
Emery	250	
Feldspar	160	0.20
Feldspar, crushed	88	
Ferrous, grind dust	125	
Flour, compressed		
barreled	47	
loose	28	
Fullers earth, dry	30	
Glass, crown	160	0.16
Glass, flint	215	0.13
pyrex	140	0.20
ground	90	
Granite	165	0.19
loose, piled	96	
Graphite	132	0.20
Gravel, loose, plied	120	
Grit blast dust	160	
Gypsum		
compressed	152	0.26
loose	70	
Iron, gray cast	442	0.12

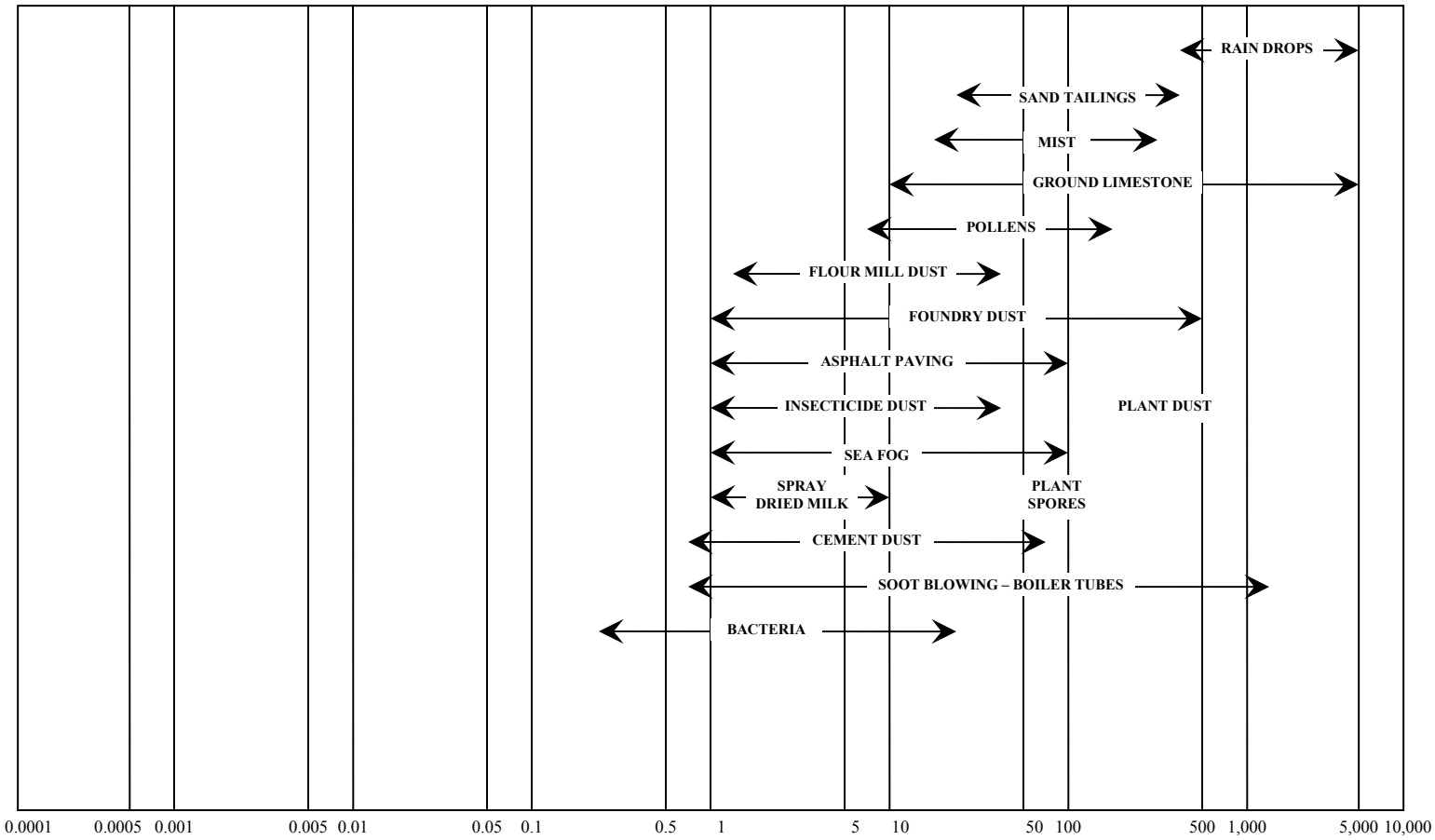
Weights and specific heats of material mean values (cont'd)

Material	Density lb. per. cu. ft.	Specific heat Btu per lb. per deg. F.
Iron ore, loose	150	
Lead	710	0.03
Lead oxide (red)	567	0.06
Leather	56	0.36
Lime	53-64	
Limestone	163	0.22
Lucite	74	
Magnesia	214	0.22
Magnesium	109	0.25
Magnesium dust	30	
Manganese ore, crushed	259	
Mica	183	0.21
Monel metal	556	0.13
Natural gas	0.04475	0.526
Nickel	547	0.11
Nylon	70	0.55
Paper	58	0.32
Strawboard or newspaper	33-44	
Paraffin	56	0.69
Peat, dry	30	
Phosphate, ground	75	
Porcelain	150	0.26
Potash	60	
Quartz	165	0.21
Quartz, ground	84	
Resin	67	
Rubber, India	58	0.48
compound	115	
hard	75	0.33
hard sponge	30	0.40
tire reclaim, solid	74	
tire reclaim, shred	27	
Salt, gran, and piled	48	0.21
Saltpeter	80	
Sand, dry, loose	99	0.20
Sand, wet	110	
Sandstone	144	0.22
Sandstone, crushed	82	
Sawdust	7-15	
Shale, riprap	105	
Shavings, planer	7-15	0.52
Slag, Iron	172	
Slag, granulated	60	

Weights and specific heats of material mean values (cont'd)

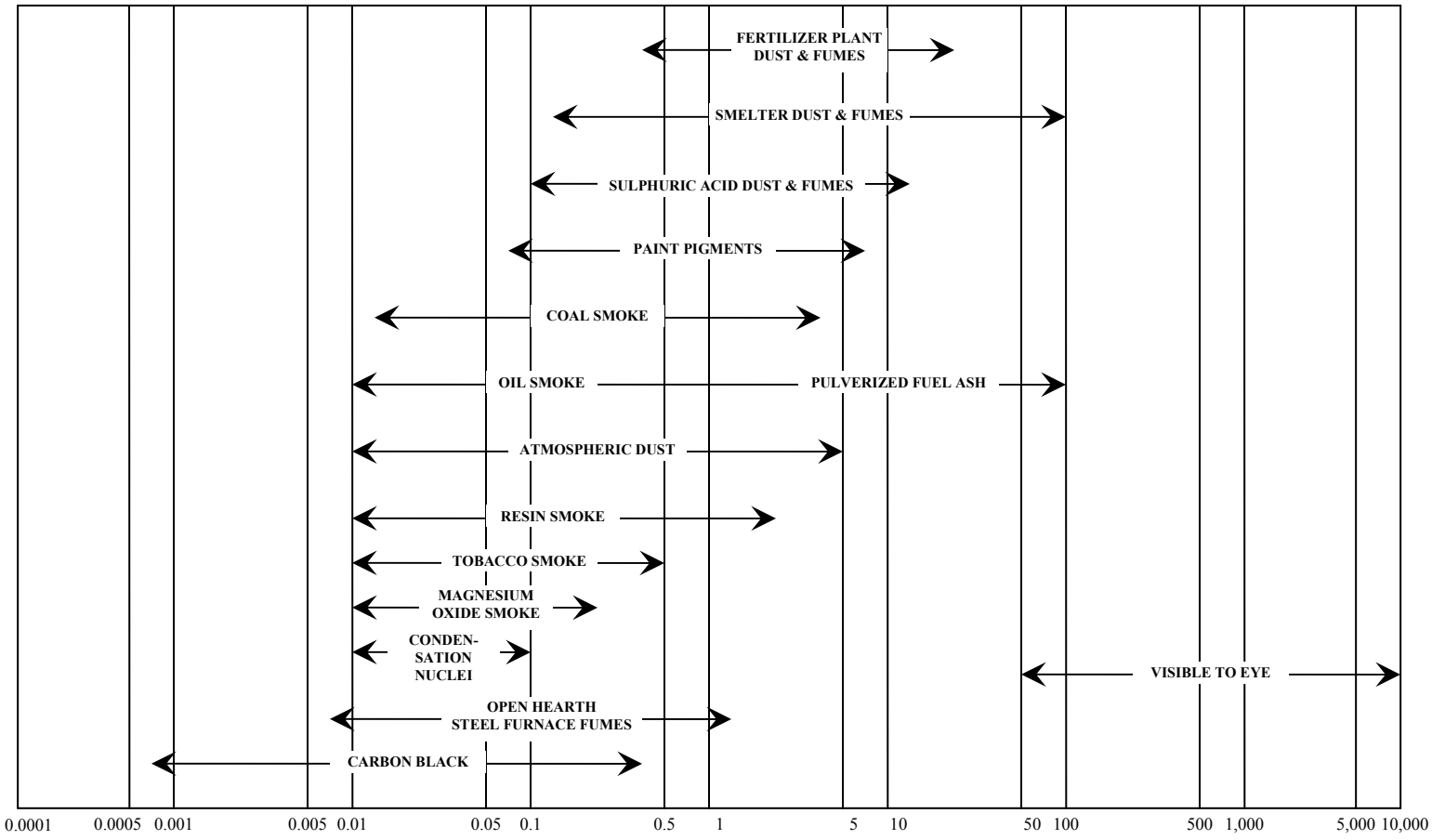
Material	Density lb. per. cu. ft.	Specific heat Btu per lb. per deg. F.
Slate	172	
Soda ash	74	
Soda ash, granulated	30	
Sodium carbonate	91	0.27
Sodium nitrate	141	0.28
Sodium sulphate	167	0.21
Starch	95	
granulated	35	
Steel	487	0.12
Sucrose	100	0.30
Sugar, bulk	55	0.28
Sulphur	126	0.17
Sulphur, crushed	50	
Talc	170	0.21
Tar, bituminous	69	0.40
Tile	113	0.15
Tin	457	0.05
Tobacco	16	
Water	62.4	1.0
Zinc	443	0.09
Zinc oxide	350	0.12

