

Alternative Cleaning Solvents and Processes

Introduction

In recent years, concerns over the ozone layer, photochemical smog and worker health have made traditional solvent cleaning products and processes increasingly regulated and expensive. Many industrial cleaning processes have relied heavily on the use of chlorinated solvents, specifically 1,1,1-trichloroethane (TCA), and 1, 1, 2-trichloro-1, 2, 2-trifluoroethane (CFC-113). These chlorinated solvents have been identified as ozone-depleting chemicals and are being phased out under the Montreal Protocol. Production of 1,1,1 TCA and CFC-113 have been prohibited since January 1, 1996 and other ozone-depleting substances are also scheduled for phase out. In addition, the 1994 National Emission Standards for Hazardous Air Pollutants (NESHAPs) place emission and operating standards on the use of carbon tetrachloride, trichloroethylene, perchloroethylene, 1,1,1 trichloroethane, chloroform, and methylene chloride.

Many users of solvents, whatever the application, are looking for safe and effective alternatives. Whatever the motivation -- cost, safety, regulatory -- companies may be able to achieve significant economic and environmental benefits by switching to alternative cleaning products or processes.

Finding the Right Alternative

Changing from a proven process to a new technology is a challenging task. Some alternatives offered as the "perfect" solutions have been found to be ineffective cleaners, too expensive, or present safety hazards. Knowledge of cleaning needs and cleaning options will aid in selecting the most cost effective and technically feasible solution without compromising worker health and safety or environmental protection.

Safety and health concerns should be a primary consideration when selecting an alternative process or product. A safer, less toxic alternative should be chosen, provided it could meet the cleaning criteria of the intended application. Consult your local health and safety specialists and the appropriate Material Safety and Data Sheets prior to implementing any alternative cleaning process or product.

Alternatives should be tested for compatibility before implementation, not only with the components to be cleaned, but also with the cleaning equipment.

No single process or product will work in every case. Careful selection and deliberate implementation are the keys to success with any new process or product.

It is essential that all environmental impacts be evaluated before switching to a new cleaning process or product. The new process may reduce certain types of pollutants, but create new ones, especially if pollution is transferred from one media to another. Each alternative should be evaluated for its impact on total materials usage, air emissions, solid and hazardous waste generation, wastewater discharges, energy and water use, and the associated costs of managing these impacts. In addition, no matter what alternative you choose, all of these environmental impacts must be evaluated in terms of applicable regulations. DEQ and your local sewerage agency can help you define those requirements.

Defining Cleaning Needs

The first and most important part of the search for an alternative is to define cleaning needs by asking:

1. What are the parts that need to be cleaned? (e.g., materials of construction, surface type, size, shape)
2. What are the contaminants to be removed? (e.g., petroleum-based oil, water-based oil, vegetable-based oil, grease, wax, flux, dirt, salts)
3. Why are the parts being cleaned? Carefully consider this question. Don't be satisfied with the answer "because they've always been cleaned." Companies have saved money by eliminating unnecessary processes that cause contamination.
4. Who is applying the contaminants to the parts? Minimizing the amount of contaminants or switching to an "easy to clean" contaminant, will ease the cleaning load and difficulty. If suppliers are applying the contaminants, work



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with them to use less contaminants and find alternatives to “hard to clean” contaminants.

5. What are the cleaning requirements? If cleaning must be done, it is necessary to know to what degree. This is a difficult step. Consider what happens to the parts following cleaning.

Once cleaning needs have been assessed, evaluation of the alternatives can begin. Following are brief descriptions of the most popular alternatives.

Aqueous Cleaners

Aqueous cleaning solutions use water as the primary solvent. Detergents and surfactants may be added, along with special additives such as builders, PH buffers, inhibitors, emulsifiers, deflocculants, sequestering agents, chelating agents, and anti-foaming agents.

Acidic aqueous solutions are routinely used to remove scale, rust, and oxides from metals. However, acid attacks most metals. The choice of acid and additives depends on the type of metal to be cleaned and the type of soil to be removed. Alkaline aqueous solutions, the most common solutions in aqueous cleaners, are good for removing salts, organic soils, oxides, metal chips, grease -- just about anything a chlorinated solvent can remove. Alkaline aqueous cleaners can be used at a very broad range of temperature.

Immersion, pressure spray or ultrasonic process equipment are often used in aqueous cleaning, depending on the application. In immersion cleaning, the parts are immersed in a cleaning solution, and some form of agitation and/or heat is added to supply the energy needed to remove contaminants. In pressure spray washing, a high-pressure spray delivers more mechanical action to help remove soils from surfaces. The ultrasonic method combines water, a detergent and high frequency sound waves to create bubbles that help to dissolve and displace particles from the surface.

