

CLEANING WITH ALCOHOL AND CYCLOHEXANE

by

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Time has run out for many managers responsible for replacing ozone depleting substances (ODS) in their cleaning processes, and they must now choose between a variety of alternative technologies. Recently, many of these managers have chosen cleaning processes involving **Alcohol or Cyclohexane**. These non-ODS solvents have a **proven record of excellent results** for precision cleaning applications, and **can be implemented for relatively low cost** in safe systems that clean using the same processes as conventional vapor-degreasing equipment.

TYPICAL APPLICATIONS FOR ALCOHOL

Typical applications for alcohols include removal of particle contamination and inorganic films such as salts, fingerprints, and highly activated fluxes from:

- Precision mechanical components
- Printed circuit boards
- Hybrid junctions
- Electromechanical components
- Optical instruments
- Medical devices and components

For electronics cleaning, alcohol is used extensively for **printed circuit board defluxing** and cleaning handling soils from **critical electronic assemblies** like gyroscope and cesium beam clock components. Alcohol offers excellent cleaning results, and parts can usually **pass dielectric tests immediately** after cleaning. As alcohol is already pre-qualified for many **milspec requirements**, it can be immediately substituted for ODS processes in many critical military applications.

For precision mechanical components and optics devices, alcohol is recognized for its superior particle removal capabilities. Alcohol's polar molecular chemistry results in repulsion forces between particles and the surface. These forces tend to shield the effect of van der Waals forces and dissipate electrostatic forces to the extent that alcohol is approximately twice as effective for removal of micron-sized particles than water.¹

In the medical field, changing to some non-ODS solvents can require an extensive approval process. Accordingly, many medical component manufacturers look for aqueous alternatives,

¹ A. Patzkò, B. Várkonyi, and F. Szántò, *Acto Phys. Chem.*, 17(1-2):91 (1971).

only to find that implementing a sanitary or pyrogen-free process can be very difficult. Alcohol, on the other hand, is already **widely accepted in the medical industry** as a cleaning agent for small-scale wiping and rinsing. This acceptance allows managers of medical companies to adopt alcohol for larger-scale cleaning operations without undertaking an exhaustive approval process. Additionally, alcohol can be implemented in a **sanitary or pyrogen-free cleaning** process much more simply than aqueous alternatives. Common examples of medical devices cleaned in alcohol processes include catheter components, angioplasty devices, surgical blades, prosthetic joints, implantable heart valves, and surgical optics.

Alcohol is known for its excellent rinsing properties, and is **frequently used for rinsing and drying parts cleaned with other solvents**. For example, precision communications hardware components contaminated with a variety of light oils and particulate have been effectively cleaned with a hydrocarbon solvent in an ultrasonic bath, followed by isopropyl alcohol (IPA) rinsing. In another example, alcohol was effective in spot-free drying of high-vacuum components cleaned in an aqueous process.

CYCLOHEXANE AS AN ALTERNATIVE

Cyclohexane, a solvent with physical properties similar to alcohol and employed in identical equipment, is effective for removing organic films (oil and grease), and is frequently used to replace processes using 1,1,1-trichloroethane in precision applications.

ALCOHOL-CYCLOHEXANE AZEOTROPE--TAKING ADVANTAGE OF EACH

For certain applications involving multiple soils, **alcohol and cyclohexane can be combined in azeotropic form** to take advantage of the cleaning capabilities of each component material. This azeotrope has been shown to be effective in removing a wide variety of contaminants.

OTHER SOLVENTS

Similarly, these solvents may be **combined with other special solvents or blends** to remove particular soils. For example, a blend of 80% cyclohexane-IPA azeotrope with 20% *DuPont Axarel 38* as the cleaning agent, followed by a series of cyclohexane-IPA azeotrope rinse steps, has been used effectively to deflux circuit boards.

While alcohol (or cyclohexane) is effective for all of the aforementioned applications, there are certainly other technologies that are also effective. Yet alcohol is often chosen because it offered distinct advantages. For example, as compared with aqueous processes, the advantages of alcohol and cyclohexane include:

- **Better Solvency:** For removing soils like high activated flux from circuit boards.
- **Lower Viscosity:** Allows solvent to flush blind holes and complex geometries.