PARTICLE CHART



PARTICLE SIZE - MICRONS

PARTICLE CHART



PARTICLE SIZE - MICRONS

ABRASION CHARACTERISTICS OF VARIOUS DUSTS	
Alfafa meal	N
Almonds, broken or whole	N
Alum	N
Alumina	VA
Aluminum	M
Ammonium chloride, crystalline	M
Antimony	VA
Apple pomace, dry	N
Asbestos, shred	M
Ashes, Hard Coal	VA
Ashes, Soft Coal	VA
Asphalt, crushed	VA
Ammonium sulphate	M
Bagasse	M
Bakelite, powdered	N
Baking powder	N
Barley	N
Bauxite, crushed	VA
Beans, -meal etc.	N
Bentonite	A
Bicarbonate of Soda	N
Bonemeal	M
Bones, crushed, minus 1/2”	M
Bones, granulated or ground, minus 1/8”	M
Boneblack	M
Bonechar	M
Borax, powdered	VA
Bran	N
Brass	M
Brewers grain, spent, dry	N
Brick	A
Buckwheat	N
Calcium carbide	A
Calcium carbonate	A
Carbon, amorphous, graphitic	M
Carbon black powder, channel	M
Carbon black powder, furnace	M
Carborundum	VA
Casein	M
Cast Iron, borings	VA
Cast Iron	VA
Caustic Soda	M
CODE: VA – very abrasive A – abrasive M – mildly abrasive N – less abrasive	

ABRASION CHARACTERISTICS OF VARIOUS DUSTS	
Cellulose	M
Cement, Portland	VA
Cement, clinker	VA
Chalk, crushed	A
Chalk, pulverized, minus 100 mesh	A
Charcoal	N
Cinders, coal	A
Clay, dry	A
Clover seed	N
Coal, bituminous	A
Coal, anthracite	A
Cocoa, powdered	N
Cocoa beans	N
Coconut, shredded	N
Coffee	N
Coke, bituminous	A
Coke, petroleum	A
Copper	VA
Copra (dried coconut)	N
Cork, fine ground	M
Corn, cracked, shelled etc.	N
Cornmeal	N
Cottonseed	N
Cullet (broken glass)	A
Dicalcium phosphate	M
Dolomite	A
Ebonite, crushed	N
Egg powder	N
Epsom salts	M
Feldspar	A
Ferrous sulphate	A
Fish meal	N
Flaxseed	N
Flour	N
Flue dust, dry	M
Fluorspar	A
Fly ash	VA
Fullers earth	A
Gelatine, granulated	N
Glass batch	VA
Glue, ground	M
Gluten mean	N
CODE: VA – very abrasive A – abrasive M – mildly abrasive N – less abrasive	

ABRASION CHARACTERISTICS OF VARIOUS DUSTS	
Grains, distillery, dry	N
Graphite	A
Grass seed	A
Gypsum	N
Hops, dry	N
Ice, crushed	N
Ilmenite ore	VA
Iron Cast	VA
Iron Oxide	VA
Lead	A
Lead Arsenate	A
Lead oxide	A
Lignite	A
Lime, ground	VA
Lime, hydrated	A
Limestone	VA
Litharge	A
Lucite	A
Magnesite	VA
Magnesium	VA
Magnesium chloride	A
Malt, dry	N
Manganese sulphate	A
Maple, hard	N
Marble	A
Marl	A
Mica, ground	M
Milk, dried, malted, powdered	N
Monel metal	M
Muriate or potash	M
Mustard seed	N
Naphthalene flakes	N
Nickel	VA
Oats	N
Oak	N
Orange peel, dry	N
Oxalic acid crystals	N
Peanuts	N
Peas, dried	N
Peas	N
Phosphate rock	VA
Phosphate sand	VA
CODE: VA – very abrasive A – abrasive M – mildly abrasive N – less abrasive	

ABRASION CHARACTERISTICS OF VARIOUS DUSTS	
Pine	N
Porcelain	M
Quartz	VA
Resin	M
Rice	N
Rubber, ground	N
Rubber, hard	N
Rubber, soft	N
Rye	N
Salt, rock	A
Salt, dry, coarse	A
Salt, dry, pulverized	A
Saltpeter	N
Sand	VA
Sandstone	VA
Sawdust	N
Shale, crushed	A
Slag, furnace, granulated	VA
Slate	A
Soap, chips, flakes	N
Soap powder	N
Soapstone talc	M
Soda ash, light	M
Soda ash, heavy	M
Sodium Nitrate	A
Sodium Phosphate	A
Soybeans, meal and whole	N
Starch	N
Steel	A
Steel chips, crushed	A
Sugar	N
Sugar beet pulp, dry	N
Sulphur	N
Talc	M
Tanbark, ground	M
Timothy seed	N
Tin	A
Titanium	VA
Tobacco	N
Vermiculite ore	A
Wheat	N
White lead	A
Zinc Oxide	A
CODE: VA – very abrasive A – abrasive M – mildly abrasive N – less abrasive	

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Cotton Wood Peat	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Cotton			98	72		38	25	44	24	St. 1
Cellulose			92	71		20	3	51	66	
Wood dust				90		47	7	33		
Wood dust	58		57	55		43	39	80		
Wood dust, (Chipboard)				70		30		43	102	St. 2
Wood/ cardboard/jute								26		
Wood/card-board/jute/resin										
Lignin dust			96	85		66	57	18	208	
Paper dust				91		83	73	<10	18	
Paper tissue dust			75	58				54	52	(St. 2)
Paper (□henol-resin treated)				100		90	25	23	190	
Peat (15% moisture)			84	58		26	3	58	157	St. 1
Peat (22% moisture)			82	65		40	15	46	69	St. 1
Peat (31% moisture)			87	76		43	20	38	64	
Peat (41% moisture)			88	76		40	18	39		
Peat (from bottom of sieve)			78	48		22		74	51	St. 1
Peat (dust deposit)				66		33	11	49	144	St. 1
Paper				93		76		29	168	
Food Feed	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Gravy powder (21% starch)					100				12	
Citrus pellets					100				39	
Dextrose, ground			100		94	71		22		St. 2
Dextrose				38		5	4	80	18	St. 1
Fat/whey mixture	76		11	3				330	23	
Fat powder (48% fat)		100	75		24	7		92	20	St. 2
Do.					100					
Fish meal	68		23		12			320	35	
Fructose (from filter)	99		39	17				150	102	
Fructose	92		15					200	28	

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Food Feed	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Fructose	81							400	27	
Barley grain dust		79	51	25		8	3		240	
Do.					100				83	
Oats grain dust	64		24		8			295	14	St. 1
Wheat grain dust				48		30		80	112	St. 1
Wheat grain dust	100	81	50		32	25		125		St. 2
Coffee (from filter)				100		99	89	<10	90	
Coffee (refined)					100				11	
Cocoa bean shell dust					100				68	
Cocoa/sugar mixture	53		20					500	43	St. 1
Potato granulate					100				21	
Potato flour			86	53		26	17	65	69	
Lactose (from filter)				83		60	47	22	29	
Lactose (from cyclone)				97		70	41	23	81	St. 2
Maize seed waste (9% moisture)	98	67	40		23	16		165	117	
Milk powder			34	18				165	90	
Milk powder	98		15	8				235	75	
Milk powder (low fat spray dried)	100	100	99		60	17		46	109	
Milk powder (full fat spray dried)				30				88	83	St. 1
Whey fat emulator	62		7	2				400	38	
Olive pellets					100				74	
Rice flour					100				57	
Rye flour			94	76		58	15	29	79	
Soy bean flour				85		63	50	20	110	St. 1
Potato starch					100				43	
Potato starch				100		50	17	32	(89)	
Maize starch				99		98	94	<10	128	
Maize starch				94		81	60	16	158	St. 1
Rice starch (hydrolyzed)				29		15		120	190	(St. 2)
Rice starch				99		74	54	18		
Rice starch				86		62	52	18	190	(St. 2)
Wheat starch						84	50	20	132	(St. 2)
Tobacco			81	64		29		49	12	
Tapioca pellets				61		42		44	53	St. 1

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Food Feed	**Particle Size Distribution**									
	Weight %<Size (µm)							**Median**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Tea (6% moisture)					100				68	
Tea (black from dust collector)			64	48		26	16	76	59	St. 1
Meat flour			69	52		31	21	62	106	St. 1
Wheat flour								50		
Wheat flour			97	60		32	25	57	87	
Wheat flour 550				60		34	25	56	42	
Milk sugar				99		92	77	10	75	
Milk sugar				98		64	32	27	82	St. 1
Sugar (Icing)				88		70	52	19		
Coal Coal products	**Particle Size Distribution**									
	Weight %<Size (µm)							**Median**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Activated Carbon				99		80	55	18	44	
Activated Carbon				88		64		22	No Ignition	
Activated Carbon (16% moisture)			84	65		38		46	67	
Brown coal			83	69		40	20	41	123	
Brown coal (from electrostatic filter)			75	60		27		55	143	St. 1
Brown coal (dust from grinding)			71	56		38	30	60	107	
Brown coal/ anthracite (80-20)				66		43	24	40	108	
Brown coal/ anthracite (20-80)				91		85	80	<10	1	
Brown coal coke	93		18	13				290	115	St. 1
Brown coal (graphitized)				82		55	35	28	No Ignition	
Charcoal				99		88	67	14	10	St. 1
Charcoal				95		85	58	19	117	
Charcoal	36							>500	No Ignition	
Asphalt				83		54	32	29	117	
Bituminous coal				97		93	85	<10	55	
Bituminous coal (Petchora)			76	65		46	37	38	86	
Bituminous coal (high volat.)							99	4	59	

Other natural organic products	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Cotton seed expellers	66		24	10				245	35	St. 1
Dextrin				57		26	5	55	109	St. 1
Wheat gluten (after mill)				78		28	13	48	105	
Blood flour			93	61	27	5	57	85		
Hops, malted	52		14	9				490	90	
Leather dust (from collector)										St. 2
Linen (containing oil)	63		21					300	17	
Lycopodium					100	91				
Oil shale dust				99		79	50	20	35	
Oil shale dust				71		50	39	32	No Ignition	
Grass dust	96		26					200	47	
Walnut shell powder										St. 1
Plastics Resins Rubber	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Acryinitrate-Butadiene-Styrene-Co-polym.	79	37	24					200	147	(St. 2)
Epoxy Resin (or powder coating)		100	82		58	28		55	147	(St. 2)
Cellulose-2 5-Acetate				100		89	53	19	180	
Polyester resin with glass	92	91	89		80	72		14		(St. 2)
Rubber (dust from grinding)			78	43		12		80	138	
Resin (from filter)				97		44		40	108	
Epoxy resin 60% resin + 36% TO_2				99		67	43	23	155	
Epoxy resin				95		60	36	26	129	St. 1
Epoxy resin with Al				90		46		34	208	
Melamin resin				99		84	55	18	110	St. 1
Melamin resin				66		24	13	57	172	St. 1
Phenol resin				100		99	94	<10	129	(St. 2)
Phenol Formal-dehyde resin)	100	98	81		50	30		60		St. 1
Polyamid resin				95		84	64	15	105	