Aqueous cleaning may create new waste streams and environmental requirements, such as sludge disposal or sewer permits. Check with DEQ and your local sewerage agency to determine those requirements.

Semi-Aqueous Cleaners

Semi-aqueous solutions are semi-stable mixtures of water and solvents, also called emulsions. Semi-aqueous cleaners are made of natural or synthetic organic solvents, surfactants, or corrosion inhibitors, and other additives. These

cleaners are often used with immersion or ultrasonic systems, which are effective on removing waxes, heavy greases, tar and baked-on organic materials.

Water insoluble semi-aqueous cleaners, such as high-molecular-weight esters, terpenes, glycol ethers, and petroleum hydrocarbons, are a mixture of a non-water-soluble solvent and an emulsifying surfactant and water. Terpenes, often found in household cleaners, deodorizers, and pharmaceuticals, are extracted from plants such as tree bark or citrus fruits. Hydrocarbons, usually combined with a surfactant and rust inhibitor, are effective in removing cutting oils, coolants, greases and waxes, and can be effectively recycled.

Water-soluble semi-aqueous cleaners use water as filler to reduce volatile organic compound (VOC) emissions. Common water-soluble, semi-aqueous cleaners include low-molecular weight alcohol, ketone, ester, and organic amine.

Semi-aqueous cleaning includes processes where parts are first cleaned in a solvent, then rinsed in water. The semi-aqueous processes usually require at least a partially closed-loop process where the used semi-aqueous solution is collected. It can also be set up as a completely closed-loop process. The water and the solvents can be partly or totally reused in wash or rinse processes.

Semi-aqueous cleaners are non-ozone depleting but they may contain VOCs. Concerns with the use of semi-aqueous cleaners include aquatic toxicity, human health effects, and flammability, depending on the concentrations of water. Semi-aqueous cleaning may also entail new wastewater discharge requirements.

Carbon Dioxide (CO₂) Blasting

There are two kinds of carbon dioxide (CO₂) blasting technologies in use: CO₂ pellet, and CO₂ snow. CO₂ pellet uses small, uniform pellets of solid CO₂ as a blasting medium. CO₂ pellets are shot at a surface with air or other gases to strip paints and to remove grease and oil. CO₂ snow uses soft "snow flakes" of frozen CO₂ gas to clean surfaces. It has been used for removing small particles from optical components, gyroscopes, thin film mirrors, and other delicate surfaces. Little waste is generated because the CO₂ evaporates, but it is more expensive than other options.

Supercritical Fluids

Supercritical fluids (SCFs), which result from subjecting substances to temperatures and pressures above their critical points, possess properties intermediate between liquid and gases. In this state, SCFs can rapidly penetrate substrates and small spaces, dissolve the contaminants, and then be easily and completely removed since the SCFs lack surface tension. This makes it very good for cleaning complex parts with tight tolerances. Carbon dioxide (CO₂) is the most commonly used supercritical fluid in cleaning applications. This process is relatively new and expensive.

Media Blasting

The media blasting process combines an abrasive media, a pressurized delivery system and one of a variety of cleaning chambers. This method leaves no residue on the cleaned surface, but it is not typically appropriate for grossly contaminated parts, since the contaminants can cause the media to stick together. However, media cleaning is appropriate for ordinary machining oils and contaminants. Media blasting is also used for removing paint and surface corrosion. Glass beads and sand have been used as media in this process for years. The more recent use of plastic, sodium bicarbonate and wheat starch as blasting media allow the technology to be used on a wider variety of surfaces and soils. Abrasive blast waste, however, may need to be tested for hazardous waste determination and may increase waste disposal responsibilities.

Solvent Cleaning

Solvents in 100% concentration are used in a variety of cleaning applications. Some have been used for many years, such as the non-chlorinated solvents (e.g., acetone, alcohols, ketones) and petroleum distillates (e.g., mineral spirits, Stoddard solvents and naphtha solvents). Low vapor pressure solvents such as esters, terpenes, glycols, ethers and N-methyl pyrrolidone are used in some applications. Hydrochlorofluorocarbons (HCFCs) were developed as temporary replacements for chlorofluorocarbons (CFCs); however, HCFCs deplete the ozone layer, and their production is scheduled for phase-out.