- **Better Spot-Free Drying:** Low surface tension reduces spotting on optics and similar surfaces.
- **No Corrosion:** Excellent for cleaning low-alloy metals.
- **Low Conductivity:** Motor windings can be cleaned and immediately pass dielectric tests.
- **Smaller Footprint:** Water-based cleaning requires more rinse steps and more complicated drying, resulting in a larger system.
- **Low Solvent Use:** While a large aqueous cleaner could use thousands of gallons of de-ionized water per week, even the largest alcohol cleaner typically uses less than 50 gallons of solvent per week.

There are, of course, many other options for managers who cannot use aqueous processes. While each of these options has its advantages and disadvantages, managers who choose alcohol or cyclohexane over these other options are frequently motivated by cost. The **cost of alcohol**, for example, is **typically \$2-3 per gallon**. As a comparison at the other end of the cost spectrum, perfluorocarbons (PFCs) also have good rinsing properties, but typically cost \$14 per pound, or about \$196 per gallon. Similarly, alcohol and cyclohexane disposal can be accomplished by incineration. The pick-up and handling cost to incinerate the alcohol is typically \$2 per gallon. when the solvent is recycled as a fuel in industrial processes.

Another factor that influences managers' decisions to use alcohol or cyclohexane is the relative **simplicity of the cleaning process**. System designs are **identical to conventional vapor-degreasers** from a cleaning process perspective. Operators using a conventional vapor degreaser see little difference from a process standpoint when the equipment transition is made. Of course, equipment for alcohol does differ from conventional equipment in that it is designed for use with low flash point substances.

Finally, a major reason managers turn to cleaning with solvents like alcohol is that these solvents **deliver the cleanliness results** they require. For example, cleanliness testing was recently conducted in a four-stage cleaning system using an isopropyl alcohol-cyclohexane azeotrope in the first tank followed by a series of alcohol rinses. The system is used to clean high vacuum components. Some of the components are cleaned with an aqueous process and then rinsed with the alcohol, and some of the components are cleaned by the alcohol-cyclohexane azeotrope. The process test parameters were as follows:

1. Ultrasonic immersion	Isopropyl Alcohol/Cyclohexane Azeotrope	60°C
2. Ultrasonic immersion	Isopropyl Alcohol	70°C
3. Immersion rinse	Isopropyl Alcohol	40°C
4. Vapor rinse	Isopropyl Alcohol	80°C

The major contaminants of concern were fluorine, sodium, chlorine, silicon, zinc, and calcium. ESCA analysis showed micro-layer contamination by these elements less than 0.5 %. The operator's cleanliness specification is 2%.

LOW FLASH POINT CONSIDERATIONS

Given that companies selected alcohol cleaning because they were able to get good cleaning results at low cost, it is important to understand how the low flashpoint issue was addressed.

In the United States, equipment designed to use solvents with low flash points must be "explosion-proof." "Explosion-proof" is a term that has an officially recognized meaning as defined by the National Fire Protection Association (NFPA). NFPA sets standards for the design, installation, and operation of equipment that uses liquids that are "flammable." Solvents like alcohol and cyclohexane are classified as Class 1 B Flammable in accordance with the NFPA definition of flammable:

"Any liquid having a flash point below 100°F (38°C) and having a vapor pressure not exceeding 40 psia (2069 mm Hg) at 100°F."

Properly applied, the **NFPA standards allow widespread use of flammable substances with relatively little safety risk.** For example, very few people stop to think about the risk of fire when they fill their automobile with gasoline, yet gasoline is a particularly flammable substance. Fortunately, gasoline dispensing mechanisms conform to applicable fire protection standards, and the risk of fire is very low. More importantly, the risk of fire is outweighed by the benefits of using gasoline as automobile fuel.

Like suppliers of automobile refueling equipment, suppliers of "explosion-proof" cleaning equipment designs should be able to **explain how their designs meet applicable NFPA standards.** Experienced vendors will have had their designs certified for safe use with flammable solvents by a nationally recognized testing laboratory, such as **Underwriters Laboratory (UL) or Factor Mutual (FM).** An added benefit of the certification is that introduction of this type of equipment into a facility will **not typically increase insurance rates.** Finally, many vendors can provide a list of "safety references"--other companies using similar designs--that can be called to **discuss the system's safety record.**

When considering cleaning systems for use with solvents like alcohol, primary design considerations to prevent a fire are:

- to keep the vapor concentration outside the system well below the lower flammable limit, and
- to prevent spark or flame initiation inside the system.

