

Technical Profiles

Click on any of the 15 technology categories — representing the core of critical cleaning — for general principles, strengths and limitations, plus compatibility issues and selection considerations.

[Aqueous Cleaning Systems](#)

[Organic Solvent Cleaning Systems](#)

[Semiaqueous and Hybrid Systems](#)

[Ultrasonic Cleaning Systems](#)

[Megasonic Cleaning Systems](#)

[Carbon Dioxide Cleaning](#)

[Manual Cleaning Systems](#)

[Aerosol Cleaning Agents](#)

[Plasma Cleaning](#)

[Laser Cleaning Systems](#)

[UV/Ozone Cleaning](#)

[Drying Systems](#)

[Filtration and Recycling Systems](#)

[Wastewater Treatment Systems](#)

[Cleanliness Verification Techniques](#)

Ultrasonic Cleaning

Bubbling Over

Ultrasonic cleaning is a good fit for a wide range of applications, from removing swarf and grinding and polishing residue to treating parts covered in oil, grease, or layers of paint. Ultrasonics can be used to clean miniature watch parts or to support the overhaul of jumbo jet engines. And from an industry perspective, the fields of electrotechnics, precision mechanics and light engineering, optics, metal processing, and medical equipment have proven particularly receptive to the ultrasonic concept.

So the impact of ultrasonic cleaning is clearly recognizable. But to truly understand the value of ultrasonics, one must understand how ultrasonic cleaners really work.

Ultrasonic Cleaning Explained

The cleansing effect of ultrasound is the product of a phenomenon called cavitation. Billions of minute gas bubbles implode, causing shock waves that undermine dirt and blast it off a part's surface. One of the key advantages of this process is that it allows users to clean part surfaces that are completely inaccessible to a manual cleaning process.

Ultrasound frequencies generally range between 20 kilohertz and 50 kilohertz, depending on application requirements. Ultrasonic cleaning is typically performed at temperatures between 122 C and 176 C.

In an ultrasonic cleaning system, cavitation is produced by introducing sound waves into a cleaning liquid by means of a series of transducers mounted to a cleaning tank. The sound travels throughout the tank and creates waves of compression and expansion in the liquid. In the compression wave, the molecules of the cleaning liquid are compressed together tightly. Conversely, in the expansion wave, the molecules are pulled apart rapidly. The expansion is so dramatic that the molecules are ripped apart, creating microscopic bubbles. The bubbles contain a partial vacuum. As the pressure around the bubbles becomes greater, surrounding fluid rushes in and collapses the bubble. When this occurs, a jet of liquid is created, resulting in temperatures as high as 9,032 F (roughly the temperature of the surface of the sun). The extreme temperature, combined with the liquid jet's velocity, provides a very intense cleaning action. However, because the bubble expansion and collapse cycle is so short, the liquid surrounding the bubble quickly absorbs the heat, preventing the tank and cleaning liquid from becoming overly hot during the cleaning process.

Secrets to Ultrasonic Success

There are seven major concerns related to successful ultrasonic cleaning:

1. Time
2. Temperature
3. Chemistry
4. Part Fixture Design
5. Ultrasonic Output Frequency
6. Watts Per Gallon
7. Loading

Time

Cleaning times can vary tremendously in an ultrasonic process, depending largely on how dirty the part is and how clean is clean. A normal trial period is two to 10 minutes, since very few parts are sufficiently clean in a shorter period of time. Precleaning may be required to remove gross contamination or to chemically prepare the parts for a final clean. Some applications require more than one ultrasonic treatment to complete the required cleaning. Ultrasonic rinsing may also be required in some cases to more thoroughly remove wash chemicals.

Temperature & Chemistry

Temperature and chemistry are closely related. Generally, ultrasonic cleaning in an aqueous solution is optimized at 140 F. Some high pH solutions require higher temperatures. The chemical pH is a good place to start; but a thorough examination of chemistry is beyond the scope of this article.

In brief, the following should be considered the main components of aqueous ultrasonic cleaning chemistry:

- A. Water (hard, soft, DI, or distilled)
- B. pH
- C. Surfactants
 - Wetting agents
 - Dispersants
 - Emulsifiers
 - Saponifiers
- D. Optional Ingredients
 - Sequestrants
 - Inhibitors
 - Buffering agents
 - Defoamers

The chemical formulation must consider all of the above characteristics. Some chemicals designed for spray cleaning — or that include rust inhibitors — are not suitable for ultrasonic cleaning.

Part Fixture Design

The procedure for ultrasonic cleaning is generally as follows: Put parts in basket and place basket through three or four process steps (i.e., ultrasonic wash, spray rinse (optional), immersion rinse, dry). Some parts loaded in baskets can mask or shadow from the radiated surface of the ultrasonic transducers. Most ultrasonic cleaning systems are designed for specific applications. Bottom-mounted transducers or side-mounted transducers are important considerations during the process design stage. Automated systems must specifically address the location of the transducers to ensure cleaning uniformity. Some parts require individual fixturing to separate the part for cleaning or subsequent processes. Some parts require slow rotating or vertical motion during the cleaning to ensure critical cleanliness.

Ultrasonic Output Frequency

The majority of the ultrasonic cleaning that is done in industrial applications today uses 40 kHz as a base frequency. Lower frequencies, such as 20-25 kHz, are used for large masses of metal where ultrasonic erosion is of little consequence. The large mass dampens or absorbs a great amount of the ultrasonic cleaning power.

Watts Per Gallon

In general, smaller parts require higher watts per gallon to achieve the desired level of cleanliness. Most industrial ultrasonic cleaning systems use watt density from 50 to 100 watts per gallon. However, tanks over 50 gallons usually require only about 20 watts per gallon because ultrasonic processes traditionally have shown diminishing returns in large tanks sizes.

Loading

Loading of the parts to be cleaned must be considered when developing an ultrasonic cleaning process. A large dense mass, for example, prevents internal surfaces from being thoroughly cleaned (i.e., metal castings). A rule of thumb is that the load by weight should be less than the weight of half the water volume. So, for example, in five gallons (approximately 40 lbs.) of water, the maximum workload should be less

than 20 lbs. In some cases, it is better to ultrasonically clean two smaller loads rather than one larger load.

Each of the factors outlined here must be considered when specifying an ultrasonic application to ensure a high level of cleaning success. Neglecting any single factor can have a negative impact on the overall cleaning process.

Ultrasonic Cleaning Equipment

Transducer

The heart of every ultrasonic cleaning system is the transducer. The transducer is the device that produces the cavitations that generates the cleaning action.

Portable Systems

Ultrasonic cleaning systems are available in portable models, which offer the convenience of a separate cleaning tank and generator for applications that require a certain amount of mobility.

Immersible Systems

Immersible ultrasonic systems can be used to bring additional ultrasonic power to an existing tank. As such, they can be used to support higher frequencies in a tank that is typically used for lower frequency applications.

Self-Contained Systems

Self-contained ultrasonic cleaners include all of the necessary components and accessories in a single cabinet.

Console Systems

Console systems support batch cleaning, rinsing, and drying in a single cabinet. Typically console systems are designed to minimize the use of space.

Heavy-Duty Systems

Heavy-duty systems are designed for users that need large tank sizes to support heavy workloads, long duty cycles, and/or aggressive chemistry.

Automated Systems

Automated systems are available for applications that require low-volume precision cleaning with minimal handling.