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Plastics Resins Rubber	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Polymethacrylate	56				100	33			199	
Silicon resin	91		59	39		20	13	100	80	
Caoutohouc			58	40		20		95	192	
Polystyrene (Copolymer)			32	11				155	110	
Polystyrene (Hard-foam)	30		10	5				760	23	
Polyurethane					100	90		3	(156)	
Polyvinylacetate (Copolymer)						83	50	20	86	St. 1
Polyvinylalcohol				74		55	44	26	128	(St. 2)
Polyvinylalcohol				57		29	9	56	83	St. 1
Polyvinylchloride						100		<10	168	
Polyvinylchloride			46	15				125	68	
Polyvinylchloride (Em., 97.5% PVC)				97		73	26	25	42	
Polyvinylchloride (Em., 97% PVC)				60		31	14	51	63	
Polyvinylchloride (Susp.)			66	23				105	45	St. 1
Polyvinylchloride (Susp.)			30					137	No Ignition	
Urea-formaldehyde (mold.-form)				99		91	75	13	136	St. 1
Melamine-formaldehyde (mold.-form)				93		86	70	14	189	St. 1
El. stat. coating powder (Epoxy)				100		70		29	100	(St. 2)
El. stat. coating powder (Polyurethane)				100		66	22	29	89	St. 1
Shellac					100	33			144	(St. 2)
Wax (NN Ethylene distearmide)					100	95		10	269	(St. 2)
Pharmaceutical Cosmetics Pesticide	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Acetyl salicylic acid					100				217	(St. 2)
Amino phenazone						100	98	<10	238	
Ascorbic acid. L(+)-				93		75	61	14	48	(St. 2)
Ascorbic acid				92		38	15	39	111	(St. 2)

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Pharmaceutical Cosmetics Pesticide	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Coffein					100				165	(St. 2)
Cysteine hydrate				100		98	94	<10	40	
L-Crystin				100		95	69	15	142	
Digitalis leaves				59		42		46	73	
Dimethylamino-phenazone						100		<10	337	
2-Ethoxybenza-mide					100				214	(St. 2)
Fungicide (Captan)			100		99	93		5		St. 1
Fungicide (Org. zinc comp.)						99	96	<10	154	
Fungecide (Maneb)				98		97	93	<10		
Methionine				100		99	95	<10	143	
Methionine				100		98	87	<10	128	
Sodium – L(+) ascorbate				97		67	45	23	119	St. 1
Paracetamole					100				156	(St. 2)
Pesticide				99		98	98	<10	151	
Intermediate products Auxiliary Materials	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Adipinic acid				98		92		<10	97	(St. 2)
Aging protective					100	67		<32	256	(St. 2)
Anthracene	89		20	7				235	231	
Anthrachinone						100		<10	364	
Anthrachinone				100		90	75	12	91	
Azodicarbonamide						100		<10	176	
Benzoic acid										(St. 2)
Betaine hydrochloride				93		85	78	<10	114	(St. 2)
Betaine monohydrate	34		4					710	63	St. 1
Diphenol ketylene				98		80	60	15	270	
Calcium acetate			74	41		25	17	92	9	St. 1
Casein					99		65	40	24	115
Sodium caseinate (from filter)				100		99	77	17	117	
Carboxy methyl cellulose				97		89		<15	184	
Carboxy methyl cellulose				50		20	12	71	127	St. 1
Methyl cellulose				96		87	30	22	157	
Methyl cellulose				100		69	10	29	152	

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Intermediate products Auxiliary Materials	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Methyl cellulose				93		37	12	37	209	
Ethyl cellulose				66		40		40	162	
Chloroacetamide	98	79	33		13	3		170		St. 1
Cyanoacrylicacid methylester	69		20					260	269	(St. 2)
Dicyandiamide				99		98	97	<10	9	
1.3-Diethyldiph-enyl urea				98		93	83	<10	163	(St. 2)
1.3-Diethyldiph-enyl urea	8							1300	116	(St. 2)
Dimethyl terephtalate						60		27	247	
Diphenyl urethane	93		49	27				128	218	(St. 2)
Diphenyl urethane	31							1100	51	(St. 2)
Emulgator (50% CH, 30% fat)			89	50		11		71	167	
Ferrocene			71	33				95	267	
Fumac acid	100	75	24		15	11		215		(St. 2)
Epoxy resin hardener				97		85	60	17	64	
Urea	4	2	<1					2900		St. 1
Hexamethylene tetramine				100		69	42	27	286	
Hexamethylene tetramine	100		30	9				155	224	
Cellulose ion exchange resin								<10	91	(St. 2)
Cellulose ion exchange resin				27		9		112	112	
Condensation product (phenol)				92		74	50	20	171	(St. 2)
D(-)-Mannite				61		24	13	67	54	St. 1
Melamine				98		95	88	<10	1	St. 1
Melamine peroxide				61		56	46	24	73	St. 1
Melamine phosphate					100	79		22		St. 1
Melamine phtalate				99		89	65	16	52	St. 1
Metal soap (Ba/Pb-stearate)					100	48			180	(St. 2)
Metal soap (Zn-behenate)					100	80			119	(St. 2)
Methacrylamide	42							580	113	
Naphtalene	89		66		35	12		95	178	
Naphtalic acid anhydride						97	69	16	90	

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Intermediate products Auxiliary Materials	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
2-Naphtol				100		96	94	<10	137	
Sodium amide										(St. 2)
Sodium cyclamate	97	52	13		5	2		250		St. 1
Sodium hydrogen cyanamide			95	90		28	8	40	47	
Sodium lingo sulphonate			100		63	20		58		St. 1
Oil Adsorber (hydrophobic cellulose)			65	51		31	21	65	42	
Paraformaldehyde				89		65	41	23	175	(St. 2)
Paraformaldehyde				86		58	37	27	222	
Pectin				86	61		21		59	162
Pectinase				91		47	20	34	177	
Pentaerythrite				100		98	86	<10	120	
Pentaerythrite (from filter)			90	33		6	3	85	188	
Pentaerythrite	86		47	36		20	12	135	158	
Phtalic acid anahydride										(St. 2)
Polyethylene oxide	99	83	53		29	14		115		(St. 2)
Polysaccharide					100	78		23		St. 1
Propyleneglycol alginate			57	24				115	82	
Salicylic acid										(St. 2)
Saponin				93		77	65	13	150	St. 1
Lead stearate			99	96		90	80	<10		
Lead stearate							90	12	152	
Calcium stearate				99		92	84	<10		
Calcium stearate						92	80	<10	99	
Calcium stearate	100		43	25				145	155	
Magnesium stearate										(St. 2)
Sodium stearate				92		67	45	22	123	St. 1
Zinc stearate										(St. 2)
Zinc stearate				95		86	72	13		
Stearin/Lead				99		95	75	15	111	
Stearin/Calcium				100		89	64	16	133	
Stearic acid	12							1300	34	(St. 2)
Terephthalic acid dinitrile					100	78			260	
2.2-Thiodiacetic acid				48		27	18	75	72	St. 1
Thio urea	56		1					460	8	St. 1
Trimellitic anhydride	4							1250	33	
Trisodium citrate	36	2	1					800		St. 1

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Intermediate products Auxiliary Materials	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Tyrosine (final product)	100		99			48		10		(St. 2)
Tyrosine (raw product)	99		96		91	74		15		(St. 2)
Viscose flock					100	94		13		St. 1
Tartaric acid	100	5	1					480		St. 1
Zinc cyanamide				99		96	94	<10		
Zinc cyanamide	47	34			27	14		600	(53)	No. ign.
Zinc pyridine thione						100				St. 1
Other Technical/ Chemical products	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Organic dyestuff (blue)					99		98	95	<10	73
Organic dyestuff (red)								<10	249	
Organic dyestuff (red)				65		33	23	52	237	(St. 2)
Organic dyestuff (Azo. yellow)				100		98	95	<10	288	(St. 2)
Organic dyestuff (brown)										St. 1
Organic dyestuff (Pthalocyanine)				96		86		<10	73	St. 1
Fushsin base				74		45	26	36	115	
Bituminous hydrocarbon			23	11				260	63	
Light protection agent				97		92	83	<10	214	
Light protection agent				100		93		<15	310	
Soap								65	111	
Surfacer (Epoxy based)					100	77		24		St. 1
Surfacer (Polyester based)					100	85		19		St. 1
Washing agent (Na-sulph.)	88		14					275	267	(St. 2)
Wax raw material (Alkylaryl sulphonate)										(St. 1)
Wax raw material (Olefin sulphonate)			60	28				105	115	

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Metal Alloys	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Aluminum powder				94		88	79	<10	515	
Aluminum powder				98		70	45	22	400	
Aluminum powder				99		64	47	22	1100	
Aluminum powder				94		60	17	29	415	(St. 3)
Aluminum grit				100		96		23	320	
Aluminum grit				99		16	2	41	100	
Aluminum grit	92		26	6				170		
Aluminum shavings	80		35	20				190		
Aluminum shavings	79		29	17				240		
Aluminum/Iron (50:50)				93		68	48	21	230	
Aluminum/ Magnesium			47					130	52	St. 1
Aluminum/ Nickel					95		86		<10	300
Aluminum/ Nickel (50:50)				37		18		90		
Bronze powder						97	60	18	31	St. 1
Calcium/ Aluminum (30:70)						68	46	22	420	
Calcium/Silicon (from cyclone)				94		75	48	21	200	(St. 2)
Calcium/Silicone				87		55		28		
Iron (from dry filter)				98		82	67	12	50	
Iron Carbonyl							96	<10	111	(St. 1)
Ferrochromium				96		82	73	<10	86	
Ferromanganese				99		97	90	<10	84	
FeSiMg (22:45:26)				99		77	57	17	169	
Ferrosilicon (22:78)				97		70	47	21	87	
Hard metal (TiC, TiN, WC, VC, Mo)		100	95		68	40		43		St. 1
Co-Al-Ti (62:18:20)				92		61	41	25	134	
Magnesium				100		70		28	508	
Magnesium	99		1					240	12	(St. 2)
FeSiMg (24:47:17)				99		70	47	21	267	

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Metal Alloys	**Particle Size Distribution** Weight %<Size (µm)							**Median**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Manganese (electrolyt.)				82		70	57	16	157	
Manganese (electrolyt.)				70		41		33	69	
Molybdenum				100		96	92	<10		
Niobium (6% Al)	87	44	24		9	3		250		St. 1
Silicon				99		98	97	<10	126	
Silicon (from filter)						100	99	<10	116	
Silicon (from cust extr.)				90		70	57	16	100	
Steel (100 Cr6) dust					100	74			(82)	(St. 2)
Tantalum/Niobium				97		90	80	<10	37	
Titanium				98		55	24	30		
Titanium (pre-oxidized)				77		46	26	35		
$TiTiO_2$ (dust deposit)	61	40	28		12	6		310		(St. 3)
Zinc (from zinc coating)				91		72	53	19	85	St. 1
Zinc (from zinc coating)				93		70		21	93	
Zinc (dust from collector)							99	<10	125	(St. 2)
Zinc (dust from collector)				97		91	72	10	176	St. 1
Other Inorganic Products	**Particle Size Distribution** Weight %<Size (µm)							**Median**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
NH4NO3/ Dicyanimide (66:34)				60		42	35	50	21	
Graphite (99.5% C)					100	97		7	71	
Carbon fibers (99% C)										St. 1
Molybdenum disulphide				92		75	53	19	37	St. 1
Petroleum coke				93		75	59	15	47	St. 1
Petroleum coke			83	51		22	14	71	3	
Petroleum coke (calcinated)			94	86		64	47	22	14	
Phosphorous (red)			100		92	59	18	526		
Soot							99	5	85	