Based on this criteria, the **typical explosion-proof design features** include:

- **Intrinsically safe devices** used in high vapor concentration areas of machine.
- **Ventilation exhaust** system to limit vapor build-up outside the intrinsically safe areas
- **Positive monitoring** of exhaust flow.
- **Nitrogen purge** of electronic equipment that is not intrinsically safe. (e.g. ultrasonic transducers).
- **Monitoring of solvent vapor concentration** by independent sensors.
- **Warning devices and automatic shutdowns** if vapor levels reach specified levels.
- **Fire detection and automatic suppression.**

SUMMARY

Hundreds of facilities throughout the world have successfully eliminated ozone depleting substances from their cleaning processes by switching to **alcohol** or **cyclohexane**. Managers who have chosen alcohol have recognized that systems **can be designed to operate safely**. Alcohol has a **proven record of excellent results** for precision cleaning applications, and **can be implemented for relatively low cost** in systems that clean using the same processes as conventional CFC equipment.

PRECISION CLEANING AND DRYING IN IPA AND COSOLVENT SYSTEMS

by Anthony Durante, Ph.D.

Abstract:

Precision cleaning and drying with isopropyl alcohol (IPA) and cosolvents are discussed. But, cleaning with IPA is not new and it is a widely accepted and effective solvent in many industrial applications. What is new is a technology which safely deals with volatile organic solvents like IPA at their boiling points, so that they can be utilized in vapor degreasing and cleaning operations. Other solvents such as volatile silicones, IPA/hydrocarbon azeotropes and low boiling alcohols can also be used. This new technology, coupled with proven, high performance CFC alternatives for cleaning and fast evaporating solvents for drying, will be of great value for precision cleaning of small parts, complex geometries and water sensitive components and devices. Parts whose shape and size are likely to entrap water in aqueous and semi-aqueous processes can be effectively cleaned and dried, residue free with this familiar vapor degreasing process. Since the process uses no water, there are no problems associated with water spotting, nor with waste water management.

The process involves immersing parts in a selected cleaner or solvent to loosen and remove oils, greases, waxes and other soils. Then parts are rinsed and dried in IPA vapors. This is accomplished in a single tank where parts are cleaned in a boiling blend of IPA and cosolvent and dried in IPA vapors above the liquid surface. Alternatively, this is accomplished in two tanks where each solvent is contained separately, one used for washing and the other for rinsing and drying. In both cases, the parts emerge clean, dry and residue free.

Introduction:

Cleaning processes for parts and tools in industry are being profoundly affected by several trends which are now shaping precision cleaning operations. Environmental regulations and global agreements are forcing industry to seek alternatives for CFC's and other ozone depleting substances used for cleaning, stripping and degreasing. As a consequence, the introduction of numerous alternatives in both cleaning chemicals and process equipment has caused confusion because of the multitude of combinations now possible. Numerous manufactured parts have been developed with unique design criteria specifically intended to facilitate new cleaning and drying techniques. Many of the alternative cleaners call for multiple washes and water rinses, phase separations and new waste handling practices, all of which are unfamiliar to many users.

Since there is no single solution, there is also no single selection process which can completely satisfy manufacturers besieged with the need to change. Some have chosen to first select a chemistry which works well with their particular soils and substrates, and have

later matched this with specifically designed equipment. others have taken the reverse approach: first, equipment; then chemistry.

since there are no "drop in" replacements, any alternative cleaning technology will require investments in new equipment and in the time required to learn about its operation. The cost of owning this equipment is the sum of the costs associated with buying the equipment and those associated with its daily operation, which includes utilities, chemicals, waste disposal and maintenance.

There is genuine need for a complete systems approach to cleaning without compromising product performance or reliability, without adversely affecting worker safety or the environment, and without involving complicated wash/rinse cycles and waste management practices. Cleaning and drying precision parts in IPA and cosolvent systems offers a fresh approach, based on familiar vapor degreasing practices. The success of such systems requires process equipment capable of meeting strict safety standards for handling a variety of low boiling solvents.

IPA is a non-ozone depleter, is not a significant global warmer, has been used for years for cleaning precision parts by hand, is used in the EPA/DOD/IPC Phase II testing, and is included in the EPA's Significant New Alternatives Program (SNAP). IPA, either alone or together with other less volatile CFC and ODC alternatives will provide a long term solution to cleaning precision parts.

The technique has allowed residue free cleaning of the complex geometries found in optics, military appliances, electronic components, semiconductors, circuit board assemblies, medical implants, and other applications where cleanliness is critical to performance and reliability.