CleanTech Glossary of Terms

1,1,1-trichloroethane (TCA)

Also called methyl chloroform, a chlorinated organic hydrocarbon (an alkane) which is a traditional solvent used in vapor degreasing.

abrasive media

Material used in aggressive cleaning, most commonly sand, aluminum oxide, garnet, and steel.

acid

Aqueous solutions with a pH less than 7 (on scale of 1 to 14). Strongly acidic materials have a pH less than 3.

acid cleaning

The use of acids with surfactants to clean as well as remove metal, rust, or scale. Acids with a pH less than 6 are not functional as degreasers.

acid pickling

Removal of rust and scale from metal using mineral acid.

acoustic streaming

One-dimensional currents which flow through a liquid due to sonic waves, as from a transducer used in ultrasonic cleaning.

activated carbon

Porous carbon network, capable of physically adsorbing organic compounds many times its weight due to an extensive pore structure. Often used as a unit operation in wastewater treatment.

acute toxicity

The short-term toxicity of a product. Can be divided into oral, dermal, and respiratory toxicity.

additive

Chemicals including corrosion inhibitors, defoamers, emulsifying agents, chelating agents, inhibiting agents, water softening agents, and other substances which may be added to a cleaning agent in order to optimize its performance.

adsorption

A contact phenomenon whereby a substance can form a physical (physisorption) or chemical (chemisorption) bond with a surface.

aerosol

A suspension of fine particles of liquid or solid in a gas (air).

aggressive cleaning

Employment of abrasive media, with potential for damage to the substrate.

air knife

Component of conveyORIZED drying process where wet parts pass under a series of laminar air flow nozzles which apply temperature and air movement to carry away vaporized water.

alcohols

A series of oxygenated hydrocarbon derivatives with at least one hydrogen atom replaced by an OH group. The simplest alcohols (methanol, ethanol, n-propanol, and isopropanol) are good solvents for some organic soils, but are flammable and can form explosive mixtures with air. Their use requires caution and well-designed equipment.

aliphatic hydrocarbons

Hydrocarbons which are based upon linear or branched arrangement of carbon atoms. Basic hydrocarbons contain only hydrogen and carbon atoms. Alkanes, alkenes, and alkynes contain single, double, and triple bonds, respectively. Other aliphatic compounds include carboxylic acids, esters, ethers, polycyclic, and other compounds which can be formed upon substitution of various functional groups for hydrogen.

alkaline

Aqueous solutions with a pH greater than 7 (on scale of 1 to 14). Strongly alkaline materials have a pH greater than 10. Also called base.

alkaline cleaning

Aqueous cleaning performed at a pH greater than 7 using caustic silicates, phosphates, or other alkaline salts mixed with surfactants in water.

American Conference of Government and Industrial Hygienists (ACGIH)

The laboratory that performs testing services for and makes recommendations to OSHA concerning exposure levels of hazardous substances in the workplace.

angstrom

Unit of linear measurement often used for particle size determination. Ten angstroms (each 1×10^{-10} meter) equal one nanometer; 10,000 angstroms equal one micron.

anion

A negatively-charged molecule that contains more electrons than protons, due to a gain in the number (ionization) of electrons.

anode

The electrode in an electrochemical battery where oxidation occurs.

anodization

Cleaning of a metal surface by electrolysis using the metal as the anode. Also referred to as anodic cleaning.

anodized metal

Metal (generally, aluminum or other active metal) with an oxide layer formed on its surface due to an electrochemical reaction where the metal serves as the anode. See oxidation.

aqueous

Water-based.

aqueous cleaning

Employment of water-based solutions, which may include suitable detergents, saponifiers, or other additives used to enhance solubility and removal of soils. Aqueous cleaners are either acidic, neutral, or basic.

aromatic hydrocarbons

Hydrocarbons based upon a benzene ring (a hexagonal arrangement of carbon atoms

with alternate single and double bonds, which is actually equivalent to six bonds of equal strength).

aspiration

Fluid removal by the transfer of small droplets of a liquid into a region of low pressure.

American Society for Testing and Materials (ASTM)

American Society for Testing and Materials. A technical organization that develops standards for the performance and testing of materials.

Auger Electron Spectroscopy (AES)

Compositional analysis technique to determine atoms present up to 10 monolayers from a substrate's surface. Electrons are directed towards the surface, generally at 2000 to 3000 electron volts; secondary electrons are then ejected from the surface, where the vacancies they create are filled by outer electrons. An outer-shell (auger) is ejected at an energy characteristic of the surface atoms.

azeotrope

A liquid solution of at least two components that retains a constant composition upon boiling and cannot be separated by distillation. An azeotrope boils at a temperature that is different from the boiling points of each component.

base

The opposite of acid; same as alkaline (pH greater than 7).

biodegradable

Products that can be naturally broken down or digested by microbial (biological) activity.

biological oxygen demand (BOD)

A measurement of the extent of pollution of a water system, based upon the quantity of oxygen necessary to allow for complete microbial (biological) oxidation of organic constituents. A five-day test is standard. See chemical oxygen demand.

blast cleaning

Use of low or high-pressure spraying of abrasive media for surface cleaning.

blends

A mixture of two or more components which form a uniform phase whereby the components cannot be distinguished. The blend formed from the mixture of at least two soluble liquids is referred to as a solution. See solubility.

brominated

A substance containing bromine.

brominated hydrocarbon

A hydrocarbon substance that contains bromine. A modern cleaning solvent is n-propyl bromide, which has low ODP, low GWP, and is not flammable or combustible. Methyl bromide, on the other hand, is an acute toxin and an ODS.

buffers

Salt solutions used with aqueous systems in order to maintain a desired pH range. Buffers are commonly used in aqueous cleaners, as the solubility and precipitation of metals are affected by the pH.

builders

Additives to detergent formulations used to increase their effectiveness by sequestering metals, such as calcium and magnesium. Many builders, such as phosphates, cause environmental problems.

carcinogen

A substance which has been identified as, or is suspected to be, a cause of cancer in humans. Cancer is a chronic effect of a single or multiple exposure(s), with symptoms typically not appearing until long after the time of exposure.

cascade rinse

The rinsing of products transferred through a series of rinse tanks, where rinsewater flowed into the final rinse tank overflows to successive tanks to the initial rinse tank, so that the flow of water is countercurrent (opposite) the direction of product transfer. Allows for products to be exposed to increasingly cleaner water.

cathode

The electrode in an electrochemical battery where reduction occurs.

cation

A positively-charged molecule that contains more protons than electrons, due to a loss in the number (ionization) of electrons.

caustics

A strong alkaline. When used alone the term usually refers to caustic soda (sodium hydroxide, extremely corrosive) used in the manufacture of soap as well as a neutralizing agent for acids.

cavitation

In ultrasonics, the expanding and collapsing (implosion) of air bubbles within a liquid, where the implosion results in an energy transfer capable of dislodging contaminants from a substrate surface.

centrifugal drying

A batch drying process which employs a rapidly spinning basket to separate excess water, oils, or other materials from a part's surface. Can be enhanced with the use of a turbine fan mounted below the basket to draw air through the load.

CFC-113

The common designation for the chlorofluorocarbon solvent 1,2,2-trichloro-1,1,2-trifluoroethane, a traditional solvent used in vapor degreasing.

chelation

The mechanism by which chemicals that would otherwise precipitate are complexed in solution with a chelating agent. This agent forms a bond with the ions, such as calcium and magnesium ions, thus preventing precipitation of calcium and

magnesium salts as "hard water." The solubility of chelated compounds usually depends on pH.

chemical oxygen demand (COD)

A measurement of the extent of pollution of a water system. The COD is based upon the quantity of oxygen necessary to oxidize organic and any oxidizable inorganic material. Potassium dichromate (a strong oxidizing agent) is generally used to perform the COD test. See biological oxygen demand.

chlorinated

A substance containing chlorine.

chlorinated hydrocarbon

An organic chemical compound which contains hydrogen and chlorine atoms bound to carbon atoms. Examples of chlorinated hydrocarbons include trichloroethane, trichloroethylene, perchloroethylene, methylene chloride, and vinyl chloride. Chlorinated hydrocarbons usually exhibit some combination of flammability, combustibility, volatile organic compound, ozone depleting, hazardous air pollutant, or toxicity characteristics.

chlorofluorocarbon (CFC)

An organic chemical composed of chlorine, fluorine, and carbon atoms. CFCs are generally characterized by high stability, thus contributing to a high ozone depletion potential (ODP). The most commonly used CFC in cleaning applications is CFC-113.

chromate treating

The production of a protective coating on a metal surface by the action of a hexavalent chromium (Cr+6) solution, such as potassium dichromate.

chronic toxicity

The long-term toxicity of a product, whose chronic effects may take a number of years to be expressed. Examples of chronic effects include cancer, which may result from the toxicity of a single or multiple exposures encountered many years prior.