For non-flammable solvents, a common method of cleaning is vapor degreasing. In this process, solvent losses occur mainly when the vapor zone is disturbed by air drafts, when the parts are lowered into or raised out of the machine, or when condensed solvent is removed with the parts. Recent developments in cleaning

equipment now offer “closed” systems for solvent cleaning to minimize releases.

No single solvent provides the perfect cleaning solution for all applications. Among the many things to consider when choosing a solvent are the potential environmental, health and safety impacts, solvency, flammability, stability, cost, whether it is a regulated VOC, and whether it is approved as a Significant New Alternative Policy (SNAP) cleaning alternative.

Assistance is Available

This factsheet gives an introduction to alternative cleaning options, but additional information and opportunities more specific to your business or industry may be available. For information or resources, or a copy of this factsheet’s companion, the **Alternative Cleaning Solvents and Processes Vendor List**, please call the nearest DEQ regional office, or call the main receptionist at (503) 229-5696 or toll free within Oregon at 1-800-452-4011.

Regional Office	Phone Number
Bend	(541) 388-6146
Coos Bay	(541) 269-2721
The Dalles	(541) 298-7255
Eugene	(503) 686-7838
Medford	(541) 776-6010
Portland	(503) 229-5263
Pendleton	(541) 276-4063
Roseburg	(541) 440-3338
Salem	(503) 378-8240

This publication is available in alternative format (e.g. large type, braille) upon request by contacting DEQ at (503) 229-5317, or TTY (503) 229-6993. Both publications are available on the DEQ web site www.deq.state.or.us.

Resources on the Internet

- RTI’s Solvent Alternatives Guide (SAGE): <http://clean.rti.org/index.cfm>
SAGE is a comprehensive guide designed to provide pollution prevention information on solvent and process alternatives for parts cleaning and degreasing. SAGE does not recommend any ozone depleting chemicals.
- Integrated Solvent Substitution Data System (ISSDS): <http://es.epa.gov/issds>
The Integrated Solvent Substitution Data System (ISSDS) has been developed to access solvent alternative information through a single, easy to use command structure.



- EPA EnviroSense:
<http://www.epa.gov/envirosense>
EnviroSense, part of the U.S. EPA's web site, provides a single repository for pollution prevention, compliance assurance, and enforcement information and databases. The search engine searches multiple web sites (inside and outside the EPA), and offers assistance in preparing a search.

- P2 Gems:
<http://www.p2gems.org>
P2 Gems is an internet search tool for facility planners, engineers and managers who are looking for technical, process, and materials management information on the Web.

- DoD Ozone Depleting Substance (ODS) MILSPEC Database
<http://assets-www.idss.ida.org>
This database contains a listing of military and federal specifications that may require the use of Class I ODS. The database includes information on each document including the identity of the ODS, how it is used, whether non-ODS alternatives are specified, potential substitutes for the ODS called out in the documents and modification/cancellation information. The database is maintained by the U.S. Navy CFC & Halon Information Clearinghouse.

- Pacific Northwest Pollution Prevention Resource Center (PPRC)
<http://pprc.org/pprc/p2tech/p2tech.html#clean>
PPRC provides a range of pollution prevention resources, including cleaning for manufacturing, are divided into several sections including an overview of the technology, technical and economic performance, an identification of research that has been done and discussion of gaps in the existing research.

<http://www.pprc.org/pprc/p2tech/COMMON96/RESLIST.html>
Cleaning-related projects, from the research projects database, are grouped by topic area.

Topic areas include aqueous and semi-aqueous cleaning research, carbon dioxide cleaning research, no-clean research, and cleanliness evaluation methods.

- Solvent Replacement for Green Processing
<http://web.mit.edu/huibers/www/greenchem.html>
This web site summarizes the solvent substitution resources currently available on the internet. A list of programs developed for property prediction, solvent replacement studies, and reaction design is also included.

- Other Links:
Ohio EPA Office of Pollution Prevention:
<http://www.epa.state.oh.us/opp/solvents>
North Carolina Department of Environment and Natural Recourse: <http://www.p2pays.org>
Colorado Department of Public Health and Environment (CDPHE) – P2 for solvent cleaning alternatives:
<http://www.cdphe.state.co.us/ap/P2/solvent.htm>
Questions and Answers on Alternative solvents:
<http://www.epa.gov/ozone/title6/snap/solvents.html>
Factsheet of Great Lakes Regional Pollution Prevention Roundtable:
<http://www.glrppr.org/topicchubs/solvents>
Alternative Solvent Degreasers:
<http://www.mntap.umn.edu/other/solvent.html>

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