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Other Inorganic Products	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Soot (from filter)								<10	88	
Sulphur				97			85	71	12	
Sulphur				96		70	51	20	151	(St. 2)
Sulphur				86		23		40		
Sulphur			53			7		120		
Titanium carbide										(St. 2)
Titanium hydride										St. 1
Titanium monoxide										(St. 2)
Other Materials	**Particle Size Distribution**									
	Weight %<Size (µm)							**Med-ian**	**K_{St}**	**Explos. < 63 µm**
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Flyash (from electrofilter)			100		99	92		6	35	No. Ign.
Ash concentrate				87		61	48	21	91	
Bentonite/ Asphalt/Coal/ Org. (15:45:35:5)		90			55			54		St. 1
Bentonite/Coal (50:50)		98	86		69	41		42		St. 1
Bentonite der. + org. comp.				89		45	23	35	123	
Pb and Ca stearate mixture		98			70		35			(St. 2)
Break liner (grinding dust)				98		95	89	<10	71	
Brush dust (Al-brushes)				99		74	30	25	360	
CaC/Diamide lime/Mg (72:18:10)		99		93		87	80	8	30	
Mud from settling chamber			99	91		62	45	23	96	
Dust from polishing (Al)			44	26				150	18	
Dust from polishing (Zn)		60	35		15	2		190		St. 1
Dust from polishing (brass)										St. 1
Dust from grinding (Al)					100	85			(214)	(St. 2)
Dust from grinding (Zn)					100	67			(24)	St. 1
Dust from grinding cardbd.	70	64	44		25	10		160		St. 1

Ignitability and Explosibility of Dust Clouds (Ref 2 & 3)

Other Materials	Particle Size Distribution									
	Weight %<Size (µm)							Med-ian	K_{St}	Explos. < 63 µm
Dust Type	500	250	125	71	63	32	20	µm	bar•m/s	Class
Dust from grinding polyester				98		95	93	<10	153	
Dust from grinding polyester			97	84		60	41	25	237	
Dust from grinding (Ti)	89	64	37		18	4		170		(St. 2)
Dust from grinding + polishing (polyester)				99		96	91	<10		
Blasting dust (light metals)					100	82			242	(St. 2)
Immersion polishing agent	46							600	11	St. 1
Textile fibers (nat. + synth.)										St. 1
Toner							100	<10	196	
Toner							100	<10	137	
Toner				100		96	48	21	134	
Toner				100		95	30	23	145	
Toner/iron powder				58		37		60	169	
Toner/resin				98		78	55	18		
Zinc stearate/ Bentonate (90:10)										(St. 2)
Zinc stearate/ Bentonate (20:80)										(St. 1)

Explosion Classes
St. 1 = 200 kst or less
St. 2 = 300 kst or less

Equations per NFPA 68, Sec. 7-1.1.1, p. 68-27

Av = a*V^(2/3)*Kst^b*Pred^c

where

a = 0.000571 e^(2*Pstat)

b = 0.978 e^(-0.105* Pstat)

c = -0.687 e^(.226*Pstat)

Variables: Pstat (bars) – Vent Release Pressure
Pred (bars) – Max. Press. During Venting
Kst (bar*m/sec) – Deflagration Index
V (m^3) – Volume of Vessel
Av (m^2) – Required Vent Area

See Reference #3

Misc. Ref.

Weight of rolled steel

Thickness			Weight		
MSG no.	**Sheet equiv-alent inches**	**Order limit inches**	**Pounds per square foot**	**Order limit pounds**	**MSG no.**
8	.1644	.1716 to .1570	6.675	7.187 to 6.563	8
9	.1495	.1569 to .1420	6.250	6.562 to 5.938	9
10	.1345	.1419 to .1271	5.625	5.937 to 5.313	10
11	.1196	.1270 to .1121	5.000	5.312 to 4.688	11
12	.1046	.1120 to .0972	4.375	4.687 to 4.063	12
13	.0897	.0971 to .0822	3.750	4.062 to 3.438	13
14	.0747	.0821 to .0710	3.125	3.437 to 2.969	14
15	.0673	.0709 to .0636	2.812	2.968 to 2.657	15
16	.0598	.0635 to .0568	2.500	2.656 to 2.375	16
17	.0538	.0567 to .0509	2.250	2.374 to 2.125	17
18	.0478	.0508 to .0449	2.000	2.124 to 1.875	18
19	.0418	.0448 to .0389	1.750	1.874 to 1.625	19
20	.0359	.0388 to .0344	1.500	1.624 to 1.438	20
21	.0329	.0343 to .0314	1.375	1.437 to 1.313	21
22	.0299	.0313 to .0284	1.250	1.312 to 1.188	22
23	.0269	.0283 to .0255	1.125	1.187 to 1.063	23
24	.0239	.0254 to .0225	1.000	1.062 to .938	24
25	.0209	.0224 to .0195	.875	.937 to .813	25
26	.0179	.0194 to .0172	.750	.812 to .719	26
27	.0164	.0171 to .0157	.688	.718 to .657	27
28	.0149	.0156 to .0142	.625	.656 to .594	28
29	.0135	.0141 to .0128	.562	.593 to .532	29

Weights of steel plate

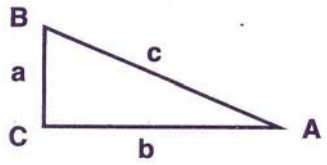
Thick-ness	**Weight per sq. ft. lbs.**	**Thick-ness**	**Weight per sq. ft. lbs.**	**Thick-ness**	**Weight per sq. ft. lbs.**
3/16	7.65	7/16	17.86	11/16	28.03
1/4	10.20	1/2	20.40	3/4	30.60
5/16	12.74	9/16	22.95	7/8	35.70
3/8	15.29	5/8	25.50	1	40.89

Standard Sieve Series*

Tyler Inch/Mesh	U.S. Standard Inch/Sieve #	Sieve Opening	
		Inches	Microns
3 1/2	3 1/2	0.223	5660
4	4	0.187	4760
5	5	0.157	4000
6	6	0.132	3660
7	7	0.111	2830
8	8	0.0937	2380
9	10	0.0787	2000
10	12	0.0661	1680
12	14	0.0555	1410
14	16	0.0469	1190
16	18	0.0394	1000
20	20	0.0331	840
24	25	0.0280	710
28	30	0.0232	590
32	35	0.0197	500
35	40	0.0165	420
42	45	0.0138	350
48	50	0.0117	297
60	60	0.0098	250
65	70	0.0083	210
80	80	0.0070	177
100	100	0.0059	149
115	120	0.0049	125
150	140	0.0041	105
170	170	0.0.35	88
200	200	0.0029	74
250	230	0.0024	62
270	270	0.0021	53
325	325	0.0017	44
400	400	0.0015	37

*Sieve analysis is limited in its usefulness in industrial ventilation and dust collection because it does not register particles in the submicron range.

Right Triangle Trig Formulas



A, B, C = Angles a,b,c = Distances

$\sin A = \frac{a}{c}$, $\cos A = \frac{b}{c}$, $\tan A = \frac{a}{b}$

$\cot A = \frac{b}{a}$, $\sec A = \frac{c}{b}$, $\operatorname{cosec} A = \frac{c}{a}$,

Given a and b, Find A, B, and c

$\tan A = \frac{a}{b} = \cot B$, $c = \sqrt{a^2 + b^2} = a\sqrt{1 + \frac{b^2}{a^2}}$

Given a and c, Find A, B, b

$\sin A = \frac{a}{c} = \cos B$, $b = \sqrt{(c+a)(c-a)} = a\sqrt{1 - \frac{a^2}{c^2}}$

Given A and a, Find B, b, c

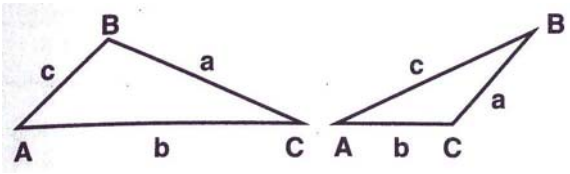
$B = 90° - A$, $b = a \cot A$, $c = \frac{a}{\sin A}$

Given A and b, Find B, a, c

$B = 90° - A$ $a = b \tan A$, $c = \frac{b}{\cos A}$

Given A and c, Find B, a, b

$B = 90° - A$, $a = c \sin A$, $b = c \cos A$



Given A,B and a, Find b, C, and c

$b = \frac{a \sin B}{\sin A}$, $C = 180° - (A + B)$, $c = \frac{a \sin C}{\sin A}$

Given A,a and b, Find B, C, and c

$\sin B = \frac{b \sin A}{a}$, $C = 180° - (A + B)$, $c = \frac{a \sin C}{\sin A}$

Given a,b and C, Find A, B, and c

$A + B = 180° - C$, $c = \frac{a \sin C}{\sin A}$

$\tan 1/2\ (A - B) = \frac{(a - b) \tan 1/2, (A + B)}{a + b}$

Given a, b and c, Find A, B, and C

$s = \frac{a + b + c}{2}$, $\sin 1/2\ A = \sqrt{\frac{(s - b)(s - c)}{bc}}$

$\sin 1/2\ B = \sqrt{\frac{(s - a)(s - c)}{ac}}$, $C = 180° - (A + B)$

Given a, b and c, Find Area

$s = \frac{a + b + c}{2}$, $\text{Area} = \sqrt{s(s - a)(s - b)(s - c)}$

$\text{Area} = bc \sin \frac{A}{2}$, $\text{Area} = \frac{a^2 \sin B \sin C}{2 \sin A}$

Surface and volume of Solids

Cylinder

(Right or Oblique, Circular or Elliptic)

Perimeter or base, P_b; perpendicular height, h, — Lateral Surface = $P_b h$

Perimeter, P, perpendicular to sides; lateral length L, — Lateral Surface = PL

Area of base, B; perpendicular height, h, — Volume = Bh

Area of section perpendicular to sides A, lateral length L, — Volume = AL

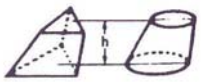
Pyramid or Cone

(Right or Oblique, Regular or Irregular)

Area of base, B, perpendicular height, h, — Volume $= \overline{1/3}\ \sqrt{Bh}$

= 1/3 the volume of prism or cylinder of same base and perpendicular height or 1/2 the volume of hemisphere of same base and perpendicular height.