Clean Air Act (CAA)

A 1970 federal regulation that established air quality standards for carbon monoxide, sulfur oxides, nitrogen oxides, hydrocarbons, photochemical oxidants, and particulates. See Clean Air Act Amendments.

Clean Air Act Amendments (CAAA)

Based upon the 1987 Montreal Protocol, 1990 revisions to the Clean Air Act calling for the production phaseout of ozone depleting chemicals, to include 1,1,1-trichloroethane, CFC-113, and some hydrochlorofluorocarbon compounds.

Clean Water Act (CWA)

A 1972 federal regulation enacted to clean up waterways by establishment of discharge standards. Amended in 1987 to extend its applicability to estuaries, toxic waters, polluted runoff, and sewer construction.

closed-loop system

A wastewater recycling system which, upon treatment and purification, recirculates

water back into the wash and rinse tanks of an aqueous cleaning system. Ion-exchange, membrane filtration, and reverse osmosis are methods commonly used to purify water to the extent necessary for its re-use.

coagulation

The growth of particles within a liquid medium to form a larger particle which can be filtered. Can be enhanced by the addition of coagulating agents. See flocculation.

coalescence

Small, discrete particles that are brought together to form a single, larger particulate. A coalescing filter is commonly used to concentrate oil in wastewater treatment.

Code of Federal Regulations (CFR)

A codification of rules, divided into 50 titles representing broad areas of regulation, published in the Federal Register by the executive departments and agencies of the federal government.

cold cleaning

Direct immersion of parts into a solvent bath, with cleaning occurring by dissolving the contaminants into the solvent.

combustibility

The ability of a substance to burn. A combustible substance has a higher flash point (is less volatile) than a flammable material. See flammability.

Comprehensive Environment Response, Compensation and Liability Act (CERCLA)

Also known as Superfund. 1980 Federal law authorizing identification and remediation of abandoned hazardous waste sites. See SARA.

condensate

The liquid generated by the condensation of a vapor.

conductivity

The ability of an aqueous solution to conduct electricity. Conductivity is the reciprocal of the resistance; the purer the water, the lower the conductivity, the higher the resistance. Ion-exchange, ultrafiltration and reverse osmosis methods are used to produce low-conductivity ultra-pure water.

contact angle

The angle that a liquid drop (bubble) makes with a solid surface. Liquids that wet a surface will spread out and have a small contact angle that approaches zero, while a non-wetting bubble will make a large contact angle with the surface.

contact angle measurement

Performed with a goniometer, assessment of the contact angle of a droplet on a surface to determine the wettability of that surface.

contract cleaning

Contracting out of cleaning operations to specializing companies that cater to a wide

spectrum of industries, supplying services ranging from simple aqueous or solvent cleaning to analytical testing.

corrosion

Natural oxidation of iron. Can only be slowed, not stopped, by corrosion inhibitors.

cosolvent system

A process based upon the use of at least two solvents pumped from separate reservoirs to perform cleaning and rinsing. Cleaning action is a function of the properties of each solvent, which are chosen to optimize the system for the cleaning of specific contaminants. Cosolvent systems can be based upon semi-aqueous (Class I); insoluble, high flash point (Class IIA); insoluble, low flash point (Class IIB); soluble solvents (Class III); and an azeotrope solvent (Class IV) chemistry. A separate rinse solvent is required for all except the Class IV cosolvent systems.

critical point

The temperature and pressure at which two phases of a substance behave as one identical supercritical phase. There is no differentiating between the two phases at temperatures and pressures above the critical point. See supercritical fluid, triple point.

cubic feet per minute (cfm)

Unit of measure for the flow rate of air or gas volume through a nozzle, duct, smokestack, etc.

deburring

Removal of sharp edges from a metal surface using abrasives contained within a suspension.

defluxing

Removal of flux materials subsequent to a soldering operation.

deionized (DI) water

Water at increased purity due to the removal of ionic species. De-ionization is performed by an ion-exchange process, where ions are exchanged for H⁺ and OH⁻ ions, or a membrane process such as reverse osmosis. Conductivity measurement can indicate degree of purity.

desorption

The release of an adsorbed substance (adsorbate) from a substrate material (adsorbent); the opposite of adsorption. Desorption can occur upon change of the conditions which allowed for adsorption. See hysteresis.

detergent

A surfactant compound containing both hydrophilic and hydrophobic groups, designed to render oils and greases soluble in water. Cleaning is performed upon attachment of the soils to the hydrophobic groups, and emulsification of the detergent-soil mixture in water. Builders and other additives enhance a detergent's cleaning capacity.

diphase solvents

Solvent cleaners, commonly used with paint strippers, which contain an insoluble aqueous layer. The water is the top layer when used with denser chlorinated solvents.

direct oxidation carbon coulometry (DOCC)

An electrochemical method for determining organic and inorganic carbon contaminants whereby a constant electric current creates a potential difference across the anode and cathode.

dispersing agent

A material that increases the stability of particles emulsified in a liquid-liquid or liquid-solid suspension. Also referred to as an emulsifying agent.

dissolved solids

Solids dispersed in solution within the liquid phase. Dissolved solids break up into their ions, which results in the formation of one single phase.

drawing compounds

Liquid or paste metalworking substances that increase the ductility and toughness of metal being drawn through a die.

drop-in replacement

An alternative solvent that, when used in lieu of traditional CFC solvents, requires minimal or no retrofitting or other modifications to the vapor degreasing system. No such universally accepted solvent has been discovered for CFC replacement.

electrochemical

Chemical reaction in an electrolysis cell, caused by an applied voltage across the anode and cathode.

electrolysis

Reaction involving electrical current flow through a solution, such as a cleaning bath or molten salt. Anodic cleaning (anodization) occurs by an oxidation reaction at the anode.

electron spectroscopy for chemical analysis (ESCA)

A spectrophotometric technique where X-ray bombardment of a substrate surface results in excitation of auger electrons. Due to the penetrating nature of X-rays, the substrate is commonly analyzed by grazing the X-ray beam across the surface. A spectrum is obtained for both the primary photoelectrons and auger electrons.

electroplating

Utilization of the flow of electricity through a solution in order to deposit a coating, generally decorative, on a metal surface which serves as the anode in an electrochemical reaction. See anodization.

electropolishing

Electromechanical removal of metal (from 0.1 mil to 2.5 mils of surface) preferentially from the peaks or high points, thus smoothing or polishing the surface.

emulsification

The formation of micelles during a cleaning process, through the dispersion or suspension of fine particles or globules of a liquid or solid in bulk liquid.

emulsifying agent

See **dispersing agent**.

emulsion

A stable phase that results upon mixture of what would otherwise be separate insoluble phases, due to the presence of an emulsifying agent that lowers the surface tension between phases.

emulsion cleaning

Removal of organic soils from a substrate through use of an emulsifying agent, such as a detergent, added to the cleaning solution.