Discussion:

For years isopropyl alcohol (IPA) has been the solvent of choice for cleaning and drying semiconductor wafers in the final and most critical stages of their fabrication. Drying in circulating hot air or other gases necessitates very high purity and careful submicron filtration to prevent the risk of contaminating these high value wafers. The basis for selecting IPA was that it is easily vaporized at low temperature to create a particle free environment of IPA vapors, which are capable of extracting water entrapped in the fine line geometries of microelectronic devices. The physical properties of IPA are listed in Table 1.

Thus, the use of IPA and the equipment required for its safe handling in the vapor state are now well understood. Although IPA alone is an excellent dehydrating agent, its capacity for dissolving a broad range of soils is limited. A large number of cleaners have emerged since the beginning of the ozone crisis. Many are well proven and meet a variety of selection criteria imposed by end users.

No single solvent will meet all the cleaning needs of industry. IPA is no different, and may lack the potency for specific cleaning

applications. Thus blends with other organic solvents offer promise for attacking a broader range of soils. Azeotropes of IPA and hydrocarbons offer a good balance of polar and non polar activity to enhance the solvent's ability to clean.

Three common azeotropes with IPA are listed below:

<u>HYDROCARBON</u>	<u>%</u>	<u>bp °C</u>
n-heptane	50	76
cyclohexane	32	69
n-hexane	23	63

These alternatives, which at one time would have been dismissed, are now viable because of the advances made in equipment and safeguards designed to handle flammable solvents in the vapor state. The equipment and the safe handling techniques for IPA apply also to these blends, opening up their chances for replacing ODC's in vapor degreasing equipment specifically designed to handle these and other low boiling solvents.

Many ODC alternatives have been developed over the last few years (*Precision Cleaning*, Feb. 1994), and some have gained a respected place in precision cleaning applications. All of the alternatives fall into the several categories listed in Figure 2.

Hydrocarbons are synthetic and naturally derived products which are non-polar, aprotic solvents, particularly suited to attack and remove soils like oils, greases and waxes which are chemically similar to the solvents themselves. Some of these are blends of natural and synthetic hydrocarbons together with other materials such as ester, ethers and glycols. The higher boiling members of this category have low vapor release, reducing the risk to workers and the impact on the environment. However they pose a drying problem in cleaning parts with complex geometries because of the potential entrapment of solvent in blind holes and tight clearances.

Semi-aqueous systems are based on surfactants (soaps, detergents, alkaline materials, etc.) blended with the hydrocarbons in the class mentioned above. The surfactant is added to improve their activity as a broad range cleaner and to facilitate rinsing in water. A typical cleaning process, depicted in Figure 3, requires multiple washes in the cleaner, followed by multiple rinses in water (often DI water) to free the part of residual solvent and surfactant. The rinse water requires continual phase separation to isolate and remove soils from the water which could be recirculated through the system. Parts drying, potential water spotting, corrosion and waste management issues of the solvent and the rinse water must be addressed when designing systems for these alternatives.

Aqueous systems essentially consist of detergent solutions for parts washing, followed by water rinsing. This category of cleaners is becoming widely accepted in industrial cleaning because of their safety, ease of operation and low cost. Water based cleaners are effective in removing light soils like machining and cutting oils,

and can remove heavier soils using agitated, hot cleaning solutions over long cleaning cycles. Drying, corrosion and waste management issues must also be addressed with these cleaners.

Water soluble alternatives are a class of polar organic chemicals which are completely miscible in water. The cleaning process is similar to that described for the semi-aqueous cleaners above and depicted in Figure 3. In this category are alcohols, glycols, ethers, organic amines, pyrrolidone and other water soluble solvents. Because these products tend to preferentially attack polar soils, they are well suited for cleaning and removing synthetic oils, rosins, paint, inks and other tightly bonded soils. Enhanced performance in cleaning non polar soils is attained in some of the commercial products by blending these and other materials such as organic acids and amines, surfactants and less polar solvents. Water rinsing and the problems associated with it must be addressed.

Cosolvent systems open the possibility of using any qualified alternative from those listed in Figure 2 for washing, followed by rinsing in a fast evaporating solvent. It is this final solvent rinse which facilitates drying. special material handling during this drying stage is required because fast evaporating solvents are usually regarded as flammable. Equipment capable of meeting strict safety standards is essential to the success of this technology.