Frustum of Any Pyramid or Cone
(Parallel Ends)



Areas of base, B, and top, T; perpendicular height, h,

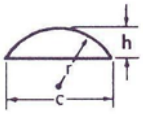
Volume = $1/3h\ (B \overline{+ T} + \sqrt{BT})$

Sphere

Area = $4\pi r^2$
Volume = $1/2/^3\pi$

Radius, r,

Spherical Segment



Radius, r; length of chord, c; height, h, — Curved Surface = $2\pi rh = \pi/4(4h^2+c^2)$

Volume = $\pi/3\ h^2\ (3r-h) = \pi/24\ h\ (3c^2+4h^2)$

Conversion Tables

Decimal and metric equivalents of common fractions of an inch

U.S. inch		Mm	U.S. inch		Mm
Frac-tion	**Decimal**		**Frac-tion**	**Decimal**	
1/32	0.03125	0.794	17/32	0.53125	13.494
1/16	0.06250	1.588	9/16	0.56250	14.288
3/32	0.09375	2.381	19/32	0.59375	15.081
1/8	0.12500	3.175	5/8	0.62500	15.875
5/32	0.15625	3.969	21/32	0.65625	16.669
3/16	0.18750	4.763	11/16	0.68750	17.463
7/32	0.21875	5.556	23/32	0.71875	18.256
1/4	0.25000	6.350	3/4	0.75000	19.050
9/32	0.28125	7.144	25/32	0.78125	19.844
5/16	0.31250	7.938	13/16	0.81250	20.638
11/32	0.34375	8.731	27/32	0.84375	21.431
3/8	0.37500	9.525	7/8	0.87500	22.225
13/32	0.40625	10.319	29/32	0.90625	23.019
7/16	0.43750	11.113	15/16	0.93750	23.813
15/32	0.46875	11.906	31/32	0.96875	24.606
1/2	0.50000	12.700	1	1.00000	25.400

Conversion ratios

Multiply	**by**	**to obtain**
Diam. circle	3.1416	Circumference circle
Diam. circle	0.8862	Side of equal square
Diam. sphere cubed	0.5236	Volume of sphere
Circular mils	0.7854	Square mils
U.S. gallons	0.8327	Imperial gallons (Brit.)
U.S. gallons	0.1337	Cubic feet
U.S. gallons	8.330	Pounds of water (20°C)
Cubic feet	62.427	Pounds of water (4°C)
Feet of water (4°C)	0.4336	Pounds per sq. inch
In. of mercury (0°C)	0.4912	Pounds per sq. inch
Knots	1.1516	Miles per hour
To obtain	**divide**	**into**

Pressure equivalents

1 Atmosphere =
= 14.696 lb. per sq. in. = 2116.3 lb. per sq. ft.
= 33.96 ft. of water = 407.52 in. water
= 29.92 in. of mercury = 760 mm. mercury
= 234.54 oz. per sq. in. = 10.340 mm. water

1 in. water =
= 0.0361 lb. per sq. in. = 5.196 lb. per sq. ft.
= 0.0735 in. mercury = 1.876 mm. mercury
= 0.002456 atmospheres = 0.5774 oz. per sq. in.
= 25.4 mm. of water = 0.08333 ft. of water

1 in. mercury =
= 0.491 lb. per sq. in. = 70.70 lb. per sq. ft.
= 25.4 mm. mercury = 7.86 oz. per sq. in.
= 0.03342 atmospheres = 345.6 mm. water
= 13.61 in. water = 1.134 ft. water

1 mm. mercury =
= 0.01934 lb. per sq. in. = 2.789 lb. per sq. ft.
= 0.3094 oz. per sq. in. = 0.001316 atmospheres
= 0.5357 in. water = 0.04464 ft. water
= 13.61 mm. water = 0.03937 in. mercury

1 lb. per sq. in. =
= 144 lb. per sq. ft. = 16 oz. per sq. in.
= 51.71 mm. mercury = 2.036 in. mercury
= 0.06804 atmospheres = 703.7 mm. water
= 27.70 in. water = 2.309 ft. water
= 0.06895 megabars (or megadynes) per sq. cm.
= 0.0703 kg. per sq. cm.

1 oz. per sq. in. =
= 0.0625 lb. per sq. in. = 9.00 lb. per sq. ft.
= 1.733 in. water = 0.1441 ft. water
= 0.1272 in. mercury = 3.23 mm. mercury
= 0.00425 atmospheres = 44.02 mm. water

1 in. of water resistance lowers wt. per cu. ft. of air by 1/4 or 1%
1 in. of mercury represents 900 ft. difference in elevation at sea level to 4,000 ft.
1 in. of mercury represents 1,000 ft. difference in elevation at 4,000 to 6,000 ft. elevation
1 in. of water represents 66 ft. difference in elevation at sea level to 4,000 ft.
1 in. of water represents 74 ft. difference in elevation at 4,000 to 6,000 ft. elevation
1,000 ft. difference in elevation at seal level represents 1.11 in. of mercury
1,000 ft. difference in elevation at 4,000 ft. represents 1 in. of mercury
1,000 ft. difference in elevation at sea level represents 15.2 in. water
1,000 ft. difference in elevation at 4,000 ft. represents 13.6 in. water
1 gm. per sq. cm. = 0.394 in. water = 0.02896 in. mercury

Weights and measures

Troy Weight

24 grains	1 pwt.
20 pwt.	1 ounce
12 ounces	1 pound

Used for weighing gold, silver and jewels

Cloth Measure

21/8 inches	1 nail
4 nails	1 quarter
4 quarters	1 yard

Cubic Measure

1,728 cubic inches	1 cubic foot
27 cubic feet	1 cubic yard
128 cubic feet	1 cord (wood)
40 cubic feet	1 ton (shipping)
2,150.42 cubic inches	1 standard bu.
231 cubic inches	1 U.S. standard gal.
1 cubic foot	about 4/5 of a bushel

Dry Measure

2 pints	1 quart
8 quarts	1 peck
4 pecks	1 bushel
36 bushels	1 chaldron

Mariners' Measure

6 feet	1 fathom
120 fathoms	1 cable length
71/2 cable lengths	1 mile
5,280 feet	1 statute mile
6,080.2 feet	1 nautical mile

Surveyors' Measure

7.92 inches	1 link
25 links	1 rod
4 rods	1 chain
10 sq. chains or 160 sq. rods	1 acre
640 acres	1 sq. mile
36 sq. miles (6 miles sq.)	1 township

Time Measure

60 seconds	1 minute	
60 minutes	1 hour	
24 hours	1 day	
7 days	1 week	
28, 29, 30 or 31 days	1 cal. month	
30 days	1 month	in comp. interest
365 days	1 year	366 days lp. yr.

Miscellaneous

3 inches	1 palm
4 inches	1 hand
6 inches	1 span
18 inches	1 cubit
21.8 inches	1 Bible cubit
2-1/2 feet	1 military pace

Measure of Volume

1 cubic centimeter	.061 cu. inch foot
1 cubic inch	16.39 cubic cent.
1 cubic decimeter	0.0353 cubic foot
1 cubic foot	28.317 cubic dec.
1 cubic meter	1.308 cubic yards
1 cubic yard	0.7646 cubic meter
1 stere	0.2759 cord
1 cord	3.624 steres
1 liter	0.908 qt. dry 1.0567 qt. liq.
1 quart dry	1.101 liters
1 quart liquid	0.9463 liter
1 dekaliter	0.3785 dekaliter
1 peck	0.881 dekaliter
1 hektoliter	2.8375 bushels
1 bushel	0.3524 hektoliter

Approximate Metric Equivalents

1 decimeter	4 inches
1 liter	1.06 quarts liquid, 0.9 qt. dry
1 meter	1.1 yards
1 kilometer	5/8 of a mile
1 hektoliter	2-5/8 bushels
1 hectare	2-1/2 acres
1 kilogram	2-1/5 pounds
1 stere or, cubic meter	1/4 of a cord
1 metric ton	2,204.6 pounds

Temperatures

	Fahrenheit
Milk	Freezes 30° above Zero
Water	Freezes 32° above Zero
Olive Oil	Freezes 36° above Zero
Wines	Freeze 20° above Zero
Vinegar	Freezes 28° above Zero
Alcohol	Boils at 173° above Zero
Water	Boils at 212° above Zero
Eggs Hatch	104° above Zero
Petrol. (av.)	Boils at 360° above Zero
Blood Heat	98.4° above Zero

Linear measure

1 foot = 12 inches
1 yard = 3 feet
1 rod = 5-1/2 yards
1 furlong = 40 rods
1 stat mile = 8 furlongs
1 stat mile = 5,280 feet
1 naut mile = 6,080 ft.
1 league = 3 miles

Circular measure

1 minute = 60 seconds
1 deg. = 60 minutes
1 circle = 4 quadrants = 2 πradians or 360 deg.
1 radian = 57.296 deg.
1 quadrant = 90 deg.

Square measure

144 sq. in. = 1 sq. ft.
9 sq. ft. = 1 sq. yd.
30-1/4 sq. yd. = 1 sq. rod
160 sq. rods = 1 acre
43,560 sq. ft. = 1 acre
640 acres = 1 sq. mile

Liquid measure

1 pint = 4 gills
1 quart = 2 pints
1 gallon = 4 quarts
1 barrel = 31-1/2 gallons
1 hogshead = 2 barrels
1 Imp. gal. = 1.2 gal (U.S.)

Volume

1 cu. foot = 7.48 gallons
1 gallon = 231 cu. inches
1 gal./hr. = 2.135 oz./min.

Avoirdupois weight

1 dram = 27.3437 grains
1 ounce = 16 drams
1 pound = 16 ounces
1 quarter = 25 pounds
1 hundredweight = 4 quarters
1 short ton = 2,000 pounds
1 long ton = 2,240 pounds
1 pound = 7,000 grains

Hat and energy units

1 ton (refrig.) = 200 Btu/min.

Apothecaries' weight

1 scruple = 20 grains
1 dram = 3 scruples
1 ounce = 8 drams
1 pound = 12 ounces

Grain = 0.0648 9.
Oz. = 28.3495 9.
Lb. = 0.4536 kg.
Ton (sht.) = 907.1848 kg.
Ton (sht.) = 0.9072 ton (met.)
Ton (lg.) = 1.0160 ton (met.)
Mineral lubricating oil has specific gravity of 0.88 to 0.94

Pressure

1 kg. per sq. cm. = 14.223 lb. per sq. in.
1 lb. per sq. in. = 0.0703 kg. per sq. cm.
1 kg. per sq. m. = 0.2048 lb. per sq. ft.
1 lb. per sq. ft. = 4.8824 kg. per sq. m.
1 kg. per sq. cm. = 0.9678 normal atmosphere

Heat and Energy units

1 kw.-hr. =
- 1,000 w/hr.
- 1.3410 h.p.-hr.
- 2,655,217 ft.-lb.
- 3,600,000 joules
- 3,413 Btu.
- 860 kg.-cal.
- 367,098 kg.-m.
- 0.235 lb. carbon oxidized with perfect efficiency
- 3,518 lb. water evap. from and at 212°F.
- 22.76 lb. of water raised from 62 to 212°F.