Environmental Protection Agency (EPA)

Environmental Protection Agency. A federal agency with environmental protection, regulatory, and enforcement authority administered through regional and state environmental agencies. Administered laws include the Clean Air Act, Clean Water Act, Resource Conservation and Recovery Act (RCRA), Toxic Substance Control Act.

ethanol

Ethyl alcohol, a water-soluble organic liquid commonly used as a solvent for manual cleaning.

eutrophication

The aging of a body of water, generally an enclosed lake, due to excess nutrient accumulation. This slow, naturally occurring process is often accelerated by man-made pollution, such as addition of nitrates and phosphates into the water. The nutrients stimulate the growth of algae which, when decayed, uses oxygen that otherwise would be available to support fish and other aquatic species.

fatty acids

The principal part of many vegetable and animal oils and greases that forms soap upon reaction (saponification) with alkali.

ferric metal

Iron with an oxidation state (valence) of +3. Formed by the rusting of iron.

ferrous metal

Iron with a valence of +2; less oxidized than ferric.

flammability

The ability of a vapor to flash upon contact with an ignition source. A flammable substance is similar to, but has a lower flash point (is more volatile) than, a combustible substance.

See **combustibility**.

flash lamp

Cleaning method involving dry ice (carbon dioxide) and a laser system. Surface

coatings are broken down by the laser energy and are removed within the CO₂ stream.

flash point

The lowest temperature at which the vapors of a liquid will ignite when mixed with air and exposed to a combustion source. Flash points are used to classify materials as hazardous waste, based upon flammability.

flocculating agent

Also referred to as a flocculant, the agent added to a suspension for its ability to aggregate particulates into a larger "floc."

flocculation

Aggregation of particles into a flocced mass, as occurs in solution upon addition of a flocculating agent. The flocced mass can then be separated from solution by filtration methods.

fluorinated

A substance containing fluorine.

fluorinated hydrocarbon

A hydrocarbon, generally aliphatic, that contains fluorine, hydrogen, and carbon atoms. Tend to have high vapor pressures and low water solubility, and to not be good cleaning agents.

fluorocarbon

A chemical compound containing only fluorine and carbon atoms (not hydrogen). Generally have good cleaning properties and are very inert; but also have a large ozone depleting capacity due to their atmospheric stability.

flux

Rosin applied most commonly on printed circuit boards to facilitate production of a soldering joint.

Fourier transform infrared spectroscopy (FTIR)

An infrared technique which, like conventional infrared, is capable of identifying functional groups present among surface contaminants. FTIR makes use of all applicable wavelengths simultaneously due to a mirror-like arrangement, as opposed to standard infrared, which involves scanning of wavelengths. Qualitative or quantitative data can be obtained.

gas chromatography / mass spectrophotometry

Methods of identifying surface contaminants, which are extracted into a solvent and diluted as necessary. Organic compounds are separated by gas chromatography and are identified, based upon molecular weight, by mass spectrophotometry.

global warming compound (GWC)

A compound which, when present in the atmosphere, is suspected of contributing to global warming by its ability to absorb UV radiation after reflecting off the Earth's surface. See greenhouse effect.

global warming potential (GWP)

Based on theory that increasing atmospheric concentrations of certain gases (called greenhouse gases) are capable of making long-term changes in global climate.

goniometer

Instrument used to measure the contact angle between a liquid and a substrate surface.

gravity separation

Extraction of wastewater components such as heavy solids and sludges from water by distinction of their differences in density. Not an effective separation technique for emulsified solids or small particles that will not easily flocculate/coagulate into larger particles.

greenhouse effect

A thermodynamic phenomenon whereby energy absorbed at the Earth's surface, which is normally able to radiate back out to space in the form of long-wave infrared radiation, is retained by gases in the atmosphere, causing a rise in temperature — global warming. Carbon dioxide is considered a greenhouse gas due to its potential to absorb ultraviolet radiation reflected from the Earth's surface. The same CFCs that cause ozone depletion are known to be "greenhouse gases," which a single CFC-113 molecule having the same estimated effect as approximately 10,000 carbon dioxide molecules.

halogenated

A chemical compound containing any combination of chlorine, fluorine, or bromine.

hazardous air pollutants (HAP)

189 chemicals that, when discharged as air pollutants, are regulated as hazardous as per the 1990 Clean Air Act Amendments.

heat of vaporization

The amount of energy required to produce vapor from a liquid at its boiling point. The temperature of the boiling liquid is maintained at the boiling point while liquid is converted to vapor. Vapor heated at temperatures above the boiling point is referred to as super-heated.

HEPA filter

High-efficiency particle air filter, used for filtration of fine air particles from an airstream.

high-velocity air dryer

Large-scale drying at air velocities of 10,000 to 35,000 CFM, obtained using pressure blowers or compressed air; can be applied in an in-line, continuous process. Commonly used in the semiconductor and aerospace industries.

Hildebrand solubility parameter

An experimental value that relates the ability of a substance to dissolve in a solvent, taking into account polar, non-polar, and hydrogen bonding forces between the two liquids. Useful for determining whether two or more solvents are compatible in a

hybrid cleaning system.
See **hydrogen bonding**.

hybrid system

A mixture of at least two soluble solvents, used for cleaning both hydrophilic and hydrophobic contaminants from a substrate.

hydrocarbon/surfactant blend

Mixture of hydrocarbon solvents with surfactants allows for a semi-aqueous cleaning process, where the water-soluble soils are dissolved by the non-aqueous solvent. Semi-aqueous cleaning is followed by water rinse step(s).

hydrocarbons

Organic chemicals containing only carbon and hydrogen atoms. Can be classified as aliphatic hydrocarbons or aromatic hydrocarbons.

hydrochlorofluorocarbon (HCFC)

An organic chemical composed of hydrogen, chlorine, fluorine, and carbon atoms. These chemicals are less stable and have lower ODPs than pure CFCs.

hydrofluorocarbons

Organic compounds composed of hydrogen, fluorine, and carbon atoms. As a class, they are very volatile (have a high vapor pressure) and have a low water solubility; thus, their utility in cleaning applications is limited.

hydrofluoroether

Oxygenated hydrofluorocarbon solvents which can be used in a manual cleaning, azeotrope, or cosolvent process.

hydrogen bonding

A bond between a hydrogen atom of one molecule with an atom commonly fluorine or oxygen. of another molecule. Occurs between water molecules, and is the reason why water has a high boiling point (212°F). See Hildebrand solubility parameter.

hydrogen bonding

A bond between a hydrogen atom of one molecule with an atom — commonly fluorine or oxygen — of another molecule. Occurs between water molecules, and is the reason why water has a high boiling point (212°F). See Hildebrand solubility parameter.

hydrophilic

From the Greek, meaning water-loving. Defined by ASTM as a descriptive term applied to the group or radical of a surfactant molecule that makes or tends to make it soluble in water.

hydrophobic

Water-repelling; the opposite of hydrophilic.

hygroscopic

A substance that readily absorbs moisture from air. Some hygroscopic materials can absorb enough water to completely dissolve.

hysteresis

The lagging of desorption from a surface, as compared to the quantity adsorbed under similar conditions, such as constant temperature. Commonly observed in contact angle measurements with a goniometer.

immersion cleaning

Direct immersion of a dirty substrate into the cleaning fluid. Performed by dissolving the contaminants into the cleaning fluid, the cleaning approach may be enhanced by the use of heating, ultrasonics, or spray agitation methods.

inhibitors

Agents that retard any adverse chemical reaction of an aqueous cleaner and the substrate. They are commonly used to slow down the corrosion process of iron substrates and for non-ferrous substrates at high pH (strongly alkaline).

inorganic

Compounds including water, hydrogen, oxygen, carbon dioxide, nitrogen, sulfur, phosphorus, and metals which are not based on organic carbon.

insoluble

Not soluble. Materials that do not dissolve within each other, but exist as separate phases. See solubility.

International Association for Research on Cancer (IARC)

A multi-national organization that studies and rates the carcinogenic effect of substances.

International Standards Organization (ISO)

Representing more than 90 countries, sets quality control standards for industry. ISO 9000 pertains to total quality management; ISO 14000 pertains to corporate management systems and product evaluation standards for compliance with environmentally-sound procedures.

ion-exchange

Replacement of inorganic ions (positive cations and/or negative anions) with other ions as a result of adsorption onto a resin with subsequent desorption of ions into solution. Ion-exchange resins can be used to remove heavier metals from wastewater.

isopropanol (IPA)

An alcohol solvent which can be used in manual and cosolvent cleaning processes.

Kauri Butanol (KB) number

Indication of solvency power, measured by formation of turbidity with solvent mixed with Kauri resin and n-butanol. Higher KB numbers represent better solvency; however, intermediate values are often preferred to avoid substrate damage by aggressive solvation.

KB number

See **Kauri Butanol number**.

laser cleaning

Noncontact technology applying laser systems for the ablation (removal by heat) of thin-film contamination, particulate, epoxy, or other paint layers from substrates. May be applied for coatings removal from a much smaller area than is otherwise possible with flash lamp methods.

low-velocity air dryer

Small-scale batch drying that utilizes less than 10,000 cfm of air.

lower explosive limit (LEL)

The minimum percent by volume of a gas which, when mixed with air at normal temperature and pressure (70°F and 14.7 psia), will form a flammable mixture.

manual cleaning

Contact cleaning performed by hand using swabs, cloths, or aerosol sprays. See solvent wiping.

material safety data sheet (MSDS)

A document which lists the physical and chemical properties, acute and chronic hazards, routes of exposure, emergency procedures, as well as handling, storage, and disposal information pertinent to any chemical used in the workplace.

media

The substance which performs the cleaning action. Can be aggressive, non-aggressive, or peening (spherical). See aggressive cleaning, non-abrasive media, and shot peening.

megasonic cleaning

Used primarily for particle removal in situations where ultrasonic cavitation may be too aggressive for the substrate material. Megasonics is generally performed at frequencies between 700 KHz and 1.2 MHz. See ultrasonic cleaning.

membrane filtration

Microfiltration, ultrafiltration, reverse osmosis, and similar treatment processes which utilize thin-film polymer materials to separate contaminants from wastewater.

meniscus

The curvature of the top of a liquid column due to the surface tension of the liquid. Substrate drying can be especially challenging when a liquid forms a meniscus between surfaces in contact with each other.

MESERAN

Measurement and Evaluation of Surfaces by Evaporative Rate Analysis. Quantitative method using radioactivity to analyze organic contamination on a surface. A total count method is commonly used. Lower detection limits can be obtained through use of a slope method.

metal forming lubricants

Drawing compounds used to provide a surface between the tool and the part during metal forming.

methyl chloroform

See **1,1,1-trichloroethane (TCA)**.

methylene chloride

A traditional solvent used in degreasing. Also known as dichloromethane.

micelle

An agglomerate of substances having both hydrophobic and hydrophilic properties, which form a cage around non-water-soluble oils. Detergents and other surfactants dissolved in aqueous solution occur as micelles.

microfiltration

Separation of solids to 0.1 micron through use of a polymer membrane. Often applied as a pre-filter for ultrafiltration.

mineral acid

Inorganic acids which dissociate at approximately 100 percent in aqueous solution and have a pH of approximately 1. Hydrochloric, nitric, phosphoric, and sulfuric acids are mineral acids.

molten salts

Salt heated to temperatures of 400°F to 1000°F in order to clean metal parts. An electric current can be used for certain electrolytic applications to obtain the desired reaction.

Montreal Protocol

1987 international agreement mandating the phase-out of production of ODP solvents, including traditional chlorinated organic solvents used in vapor degreasing: CFC-113, TCA, and some HCFC compounds.

***n*-propyl bromide**

A brominated hydrocarbon serving as an alternate solvent, suggested for use in vapor degreasing, cold cleaning, ultrasonic, and manual cleaning applications.

National Emission Standard for Hazardous Air Pollutants (NESHAP)

Federal regulations, effective December 2, 1997, that specify operating conditions and retrofitting requirements for vapor degreasing and cold cleaning applications that utilize methylene chloride, perchloroethylene, trichloroethylene, 1,1,1-trichloroethane, carbon tetrachloride, or chloroform.

National Fire Protection Agency (NFPA)

National organization that promotes fire prevention and safety.

National Institute of Occupational Safety and Health (NIOSH)

A branch of OSHA that performs testing services.

neutral cleaners

Include alcohols and other water-soluble surfactant formulas that function in a pH range of 6 to 8. Used in applications that require low alkalinity, they generally cause less foaming than alkaline cleaners.

neutralization

Refers to the addition of an acid to a base, or vice versa, in order to obtain a neutral solution (pH of 6 to 8 on scale of 1 to 14). Neutralization reactions are generally performed with indicators that change color at the neutral endpoint (equivalence point).

nitrate

An anion that forms neutral salts when combined with sodium or other cations. A naturally occurring ion, excessive amounts can contribute to eutrophication of natural water systems.

no-clean flux

Flux which contains low solid levels, thus eliminating the need for cleaning. See water-soluble flux.

non-abrasive media

Blast cleaning media, such as plastics and wheat starch, that may cause minimal damage to the substrate being cleaned.

non-polar

Molecule lacking a permanent dipole moment, as a result of symmetry. Non-polar solvents tend to dissolve non-polar solutes: Like dissolves like. Methane, benzene, carbon tetrachloride, and carbon dioxide are examples of non-polar molecules. Water and isopropanol, in contrast, are polar molecules. See polar.

non-volatile residue (NVR)

The inorganic material that remains on a substrate upon completion of the cleaning process.

non-volatile residue analysis

Involves dissolution of the contaminant in a solvent, with subsequent evaporation of solvent. The quantity of non-volatile residue can be determined by gravimetric means, which involves weighing the dried residue, or by instrumental methods for greater precision and accuracy.

Occupational Safety and Health Administration (OSHA)

Federal agency which oversees and regulates health and safety in the workplace. OSHA regulations can be found in 29 CFR.

optical particle counting

Methods based upon light absorption and/or light scattering from a sample of the cleaning fluid, the solid contaminants, or the substrate surface. A photodetector diode detects the degree of light scattering (small particles scatter less light); a microprocessor is used to determine the quantities for each particle size; statistical software is used to calculate contamination levels and statistical differences between test and control samples.

optically stimulated electron emission (OSEE)

Determines surface cleanliness through use of ultraviolet light. Secondary electrons emitted from a surface are collected across an air gap and the current is measured. Each contaminant can cause a characteristic decrease in the OSEE signal.

organic

Related to or deriving from living organisms containing carbon (organic) compounds. Carbon is bound with other carbon atoms through single, double, and triple bonds. Organic compounds generally contain hydrogen and are often chlorinated, fluorinated, brominated, or oxygenated.

organophilic

Oil-loving. An organophilic molecule has an affinity for organic materials (fats, oils) and tends to be soluble in organic solvents (oils, kerosene, diesel fuel, chlorinated solvents, etc.).

osmosis

Movement of a solvent through a semi-permeable membrane from a region of low solute concentration (higher solvent concentration) into a region of high solute concentration (lower solvent concentration).

oxidation

Reaction of a substance with oxygen which may result in liberation of heat (combustion) and the formation of oxidized compounds (such as rust, scale, or an oxide layer on a part's surface).