Heat and Energy units (cont'd)

1 h.p. – hr.	0.7457 kw.-hr. 1,980,000 ft.-lb. 2,545 Btu. 273,745 kg.-m. 0.1849 lb. carbon oxidized with perfect efficiency 2.622 lb. water evap. from and at 212°F.
1 lb. carbon oxidized with perfect efficiency	14,520 Btu 1.1085 lb. anthracite oxidized (varies) 2.315 lb. dry wood oxidized (varies) 26.4 cu. ft. manufactured gas (varies) 12.9 cu. ft. natural gas (varies) 14.255 kw.-hr. 5.709 h.p.-hr. 11,300,000 ft.-lb. 14.97 lb. of water evap. from and at 212°F.
1 lb. water evaporated from and at 212°F.	0.2844 kw.-hr. 0.3814 h.p.-hr. 970.2 Btu 104,400 kg.-m. 1,023,500 joules 756,500 ft.-lb. 0.0668 lb. of carbon oxidized with perfect efficiency

1 kg.-cal. = 3.9685 Btu
1 Btu = 0.2520 kg.-cal.
1 kg.-cal. per kilogram = 1.8000 Btu per lb.
1 Btu per pound = 0.5555 kg.-cal. per kg.
1 kg.-cal. per liter = 112.37 Btu per cu. ft.
1 Btu per cu. ft. = 0.0089 kg.-cal. per lb.
1 kg.-cal. per cu. m. = 0.1124 Btu per cu. ft.
1 Btu per cu. ft. = 8.8987 kg.-cal. per cu. m.

Atmospheres – atm (Standard at sea-level pressure)

x 101.325	= Kilopascals (kPa) absolute
x 14.696	= Pounds-force per square inch absolute (psia)
x 76.00	= Centimeters of mercury (cmHg) at 0°C
x 29.92	= Inches of mercury (inHg) at 0°C
x 33.96	= Feet of water (ftH_2O) at 68°F
x 1.01325	= Bars (bar) absolute
x 1.0332	= Kilograms force per square centimeter (kg/cm^2) absolute
x 1.0581	= Tons force per square foot ($tonf/ft^2$) absolute
x 760	= Torr (torr) (= mmHg at 0°C)

Barrels, Liquid, U.S. – bbl

x 0.11924	= Cubic meters (m^3)
x 31.5	= U.S. gallons (U.S. gal) liquid

Barrels, Petroleum – bbl

x 0.15899	= Cubic meters (m^3)
x 42	= U.S. gallons (U.S. gal) oil

Bars – bar

x 100	= Kilopascals (kPa)
x 14.504	= Pounds-force per square inch (psi)
x 33.52	= Feet of water (ftH_2O) at 68°F
x 29.53	= Inches of mercury (inHg) at 0°C
x 1.0197	= Kilograms-force per square centimeter (kg/cm^2)
x 0.98692	= Atmospheres (atm) sea-level standard
x 1.0443	= Tons-force per square foot ($tonf/ft^2$)
x 750.06	= Torr (torr) (= mmHg at 0°C)

British Thermal Units – Btu (See note)

x 1055	= Joules (J)
x 778	= Foot-pounds-force (ft • lbf)
x 0.252	= Kilocalories (kcal)
x 107.6	= Kilogram-force-meters (kgf • m)
x 2.93×10^{-4}	= Kilowatt-hours (kW • h)
x 3.93×10^{-4}	= Horsepower-hours (hp • h)

British Thermal Units per Minute – Btu/min (See note)

x 17.58	= Watts (W)
x 12.97	= Foot-pounds-force per second (ft • lbf/s)
x 0.02358	= Horsepower (hp)

Centares

x 1	= Square meters (m^2)

Centimeters – cm

x 0.3937	= Inches (in)

Centimeters of Mercury – cm/Hg at 0°C

x 1.3332	= Kilopascals (kPa)
x 0.013332	= Bars (bar)
x 0.4468	= Feet of water (ftH_2O) at 68°F
x 5.362	= Inches of water (inH_2O) at 68°F
x 0.013595	= Kilograms force per square centimeter (kg/cm^2)
x 27.85	= Pounds-force per square foot (lbf/ft^2)
x 0.19337	= Pounds-force per square inch (psi)
x 0.013158	= Atmospheres (atm) standard
x 10	= Torr (torr) (= mmHg at 0°C)

Centimeters per Second – cm/s

x 1.9685	= Feet per minute (ft/min)
x 0.03281	= Feet per second (ft/s)
x 0.03600	= Kilometers per hour (km/h)
x 0.6000	= Meters per minute (m/min)
x 0.02237	= Miles per hour (mph)

Cubic Centimeters – cm^3

x 3.5315×10^{-5}	= Cubic feet (ft^3)
x 6.1024×10^{-2}	= Cubic inches (in^3)
x 1.308×10^{-6}	= Cubic yards (yd^3)
x 2.642×10^{-4}	= U.S. gallons (U.S. gal)
x 2.200×10^{-4}	= Imperial gallons (imp gal)
x 1000×10^{-3}	= Liters (l)

Cubic Feet - ft^3

x 0.02832	= Cubic meters (m^3)
x 2.832×10^4	= Cubic centimeters (cm^3)
x 1728	= Cubic inches (in^3)
x 0.03704	= Cubic yards (yd^3)
x 7.481	= U.S. gallons (U.S. gal)
x 6.229	= Imperial gallons (imp gal)
x 28.32	= Liters (l)

Cubic Feet per Minute – cfm

x 472.0	= Cubic centimeters per second (cm^3/s)
x 1.699	= Cubic meters per hour (m^3/h)
x 0.4720	= Liters per second (l/s)
x 0.1247	= U.S. gallons per second (U.S. gps)
x 62.30	= Pounds of water per minute (lbH_2O/min) at 68°F

Cubic Feet per Second – cfs

x 0.02832	= Cubic meters per second (m^3/s)
x 1.699	= Cubic meters per minute (m^3/min)
x 448.8	= U.S. gallons per minute (U.S. gpm)
x 0.6463	= Million U.S. gallons per day (U.S. gpd)

Cubic Inches - In^3

x 1.6387×10^{-5}	= Cubic meters (m^3)
x 16.387	= Cubic centimeters (cm^3)
x 0.016387	= Liters (l)
x 5.787×10^{-4}	= Cubic feet (ft^3)
x 2.143×10^{-5}	= Cubic yards (yd^3)
x 4.329×10^{-3}	= U.S. gallons (U.S. gal)
x 3.605×10^{-3}	= Imperial gallons (imp gal)

Cubic Meters - m^3

x 1000	= Liters (l)
x 35.315	= Cubic feet (ft^3)
x 61.024×10^3	= Cubic inches (in^3)
x 1.3080	= Cubic yards (yd^3)
x 264.2	= U.S. gallons (U.S. gal)
x 220.0	= Imperial gallons (imp gal)

Cubic Meters per Hour - m^3/h

x 0.2778	= Liters per second (l/s)
x 2.778×10^{-4}	= Cubic meters per second (m^3/s)
x 4.403	= U.S. gallons per minute (U.S. gpm)

Cubic Meters per Second – (m^3/s)

x 3600	= Cubic meters per hour (m^3/h)
x 15.85×10^3	= U.S. gallons per minute (U.S. gpm)

Cubic Yards - yd^3

x 0.7646	= Cubic meters (m^3)
x 764.6	= Liters (l)
x 7.646×10^5	= Cubic centimeters (cm^3)
x 27	= Cubic feet (ft^3)
x 46,656	= Cubic inches (in^3)
x 201.97	= U.S. gallons (U.S. gal)
x 168.17	= Imperial gallons (imp gal)

Degrees Angular (°)

x 0.017453	= Radians (rad)
x 60	= Minutes (')
x 3600	= Seconds (")
x 1.111	= Grade (gon)

Degrees per Second, Angular (°/s)

x 0.017453	= Radians per second (rad/s)
x 0.16667	= Revolutions per minute (r/min)
x 2.7778×10^{-3}	= Revolutions per second (r/s)

Drams (dr)

x 1.7718	= Grams (g)
x 27.344	= Grains (gr)
x 0.0625	= Ounces (oz)

Fathoms

x 1.8288	= Meters (m)
x 6	= Feet (ft)

Feet – ft

x 0.3048	= Meters (m)
x 30.480	= Centimeters (cm)
x 12	= Inches (in)
x 0.3333	= Yards (yd)

Feet of Water – ftH_2O, at 68°F

x 2.984	= Kilopascals (kPa)
x 0.02984	= Bars (bar)
x 0.8811	= Inches of mercury (inHg) at 0°C
x 0.03042	= Kilograms-force per square centimeter (kg/cm²)
x 62.32	= Pounds-force per square foot (lbf/ft²)
x 0.4328	= Pounds-force per square inch (psi)
x 0.02945	= Standard atmospheres

Feet per Minute – ft/min

x 0.5080	= Centimeters per second (cm/s)
x 0.01829	= Kilometers per hour (km/h)
x 0.0051	= Meters per second (mps)
x 0.3048	= Meters per minute (m/min)
x 0.016667	= Feet per second (ft/s)
x 0.01136	= Miles per hour (mph)

Feet per Second per Second – ft/s²

x 0.3048	= Meters per second per second (m/s²)
x 30.48	= Centimeters per second per second (cm/s²)

Foot-Pounds-Force – ft • lbf

x 1.356	= Joules (J)
x 1.285×10^{-3}	= British thermal units (Btu) (see note)
x 3.239×10^{-4}	= Kilocalories (kcal)
x 0.13825	= Kilogram-force-meters (kgf • m)
x 5.050×10^{-7}	= Horsepower-hours (hp • h)
x 3.766×10^{-7}	= Kilowatt-hours (kW • h)

Gallons U.S. – U.S. gal

x 3785.4	= Cubic centimeters (cm^3)
x 3.7854	= Liters (l)
x 3.7854×10^{-3}	= Cubic meters (m^3)
x 231	= Cubic inches (in^3)
x 0.13366	= Cubic feet (ft^3)
x 4.951×10^{-3}	= Cubic yards (yd^3)
x 8	= Pints (pt) liquid
x 4	= Quarts (qt) liquid
x 0.8327	= Imperial gallons (imp gal)
x 8.328	= Pounds of water at 60°F in air
x 8.337	= Pounds of water at 60°F in vacuo

Gallons, Imperial – imp gal

x 4546	= Cubic centimeters (cm^3)
x 4.546	= Liters (l)
x 4.546×10^{-3}	= Cubic meters (m^3)
x 0.16054	= Cubic feet (ft^3)
x 5.946×10^{-3}	= Cubic yards (yd^3)
x 1.20094	= U.S. gallons (U.S. gal)
x 10.000	= Pounds of water at 62°F in air

Gallons, per Minute, U.S. – U.S. gpm

x 0.22715	= Cubic meters per hour (m^3/h)
x 0.06309	= Liters per second (l/s)
x 8.021	= Cubic feet per hour (cfh)
x 2.228×10^{-3}	= Cubic feet per second (cfs)

Grains – gr av. or troy

x 0.0648	= Grams (g)

Grains per Cubic Foot

x 2288.1	= milligrams per cubic meter (mg/m^3)

Grains per U.S. Gallon – gr/U.S. gal at 60°F

x 17.12	= Grams per cubic meter (g/m^3)
x 17.15	= Parts per million by weight in water
x 142.9	= Pounds per million gallons