ozone

The photoreactive, triatomic (O₃) form of oxygen. Contributes to smog at lower elevations in the atmosphere (the troposphere), but is essential at upper elevations (above six miles) in the stratosphere, where the ozone layer protects Earth from excessive UV exposure due to incident sunlight. Ozone is commonly used in oxidation systems with hydrogen peroxide and/or ultraviolet radiation, as in wastewater treatment.

ozone depleting substance (ODS)

A chemical that has been found, or is suspected, to contribute to depletion of the Earth's ozone layer as a result of photochemical reactions that occur between ozone and ODSs in the stratosphere.

ozone depletion

Accelerated chemical destruction of the stratospheric ozone layer by the presence of substances produced, for the most part, by human activities. The most depleting species are chlorine and bromine free radicals generated from reaction of chlorinated and brominated compounds with UV radiation.

ozone depletion potential (ODP)

A relative index indicating the extent to which a substance may cause ozone depletion, calculated from mathematical models which take into account factors such as the stability, rate of dispersion, quantity of depleting atoms per molecule, and the effect of UV light and other radiation on molecules. The ODP of CFC-113 is 0.8, compared to a reference level of 1.0 for CFC-11 and CFC-12.

particle counting

Quantitative technique to detect particles of varying sizes. Subject to errors attributable to the non-spherical nature of many particles and the presence of bubbles in the sample.

passivation

Electrochemical treatment of a metal or semiconductor substance in order to form a protective oxide layer.

perchloroethylene (PERC)

A chlorinated alkene solvent, 1,1,2,2-tetrachlorethene, commonly used in dry cleaning.

perfluorocarbon

See **fluorocarbon**.

permissible exposure level (PEL)

The time-weighted average adopted by OSHA which is the enforceable standard for concentrations of listed chemicals to which workers can be exposed in the workplace. Monitoring is often required to show compliance with applicable PELs.

pH

A logarithmic scale (from 1 to 14) used to represent measured hydrogen ion (H⁺) concentration in order to determine the acidity, basicity, or neutrality of an aqueous solution. See acid, base.

phase

The state of a liquid, solid, gas, or plasma material where the composition is uniformly distributed. As examples, sodium chloride (table salt) dissolves in water, which results in a one-phase system, whereas water and gasoline do not mix, but form two separate layers – a two-phase system.

phase imaging analysis (PI)

A surface mapping technique that applies an oscillating probe brought into soft contact with the surface. The amplitude of the oscillations (or signal) vary with changes in the surface topography. Surface areas are illustrated as light or dark.

phenolic

A highly active oxygenated aromatic organic compound used in thermosetting polymers. Greatly increases effectiveness of paint strippers.

phosphates

Form neutral salts when combined with sodium or other cation. Used to a limited extent as builders in detergents in order to sequester hard water, provide alkalinity, peptize, suspend solids, and add bulk to cleaning compounds. Such usage has been limited, however, due to the effect of phosphates on eutrophication of natural water systems. Phosphates can also be used as a coating formed by certain metals upon reaction of phosphoric acid (i.e., iron phosphate, zinc phosphate).

photochemical

Involving the interaction of light and chemistry, where chemical reactions occur upon initiation with light (sunlight).

plasma cleaning

Substrate cleaning performed by plasma, a partially or wholly ionized gas with

properties similar to a liquid. Surface cleaning is performed by either chemical reaction or physical mass transfer.

polar

A compound which possesses a net positive or negative dipole moment due to charged groups or additional electron pairs within the molecule. Polar compounds include water, oxygen, ozone, acids, bases, salts and some substituted and oxygenated organic compounds. See non-polar.

ppb

Parts per billion. A measure of the concentration of a material within another, determined on a weight basis (1 ppb = 0.0000001).

ppm

Parts per million. A measure of the concentration of one material within another, determined on a weight basis (1 ppm = 0.0001).

precipitation

The formation of a solid layer from a substance dispersed within a liquid, upon addition of a flocculating, coagulating, or other precipitating agent.

precleaning

A surface preparation step which precedes the actual cleaning or surface treatment of a substrate.

psi

pounds per square inch.

publicly owned treatment works (POTW)

Wastewater discharge to a POTW is generally based on compliance with permit requirements.

Resource Conservation and Recovery Act (RCRA)

A 1976 federal statute which initiated the clean-up of hazardous waste sites.

reverse osmosis (RO)

A membrane procedure which separates ionic species from aqueous solutions to produce water of extremely high purity. Applied pressure forces H⁺ and OH⁻ ions across a membrane that does not allow for passage of other ions. The purity of the water can be measured with a conductance meter.

Right-to-Know

A federal regulation administered by most states that mandates worker training, product labeling, MSDS requirements, and workplace reporting of hazardous chemicals.

route of exposure

Mode of entry (primarily either oral, dermal, or inhalation) for an exposure into the human body.

saponification

Commonly used with aqueous cleaning systems, the making of soap by the action of a base, such as sodium hydroxide (caustic soda), on a fat or oil.

saponifier

The base added to a fatty acid to form soap.

scale

Layer of insoluble salts of calcium or magnesium carbonate or phosphate which have been precipitated from water by heat or chemical reaction or have been left behind when water evaporates.

scanning electron microscopy (SEM)

Analysis technique which involves scanning a surface using electron beams to produce a three-dimensional image of the surface morphology, then measuring the intensity of the scattered electrons.

secondary ion mass spectroscopy (SIMS)

Technique to analyze surface composition, whereby a primary ion beam is directed at the surface, and surface atoms are then ejected as secondary ions. A mass spectrophotometer (MS) provides quantitative analysis to a depth of hundreds of atomic layers beneath the surface.

semi-aqueous

Cleaning processes which involve washing with an organic solvent and rinsing with water (inorganic solvent). Surfactants and other chemicals are commonly added in order to lower the surface tension between the solvent and the substrate contaminants.

sequestering agents

Used to bind with calcium, magnesium, and other metals so that the metals do not react with other dissolved species in water. Same as chelating agent.

shot peening

Blasting technique that utilizes steel, ceramic, glass beads, or other spherical media to eliminate burrs (sharp edges) and stresses within a surface.

Significant New Alternatives Policy (SNAP)

EPA guidance pertinent to acceptable solvent substitutes for cleaning systems.

silicates

Soluble or insoluble compounds that contribute emulsifying power and alkalinity, and act as corrosion inhibitors. Insoluble silicates, a component of sand, are used in semiconductor manufacture, while soluble silicates are used in powder or granular form as ingredients of metal cleaning compounds.

snow (CO₂) cleaning

Precision cleaning method whereby carbon dioxide (CO₂) passed through a specialized nozzle exits as a solid, liquid, and vapor. Surface contaminants removed include organic oils, fluxes, fingerprints, and fine fibers. See supercritical CO₂.

soft chemicals

Environmentally friendly chemicals, such as formic acid or benzal alcohol, used as substitutes to methylene chloride in high-pressure water blasting applications.

solubility

The ability of a substance to dissolve in another substance. Materials are generally classified as insoluble, slightly soluble, partially soluble, or completely soluble. Solubility can be quantified as grams per liter or as a weight percent.

solvent

Liquid substance used to dissolve other substances.

solvent wiping

A petroleum or chlorinated solvent applied by some absorbent material, usually a cloth or rag. See manual cleaning.