Grains per Imperial Gallon – gr/imp gal at 62°F

x 14.25	= Grams per cubic meter (g/m^3)
x 14.29	= Parts per million by weight in water

Grams – g

x 15.432	= Grains (gr)
x 0.035274	= Ounces (oz) av.
x 0.032151	= Ounces (oz) troy
x 2.2046 x 10.3	= Pounds (lb)

Grams-Force – gf

x 9.807×10^{-3}	= Newtons (N)

Grams – Force per Centimeter – gf/cm

x 98.07	= Newtons per meter (N/m)
x 5.600×10^{-3}	= Pounds-force per inch (lbf/in)

Grams per Cubic Centimeter – g/cm^3

x 62.43	= Pounds per cubic foot (lb/ft³)
x 0.03613	= Pounds per cubic inch (lb/in³)

Grams per Liter – g/l

x 58.42	= Grains per U.S. gallon (gr/U.S. gal)
x 8.345	= Pounds per 1000 U.S. gallons
x 0.06243	= Pounds per cubic foot (lb/ft³)
x 1002	= Parts per million by mass

Hectares – ha

x 1.000×10^4	= Square meters (m²)
x 1.0764×10^5	= Square feet (ft²)

Horsepower – hp

x 745.7	= Watts (W)
x 0.7457	= Kilowatts (kW)
x 33,000	= Foot-pounds-force per minute (ft • lbf/min)
x 550	= Foot-pounds-force per second (ft • lbf/s)
x 42.43	= British thermal units per minute (Btu/min) (see note)
x 10.69	= Kilocalories per minute (kcal/min)
x 1.0139	= Horsepower (metric)

Horsepower – hp boiler

x 33,480	= British thermal units per hour (Btu/h) (see note)
x 9.809	= Kilowatts (kW)

Horsepower-Hours – hp • h

x 0.7457	= Kilowatt-hours (kW • h)
x 1.976×10^6	= Foot-pounds-force (ft • lbf)
x 2545	= British thermal units (Btu) (see note)
x 641.5	= Kilocalories (kcal)
x 2.732×10^5	= Kilogram-force-meters (kgf • m)

Inches – in

x 2.540	= Centimeters (cm)

Inches of Mercury – inHg at 0°C

x 3.3864	= Kilopascals (kPa)
x 0.03386	= Bars (bar)
x 1.135	= Feet of water (ftH_2O) at 68°F
x 13.62	= Inches of water (inH_2O) at 68°F
x 0.03453	= Kilograms-force per square centimeter (kg/cm^2)
x 70.73	= Pounds-force per square foot (lbf/ft^2)
x 0.4912	= Pounds-force per square inch (psi)
x 0.03342	= Standard atmospheres

Inches of Water – in H_2O at 68°F

x 0.2487	= Kilopascals (kPa)
x 2.487×10^{-3}	= Bars (bar)
x 0.07342	= Inches of mercury (inHg) at 0°C
x 2.535×10^{-3}	= Kilograms-force per square centimeter (kg/cm^2)
x 0.5770	= Ounces-force per square inch (ozf/in^2)
x 5.193	= Pounds-force per square foot (lbf/ft^2)
x 0.03606	= Pounds-force per square inch (psi)
x 2.454×10^{-3}	= Standard atmospheres

Joules – J

x 0.9484×10^{-3}	= British thermal units (Btu) (see note)
x 0.2390	= Calories (cal) thermochemical
x 0.7376	= Foot-pounds-force (ft • lbf)
x 2.778×10^{-4}	= Watt-hours (W • h)

Kilograms – kg

x 2.2046	= Pounds (lb)
x 1.102×10^{-3}	= Tons (ton) short

Kilograms-force – kgf

x 9.807	= Newtons (N)
x 2.205	= Pounds-force (lbf)

Kilograms-Force per Meter – kgf/m

x 9.807	= Newtons per meter (N/m)
x 0.6721	= Pounds-force per foot (lbf/ft)

Kilograms-Force per Square Centimeter – kg/cm^2

x 98.07	= Kilopascals (kPa)
x 0.9807	= Bars (bar)
x 32.87	= Feet of water (ftH_2O) at 68°F
x 28.96	= Inches of mercury (inHg) at 0°C
x 2048	= Pounds-force per square foot (lb/ft^2)
x 14.223	= Pounds-force per square inch (psi)
x 0.9678	= Standard atmospheres

Kilograms-Force per Square Millimeter – kgf/mm^2

x 9.807	= Megapascals (MPa)
x 1.000×10^{6}	= Kilograms-force per square meter (kgf/m^2)

Kilometers per Hour – km/h

x 27.78	= Centimeters per second (cm/s)
x 0.9113	= Feet per second (ft/s)
x 54.68	= Feet per minute (ft/min)
x 16.667	= Meters per minute (m/min)
x 0.53996	= International knots (kn)
x 0.6214	= Miles per hour (mph)

Kilometers per Hour per Second – km • h^{-1} • s^{-1}

x 0.2778	= Meters per second per second (m/s^2)
x 27.78	= Centimeters per second per second (cm/s^2)
x 0.9113	= Feet per second per second (ft/s^2)

Kilometers per Second – km/s

x 37.28	= Miles per minute (mi/min)

Kilopascals – kPa

x 103	= pascals (Pa) or newtons per square meter (N/m^2)
x 0.1450	= Pounds-force per square inch
x 0.010197	= Kilograms-force per square centimeter (kg/cm^2)
x 0.2953	= Inches of mercury (inHg) at 32°F
x 0.3351	= Feet of water (ftH_2O) at 68°F
x 4.021	= Inches of water (inH_2O) at 68°F

Kilowatts – kW

x 4.425×10^4	= Foot-pounds-force per minute (ft • lbf/min)
x 737.6	= Foot-pounds-force per second (ft • lbf/s)
x 56.90	= British thermal units per minute (Btu/min) (see note)
x 14.33	= Kilocalories per minute (kcal/min)
x 1.3410	= Horsepower (hp)

Kilowatt-Hours – kW • h

x 3.6×10^6	= Joules (J)
x 2.655×10^6	= Foot-pounds-force (ft • lbf)
x 3413	= British thermal units (Btu) (see note)
x 860	= Kilocalories (kcal)
x 3.671×10^5	= Kilogram-force meters (kgf • m)
x 1.3410	= Horsepower-hours (hp • h)

Knots – kn (International)

x 0.5144	= Meters per second (m/s)
x 1.151	= Miles per hour (mph)

Liters – l

x 1000	= Cubic centimeters (cm^3)
x 0.035315	= Cubic feet (ft^3)
x 61.024	= Cubic inches (in^3)
x 1.308×10^{-3}	= Cubic yards (yd^3)
x 0.2642	= U.S. gallons (U.S. gal)
x 0.2200	= Imperial gallons (imp gal)

Liters per Minute – l/min

x 0.01667	= Limits per second (l/s)
x 5.885×10^{-4}	= Cubic feet per second (cfs)
x 4.403×10^{-3}	= U.S. gallons per second (U.S. gal/s)
x 3.666×10^{-3}	= Imperial gallons per second (imp gal/s)

Liters per Second – l/s

x 10^{-3}	= Cubic meters per second (m^3/s)
x 3.600	= Cubic meters per hour (m^3/h)
x 60	= Liters per minute (l/min)
x 15.85	= U.S. gallons per minute (U.S. gpm)
x 13.20	= Imperial gallons per minute (imp gpm)

Megapascals – Mpa

x 10^6	= Pascals (Pa) or newtons per square meter (N/m^2)
x 10^3	= Kilopascals (kPa)
x 145.0	= Pounds-force per square inch (psi)
x 0.1020	= Kilograms-force per square millimeter (kgf/mm^2)

Meters – m

x 3.281	= Feet (ft)
x 39.37	= Inches (in)
x 1.0936	= Yards (yd)

Meters per Minute – m/min

x 1.6667	= Centimeters per second (cm/s)
x 0.0600	= Kilometers per hour (km/h)
x 3.281	= Feet per minute (ft/min)
x 0.05468	= Feet per second (ft/s)
x 0.03728	= Miles per hour (mph)

Meters per Second – m/s

x 3.600	= Kilometers per hour (km/h)
x 0.0600	= Kilometers per minute (km/min)
x 196.8	= Feet per minute (ft/min)
x 3.281	= Feet per second (ft/s)
x 2.237	= Miles per hour (mph)
x 0.03728	= Miles per minute (mi/min)

Micrometers - µm (micron)

x 0.000001	= Meters (m)

Miles – mi

x 1.6093×10^3	= Meters (m)
x 1.6093	= Kilometers (km)
x 5280	= Feet (ft)
x 1760	= Yards (yd)

Miles per Hour – mph

x 44.70	= Centimeters per second (cm/s)
x 1.6093	= Kilometers per hour (km/h)
x 26.82	= Meters per minute (m/min)
x 88	= Feet per minute (R/min)
x 1.4667	= Feet per second (ft/s)
x 0.8690	= International knots (kn)

Miles per Minute – mi/min

x 1.6093	= Kilometers per minute (km/min)
x 2682	= Centimeters per second (cm/s)
x 88	= Feet per second (ft/s)
x 60	= Miles per hour (mph)

Minutes, Angular – (')

x 2.909×10^{-4}	= Radians (rad)

Newtons – N

x 0.10197	= Kilograms-force (kgf)
x 0.2248	= Pounds-force (lbf)
x 7.233	= Poundals
x 10^5	= Dynes

Ounces – oz av.

x 28.35	= Grams (g)
x 2.835×10^{-5}	= Tonnes (t) metric ton
x 16	= Drams (dr) av.
x 437.5	= Grains (gr)
x 0.06250	= Pounds (lb) av.
x 0.9115	= Ounces (oz) troy
x 2.790×10^{-5}	= Tons (ton) long

Ounces – oz troy

x 31.103	= Grams (g)
x 480	= Grains (gr)
x 20	= Pennyweights (dwt) troy
x 0.08333	= Pounds (lb) troy
x 0.06857	= Pounds (lb) av.
x 1.0971	= Ounces (oz) av.