South Coast Air Quality Management District (SCAQMD)

Southern California jurisdiction which promulgated Rule 1122 in 1997, requiring businesses in that region that use VOC solvents to switch to aqueous cleaning processes or to retrofit current systems.

spectroscopy

Instrumental methods based upon the absorption of radiation in order to perform qualitative or quantitative analysis of a substance. Spectroscopic methods which can be used to determine cleanliness include optically stimulated electron emission, X-ray emission, secondary ion mass, auger electron, electron spectroscopy, mass spectrophotometry (commonly used with gas chromatography), and Fourier transform infrared spectroscopy.

spray washer

A mechanical washing device consisting of a large metal cabinet or tunnel, spray nozzles in the interior reservoir tanks, and pumps generally used to clean metal and plastic.

stabilizers

Additives to solvents which are used to avoid by-product reactions with light, air, and water. Common types include metal stabilizers that pacify a surface by forming an oxide coating, anti-oxidants which minimize solvent reaction with oxygen, and acid acceptors which react with the acid formed due to the moisture effects on halogenated solvents.

Stoke's law

Relationship that describes settling of particles by particle size.

stratosphere

The upper portion of Earth's atmosphere (6 to 30 miles) where the ozone layer resides.

substrate

Soiled or oily item or component which is subject to cleaning methods.

supercritical CO₂

Carbon dioxide equilibrium formed at high temperatures (above 31°C) and pressure (72.8 atm), commonly used in a dissolution process to remove organic contaminants from parts with complex geometries. See snow (CO₂) cleaning.

supercritical fluid

The single phase which exists at temperatures and pressures above the critical point, from otherwise distinct gas and liquid phases at lower temperatures and pressures.

Superfund

See **CERCLA**.

Superfund Amendment and Reauthorization Act (SARA)

1986 CERCLA revisions authorizing emergency response planning, community Right-to-Know, and training standards for workers involved in the clean-up of hazardous waste sites.

superheated vapor drying

Involves directly heating a solvent vapor to a temperature which would not be attained by directly heating the solvent generally, 20° to 60° above the boiling point. The superheated steam results in lowering required drying time by as much as 50 percent.

surface tension

The behavior of a liquid on a surface that is dependent on the intermolecular forces that cause the liquid to contract. Surface tension of a liquid sphere on a surface can be measured as a contact angle, which approaches zero as the surface tension is reduced and the liquid "wets" the surface.

surfactant

Short for surface-active agent. Additives commonly used to reduce the surface tension between hydrophobic soils and an aqueous cleaning solution.

suspended solids

Solids which exist dispersed as a separate phase within a liquid, though not dissolved. Can be separated by filtration methods. Wastewater treatment often involves precipitation of suspended solids.

technical assistance program (TAP)

State programs established to help companies eliminate solvents and implement other pollution prevention measures such as waste minimization, reuse/recycling, and waste treatment.

terpenes

Naturally occurring organic compounds typically found in essential oils, used as cleaning agents in semi-aqueous systems. D-limonene, a hydrocarbon, is the most commonly used terpene in precision cleaning applications; some terpenes contain oxygen.

thermal cleaning

Heat-based technique commonly used in the semiconductor industry for applications

which are not conducive to wet methods for removal of volatile contaminants from a substrate. Higher temperatures and/or lower pressures are used to remove less volatile contaminants.

thermogravimetric analysis

Instrumental methods to monitor the desorption of chemically adsorbed contaminants from a substrate surface. A thermobalance detector determines contaminant weight loss as temperature is increased.

threshold limit value

The concentration of a substance to which a person can be exposed for a specified time, as determined by the American Conference of Government Industrial Hygienists. TLVs are commonly determined on an eight-hour average, a short-term (15 minute) exposure level by OSHA.

time-weighted average (TWA)

The average concentration of a substance that has been determined to be acceptable for exposure to nearly all workers in an eight-hour day, 15-minute short-term, or as an absolute ceiling. TWAs are determined based upon testing by the American Conference of Government and Industrial Hygienists and from observed acute and chronic effects of individuals from prior historical exposures. The legally-enforced TWA is published as a permissible exposure limit by OSHA.

total organic carbon (TOC)

A common monitoring parameter for rinsewater and water recycled through a closed-loop process, involves determination of all organic compounds dissolved in an aqueous system. TOC can be reduced through use of UV-oxidation systems and various filtration methods.

total organic carbon analysis

Quantifies organic materials on a substrate surface; also useful for process control of water within a closed-loop system. In-line sampling of recycled water can be analyzed to gauge organic contamination from water returning to the rinse tank.

Toxic Substance Control Act (TSCA)

An EPA regulation to control the use of toxic substances in the workplace. Restrictions are placed on usage of TSCA-listed chemicals.

toxicity

The effect of a toxin on the body, as to produce hazardous biological effects ranging from acute to chronic. See acute toxicity, chronic toxicity.

toxicology

The study of toxic agents where acceptable dosages for exposure can be calculated for acute effects and probabilities can be determined as ppm or ppb for obtaining chronic endpoints (cancer or death) over a long-term period.

transducer

An electronic device used in ultrasonics that converts an electric signal into ultrasonic waves within a fluid medium.

trichloroethylene (TCE)

A chlorinated organic hydrocarbon (an alkene) which is a traditional solvent used for metals cleaning.

triple point

The unique temperature and pressure where the otherwise distinct gas, liquid, and solid phases of a substance co-exist as one phase. Carbon dioxide exists at its triple point (70°F, 5.1 atmospheres) when passing through a nozzle during snow cleaning.

troposphere

The atmosphere level closest to the Earth's surface (0 to 7 miles).

TSD

treatment, storage, and disposal.

turbidity

Lack of clarity of a solution upon development of cloudiness or haziness. Measured by light-scattering procedures to determine the concentration of suspended substances.

ultrafiltration

Via semipermeable membrane, filtration of particles in the 0.001 to 0.1 micron size range.

ultrasonic cleaning

Sonic frequencies between 40 and 400 KHz, emitted through a transducer, cause expansion of air bubbles in a liquid until they collapse within a region of high pressure. This cavitation results in an energy transfer capable of dislodging contaminants from a substrate surface.

ultraviolet radiation (UV)

Wavelengths between visible light and X-rays, such as that produced by the sun. Also used in UV/ozone cleaning systems.

upper explosive limit (UEL)

The maximum concentration of vapor or gas in air above which propagation of flame does not occur on contact with an ignition source.

UV/ozone cleaning

Based upon the effects of UV radiation and ozone, commonly used for treatment of microorganisms and oxidation processes in wastewater.

vapor degreasing

Traditional cleaning process which employs a chlorinated solvent to clean a part placed in a chamber containing the vaporized solvent. Cleaning is performed by dissolution of the contaminants within the vapor zone above the boiling liquid.

vapor pressure

The pressure exerted by a vapor above a substance (generally a liquid), caused by evaporation of that substance. Corresponds with the molecular weight of the

substance. Lower boiling (more volatile) chemicals generally have a higher vapor pressure.

viscosity

The property of a fluid to develop and maintain a resistance to flow.

volatile methyl siloxanes

An alternative to traditional solvents, has been suggested for use in manual cleaning and azeotropic applications.

volatile organic compound (VOC)

Constituents that will evaporate at room temperature and which, by a photochemical reaction in the troposphere, will potentially cause atmospheric oxygen to be converted into smog.

volatility

The tendency of a substance to evaporate. The lower a liquid's boiling point, the greater its volatility.

water break test

Qualitative test for assessing substrate cleanliness, whereby the degree of cleanliness is determined by dipping the part in clean water (often deionized or distilled) and noting the time it takes for rinsewater to break. If the water breaks into beads, the part can be considered contaminated; if the water sheets and flows off evenly, it's clean.

water conditioner

A material that improves the quality of water for a given application. Generally a chelate or sequesterant.

water-soluble flux

A flux that leaves residues which are soluble in water and can be removed by a water rinse step.

wet blasting

Water stream exerted at high pressures along with air and dry media, commonly used for dust control.

wet honing

Blast cleaning method that applies a liquid/media slurry from a suction blast head.

wetting

The ability of a liquid to spread out and penetrate the surface of a substrate. wheat starch Dry media used in blast cleaning applications which offer improved process control, less potential damage to substrates, and can be recycled.

X-ray emission spectroscopy (XES)

Surface analysis technique that determines elemental composition to a depth of 30 monolayers. From an X-ray beam focused at the surface, electrons are emitted at an energy equal to the difference of the energy of the incident photons and the binding energy of the surface electrons.

Industry Cleaning Practices Study

Excerpts from July/August 1998 study

The Industry Cleaning Practices Study offers a detailed review of the factors influencing buyers of cleaning equipment, supplies, and agents.

This study was conducted July/August 1998 by Hart Info Systems on behalf of *Precision Cleaning* and *Parts Cleaning* magazines.

- [Industry Definitions](#)
- [What best describes the cleaning technologies \(agents and/or action\) you are using now?](#)
- [Within your company, would you say cleaning is becoming: Overall, Critical Cleaning, Somewhat Critical, Somewhat Industrial, Industrial Cleaning.](#)
- [Do you clean to a specified standard?](#)
- [What factors most influenced your current source of cleaning technology?](#)
- [Which of the following sources do you use frequently to gather information about cleaning technology products and services?](#)
- [How long since your last purchase of cleaning equipment?](#)
- [Do you have plans to purchase additional equipment \(either as an upgrade, replacement, or new system\)?](#)
- [How will the new cleaning system technology compare to your current system?](#)
- [Approximately how many people will participate in the purchase decision?](#)
- [Which category best describes your company's primary operation?](#)
- [What is your job function?](#)

Following is a sampling of printed reference material pertinent to precision cleaning. If you know of others, please e-mail title, publisher, and publisher contact information to share your referrals with the global critical cleaning community.

OTHER RESOURCES: [Amazon.com](#), a book-selling Web site boasting 2.5 million titles, allows you to search by keyword or browse by subject topic. [Yahoo](#), an Internet search site, arranges the Web in a hierarchical, library-like tree. The above link will take you down the following Yahoo tree pattern:

Alkaline Cleaner Recycle Handbook

Membrex, Inc.; Fairfield, NJ; (201) 575-8388

American Society for Testing and Materials; Conshohoken, PA; (610) 832-9585

- ASTM G-121: **Practices for Preparation of Contaminated Test Coupons for the Evaluation of Cleaning Agents for Use in Oxygen-Enriched Systems and Components**
- ASTM G-122: **Standard Test Method to Evaluate the Effectiveness of Cleaning Agents**
- ASTM G-127: **Standard Guide for the Selection of Cleaning Agents**

Aqueous Cleaner Guide

Quitmeyer, J.

W.R. Grace & Co.; Lexington, MA; (781) 863-8720

Aqueous Cleaning as an Alternative to CFC and Chlorinated Solvent Based Systems

D'Druiz, C.D. (1991)

Noyes Publications; Westwood, NJ; (201) 666-2121

ISBN# 0815512856

ASTM Manual on Vapor Degreasing, 3rd ed.

Dyroff, G., ed. (1989)

American Society for Testing and Materials; Conshohocken, PA; (610) 832-9585

ISBN# 0803112173

Choosing a Cleaning Process

(1996)

ASM International; Materials Park, OH; (800) 336-5152

ISBN# 0871705729

Cleaning Technology in Semiconductor Device Manufacturing

Ruzylo, J., ed. (1992)

Electrochemical Society; Pennington, NJ; (609) 737-1902

ISBN# 1566770122

Contamination Effects on Electronic Products

Tautscher, C.J. (1991)

Marcel Dekker; New York, NY; (212) 696-9000

ISBN# 0824784235

Guide to Acid, Alkaline, Emulsion and Ultrasonic Cleaning

(1996)

ASM International; Materials Park, OH; (800) 336-5152

ISBN# 087170577X

Guide to Mechanical Cleaning Systems

(1996)

ASM International; Materials Park, OH; (800) 336-5152

ISBN# 0871705745

Guide to Vapor Degreasing and Solvent Cold Cleaning

D'Druiz, C.D. (1996)

ASM International; Materials Park, OH; (800) 336-5152

ISBN# 0871705737

Handbook of Contamination Control in Microelectronics:

Principles, Applications and Technology

Tolliver, D., ed. (1988)

Institute of Environmental Sciences; Mount Prospect, IL; (708) 255-1561

ISBN# 0815511515

Handbook of Semiconductor Wafer Cleaning Technology: Science, Technology, and Applications

Kern, W., ed. (1993)
Noyes Publications; Westwood, NJ; (201) 666-2121
ISBN# 0815513313

Hazardous Chemicals Desk Reference, 4th ed.

Lewis, R., ed. (1996)
Van Nostrand Reinhold; New York, NY; (212) 254-3232
ISBN# 0442023227

New Cleaning Strategies: Environmental Issues and Technical Developments

Daniels, R., ed. (1994)
Miller Freeman Books; San Francisco; (415) 905-2200
ISBN# 0879302798

Oxygen Cleaning Agent Directory

Compressed Gas Association; Arlington, VA; (703) 412-0900

Surfactants and Interfacial Phenomena

Rosen, M.J. (1989)
John Wiley & Sons; New York, NY; (212) 850-6000
ISBN# 0471836516

Ultraclean Technology Handbook

Ohmi, T., ed. (1993)
Marcel Dekker; New York, NY; (212) 696-9000
ISBN# 0824787536

Ultrasonic Fundamentals and Applications

Kuttruff, H. (1991)
Elsevier Applied Sciences; New York, NY; (212) 633-3730
ISBN# 1851665536

Ultrasonics: Fundamental Technology Applications

Ensminger, D. (1988)
Marcel Dekker; New York, NY; (212) 696-9000
ISBN# 0824776593

EPA Technical Manuals: The following U.S. Environmental Protection Agency documents, available from various EPA offices, all pertain to reduction of methyl chloroform and CFC-113 in the workplace.

[Alternatives for CFC-113 and Methyl Chloroform in Metal Cleaning](#)

Stratospheric Ozone Information Hotline: 800-296-1996
Search for Document # EPA400191019

[Aqueous and Semi-Aqueous Alternatives for CFC-113 and Methyl Chloroform Cleaning of Printed Circuit Boards](#)

Stratospheric Ozone Information Hotline: 800-296-1996
Search for Document # EPA400191016

[Chemicals in the Environment: Methyl Chloroform](#)

Environmental Assistance Division

TSCA Assistance Information Service; (202) 554-1404

Search for Document # EPA749F94014

[Conservation and Recycling Practices for CFC-113 and Methyl Chloroform](#)

Stratospheric Ozone Information Hotline: 800-296-1996

Search for Document # EPA400191017

[Eliminating CFC-113 and Methyl Chloroform in Aircraft Maintenance Procedures](#)

Stratospheric Ozone Information Hotline: 800-296-1996

Search for Document # EPA430B93006

[Eliminating CFC-113 and Methyl Chloroform in Precision Cleaning Applications](#)

Stratospheric Ozone Information Hotline: 800-296-1996

Search for Document # EPA400191018

[How to Survive the Phaseout of 1,1,1-Trichloroethane](#)

Stratospheric Ozone Information Hotline: 800-296-1996

Search for Document # EPA430F92027

[Locating and Estimating Air Emissions From Sources of Methyl Chloroform](#)

Department of Commerce

National Technical Information Center; Springfield, VA; (703) 487-4650

Search for Document # EPA454R93045

[Methyl Chloroform Cleaning of Printed Circuit Boards](#)

Stratospheric Ozone Information Hotline: 800-296-1996

Search for Document #