Ounces – oz U.S. fluid

x 0.02957	= Liters (l)
x 1.8046	= Cubic inches (in)

Ounces-Force per Square Inch – ozf/in²

x 43.1	= Pascals (Pa)
x 0.06250	= Pounds-force per square inch (psi)
x 4.395	= Grams-force per square centimeter (gf/cm²)

Parts per Million by Mass – mass (weight) in water

x 0.9991	= Grams per cubic meter (g/m^3) at 15°C
x 0.0583	= Grains per U.S. gallon (gr/U.S. gal) at 60°F
x 0.0700	= Grains per imperial gallon (gr/imp gal) at 62°F
x 8.328	= Pounds per million U.S. gallons at 60°F

Pascals – Pa

x 1	= Newtons per square mater (N/m^2)
x 1.450×10^{-4}	= Pounds-force per square inch (psi)
x 1.0197×10^{-5}	= Kilograms-force per square centimeter (kg/cm^2)
x 10^{-3}	= Kilopascals (kPa)

Pennyweights – dwt troy

x 1.5552	= Grams (g)
x 24	= Grains (gr)

Poises – P

x 0.1000	= Newton-seconds per square meter ($N \cdot s/m^2$)
x 100	= Centipoises (cP)
x 2.0886×10^{-3}	= Pound-force-seconds per square foot ($lbf \cdot s/ft^2$)
x 0.06721	= Pounds per foot second ($lb/ft \cdot s$)

Pounds-Force – lbf av.

x 4.448	= Newtons (N)
x 0.4536	= Kilograms-force (kgf)

Pounds – lb. av.

x 453.6	= Grams (g)
x 16	= Ounces (oz) av.
x 256	= Drams (dr) av.
x 7000	= Grains (fr)
x 5×10^{-4}	= Tons (ton) short
x 1.2153	= Pounds (lb) troy

Pounds per Cubic Foot

x 7000	= Grams/cubic ft.
x 1.6×10^{7}	= Mg/cubic meter

Pounds – lb troy

x 373.2	= Grams (g)
x 12	= Ounces (oz) troy
x 240	= Pennyweights (dwt) troy
x 5760	= Grains (gr)
x 0.8229	= Pounds (lb) av.
x 13.166	= Ounces (oz) av.
x 3.6735×10^{-4}	= Tons (ton) long
x 4.1143×10^{-4}	= Tons (ton) short
x 3.7324×10^{-4}	= Tonnes (t) metric tons

Pounds-Mass of Water at 60°F

x 453.98	= Cubic centimeters (cm^3)
x 0.45398	= Liters (l)
x 0.01603	=Cubic feet (ft^3)
x 27.70	= Cubic inches (in^3)
x 0.1199	= U.S. gallons (U.S. gal)

Pounds of Water per Minute at 60°F

x 7.576	= Cubic centimeters per second (cm^3/s)
x 2.675×10^{-4}	= Cubic feet per second (cfs)

Pounds per Cubic Foot – lb/ft^3

x 16.018	= Kilograms per cubic meter (kg/m^3)
x 0.016018	= Grams per cubic centimeter (g/cm^3)
x 5.787×10^{-4}	= Pounds per cubic inch (lb/in^3)

Pounds per Cubic Inch – lb/in^3

x 2.768×10^{4}	= Kilograms per cubic meter (kg/m^3)
x 27.68	= Grams per cubic centimeter (g/cm^3)
x 1728	= Pounds per cubic foot (lb/ft^3)

Pounds-Force per Foot – lbt/fl

x 14.59	= Newtons per meter (N/m)
x 1.488	= Kilograms-force per meter (kgf/m)
x 14.88	= Grams-force per centimeter (gf/cm)

Pounds-Force per Square Foot – lbf/ft^2

x 47.88	= Pascals (Pa)
x 0.01605	= Feet of water (ftH_2O) at 68°F
x 4.882×10^{-4}	= Kilograms-force per square centimeter (kg/cm^2)
x 6.944×10^{-3}	= Pounds-force per square inch (psi)

Pounds-Force per Square Inch – psi

x 6.895	= Kilopascals (kPa)
x 0.06805	= Standard atmospheres
x 2.311	= Feet of water (ftH_2O) at 68°F
x 27.73	= Inches of water (inH_2O) at 68°F
x 2.036	= Inches of mercury (inHg) at 0°C
x 0.07031	= Kilograms-force per square centimeter (kg/cm^2)

Quarts – qt dry

x 1101	= Cubic centimeters (cm^3)
x 67.20	= Cubic inches (in^3)

Quarts – qt liquid

x 946.4	= Cubic centimeters (cm^3)
x 57.75	= Cubic inches (in^3)

Quintals – obsolete metric mass term

x 100	= Kilograms (kg)
x 220.46	= Pounds (lb) U.S. av.
x 101.28	= Pounds (lb) Argentina
x 129.54	= Pounds (lb) Brazil
x 101.41	= Pounds (lb) Chile
x 101.47	= Pounds (lb) Mexico
x 101.43	= Pounds (lb) Peru

Radians – rad

x 57.30	= Degrees (°) angular

Radians per Second – rad/s

x 57.30	= Degrees per second (°/s) angular

Stokes – St

x 10^{-4}	= Square meters per second (m^2/s)
x 1.076 x 10^{-3}	= Square feet per second (ft^2/s)

Tons-Mass – tonm long

x 1016	= Kilograms (kg)
x 2240	= Pounds (lb) av.
x 1.1200	= Tons (ton) short

Tonnes – t metric ton, millier

x 1000	= Kilograms (kg)
x 2204.6	= Pounds (lb)

Tonnes-Force – tf metric ton-force

x 980.7	= Newtons (N)

Tons – ton short

x 907.2	= Kilograms (kg)
x 0.9072	= Tonnes (t)
x 2000	= Pounds (lb) av.
x 32000	= Ounces (oz) av.
x 2430.6	= Pounds (lb) troy
x 0.8929	= Tons (ton) long

Tons of Water per 24 Hours at 60°F

x 0.03789	= Cubic meters per hour (m^3/h)
x 83.33	= Pounds of water per hour (lb/h H_2O) at 60°F
x 0.1668	= U.S. gallons per minute (U.S. gpm)
x 1.338	= Cubic feet per hour (cfh)

Watts - W

x 0.05690	= British thermal units per minute (Btu/min) (see note)
x 44.25	= Foot-pounds-force per minute (ft – lbf/min)
x 0.7376	= Foot-pounds-force per second (ft – lbf//s)
x 1.341×10^{-3}	= Horsepower (hp)
x 0.01433	= Kilocalories per minute (kcal/min)

Watt-Hours – W • h

x 3600	= Joules (J)
x 3.413	= British thermal units (Btu) (see note)
x 2655	= Foot-pounds-force (ft • lbf)
x 1.341×10^{-3}	= Horsepower-hours (hp • h)
x 0.860	= Kilocalories (kcal)
x 367.1	= Kilograms-force-meters (kgf • m)

NOTE: Significant Figures The precision to which a given conversion factor is know, and its application, determine the number of significant figures which should be used. While many handbooks and standards give factors contained in this table to six or more significant figures, the fact that different sources disagree, in many cases, in the fifth or further indicates that four or five significant figures represent the precision for these factors fairly. At present the accuracy of process instrumentation, analog or digital, is in the tenth percent region at best, thus needing only three significant figures. Hence this table is confined to four or five significant figures. The advent of the pocket calculator (and the use of digital computers in process instrumentation) tends to lead to use of many figures as the calculator will handle. However, when this exceeds the precision of the data, or the accuracy of the application, such a practice is misleading and timewasting.

Temperature Conversions

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
10000	18032	430	806	200	392.0	77	170.6	34	93.2	-9	15.8
9500	17132	420	788	195	383.0	76	168.8	33	91.4	-10	14.0
9000	16232	410	770	190	374.0	75	167.0	32	89.6	-11	12.2
8500	15332	400	752	185	365.0	74	165.2	31	87.8	-12	10.4
8000	14432	395	743	180	356.0	73	163.4	30	86.0	-13	8.6
7500	13532	390	734	175	347.0	72	161.6	29	84.2	-14	6.8
7000	12632	385	725	170	338.0	71	159.8	28	82.4	-15	5.0
6500	11732	380	716	165	329.0	70	158.0	27	80.6	-16	3.2
6000	10832	375	707	160	320.0	69	156.2	26	78.8	-17	1.4
5500	9932	370	698	155	311.0	68	154.4	25	77.0	-18	-0.4
5000	9032	365	689	150	302.0	67	152.6	24	75.2	-19	-2.2
4500	8132	360	680	145	293.0	66	150.8	23	73.4	-20	-4.0
4000	7232	355	671	140	284.0	65	149.0	22	71.6	-21	-5.8
3500	6332	350	662	135	275.0	64	147.2	21	69.8	-22	-7.6
3000	5432	345	653	130	266.0	63	145.4	20	68.0	-23	-9.4
2500	4532	340	644	125	257.0	62	143.6	19	66.2	-24	-11.2
2000	3632	335	635	120	248.0	61	141.8	18	64.4	-25	-13.0
1500	2732	330	626	115	239.0	60	140.0	17	62.6	-26	-14.8
1000	1832	325	617	110	230.0	59	138.2	16	60.8	-27	-16.6
950	1742	320	608	105	221.0	58	136.4	15	59.0	-28	-18.4
900	1652	315	599	100	212.0	57	134.6	14	57.2	-29	-20.2
850	1562	310	590	99	210.2	56	132.8	13	55.4	-30	-22.0
800	1472	305	581	98	208.4	55	131.0	12	53.6	-31	-23.8
750	1382	300	572	97	206.6	54	129.2	11	51.8	-32	-25.6
700	1292	295	563	96	204.8	53	127.4	10	50.0	-33	-27.4
650	1202	290	554	95	203.0	52	125.6	9	48.2	-34	-29.2
600	1112	285	545	94	201.2	51	123.8	8	46.4	-35	-31.0
590	1094	280	536	93	199.4	50	122.0	7	44.6	-36	-32.8
580	1076	275	527	92	197.6	49	120.2	6	42.8	-37	-34.6
570	1058	270	518	91	195.8	48	118.4	5	41.0	-38	-36.4
560	1040	265	509	90	194.0	47	116.6	4	39.2	-39	-38.2
550	1022	260	500	89	192.2	46	114.8	3	37.4	-40	-40.0
540	1004	255	491	88	190.4	45	113.0	2	35.6	-50	-58.0
530	986	250	482	87	188.6	44	111.2	1	33.8	-60	-76.0
520	968	245	473	86	186.8	43	109.4	0	32.0	-70	-94.0
510	950	240	464	85	185.0	42	107.6	-1	30.2	-80	-112.0
500	932	235	455	84	183.2	41	105.8	-2	28.4	-90	-130.0
490	914	230	446	83	181.4	40	104.0	-3	26.6	-100	-148.0
480	896	225	437	82	179.6	39	102.2	-4	24.8	-125	-193.0
470	878	220	428	81	177.8	38	100.4	-5	23.0	-150	-238.0
460	860	215	419	80	176.0	37	98.6	-6	21.2	-200	-328.0
450	842	210	410	79	174.2	36	96.8	-7	19.4	-250	-418.0
440	824	205	401	78	172.4	35	95.0	-8	17.6	-273	459.4

°C = Degrees Centigrade (Celsius scale). 1 unit is 1/100 of the difference between the temperature of melting ice and boiling water at standard temperature and pressure.

°F = Degrees Fahrenheit. 1 unit is 1/180 of the difference between the temperature of melting ice and boiling water at standard temperature and pressure.

°C = 5/9 (°F-32) °F = 9/5 °C + 32
Absolute Zero = 0°K = -273.16°C = -459.69°F

°K = Degrees Kelvin (Absolute temperature). This scale is based on the average kinetic energy per molecule of a perfect gas and uses the same ske degrees as the Centigrade scale. Zero (0°K) on the scale is the temperature at which a perfect gas has lost all of its energy.