Isopropyl alcohol and the cleaning equipment employed for IPA vapor drying have been adapted to these cosolvent systems. The processing is very similar to that of familiar vapor degreasing operations. Work has been conducted with cosolvent systems of IPA and several of the alternatives listed above. Parts requiring precision cleaning have been successfully cleaned by this method.

The IPA / Cosolvent clean and dry system can be operated either in a single tank or in two tanks, as outlined in Figure 4.

Cleaning in a single stage operation, depicted in Figure 5, employs in a single process tank partially filled with a boiling mixture of IPA and a high boiling solvent. Typically the mixture contains 20% of the selected high boiling solvent in IPA. The vapor space above the liquid level is rich in super heated IPA vapors which flush around and through the parts to rinse and dry them. soils which collect in the boiling sumps are continually withdrawn and concentrated in a waste accumulator. This device distills the mixture and returns super heated IPA vapors to the process tank where they condense to once again participate in the cosolvent cleaning operation. The residues of distillation, which are a highly concentrated mixture of the soils in the higher boiling cosolvent, are sent to fuels blending. A small amount of coalvent must be added periodically to the boiling mixture to balance that lost to waste.

In the two stage operation, Figure 6, the cosolvents are separated so that cleaning is accomplished by a selected cleaner in one tank, while rinsing and drying are done in the second tank containing only boiling IPA. conditions of temperature, immersion time and agitation required for cleaning can be fine tuned, independent of

the conditions for rinsing and drying. compared to the single tank design, higher soil loadings are possible with this arrangement because of the greater volume of cleaning solvent contained in the first tank. Also final rinsing is more precise because the vapor zone is generated by relatively pure boiling IPA, contaminated only with minor amounts of solvent carried out of the first tank. As in the single tank operation, the boiling IPA is continually purified by the distillation unit. In this instance, however, the distillation residues can be returned to the cleaning tank for reuse, as they contain very little concentrated soil.

The solvents which have been used in this IPA/ cosolvent cleaning method are listed below:

<u>SOLVENT</u>	<u>PRODUCER</u>
Axarel 6100	DuPont
Axarel 9100	DuPont
Axarel 36	DuPont
N-methyl-2-pyrrolidone	BASF
Ionox FCR	Kyzen
OS-10	Dow Corning
OS-20	Dow Corning
MicroPure CDF	International Specialty Products
Shipshape	International Specialty Products
PartsPrep	International Specialty Products

These solvents have been used in conjunction with IPA in commercially available vapor cleaning and degreasing equipment produced by S&K Products International. The Model IG-200 is a one tank design for single stage operation, and Model IG-300 is a two tank design for two stage operation. A variety of precision parts have been successfully cleaned by this technology, parts such as:

- Precision bearings
- Glass photo masks
- Aerospace guidance devices
- Multichip modules and hybrid devices
- Surgical equipment
- Intimate contact medical implant devices
- Precision optics
- Gyroscopes
- Circuit board assemblies
- Fiber optic connectors
- Microelectronic components

Conclusions:

A new cleaning method which employs isopropyl alcohol and other solvents in a familiar vapor degreasing configuration has been developed. Because the process relies on vapor cleaning, precision

parts with complex geometries and blind holes can be cleaned and dried residue free. No water is used in the process and so there is no need for a DI water source to reduce water spotting, and no water treatment or disposal issues arise. The technology allows for using a wide selection of cosolvents, which allows cleaning a broad range of soils and substrates. IPA is readily available at low cost, is easy to recover and reuse, and requires low energy to produce a robust vapor zone, capable of cleaning and drying a large number and variety of parts. IPA is compatible with most metal and plastic materials, and so is safe on many composite parts. Affordable equipment is readily available to safely support IPA and other low boiling solvents. Because the process is simple and confined to one or two tanks, the equipment design will naturally occupy a small footprint, fitting easily into clean rooms or clean areas. Cost of ownership is competitive with process equipment designed to support many of the ODC alternatives on the market today.

PHYSICAL PROPERTIES OF IPA

Boiling Point (1 atm)	82.3°C (180°F)
Flash Point (CC)	12°C (53.6°F)
Relative Evaporation Rate (CFC-113 = 100)	17
Density (gm/cc @ 20°C)	0.787
Heat of Vaporization (Btu/lb)	287
Occupational Exposure Limit (ppm)	400
ODP	zero

Figure 1

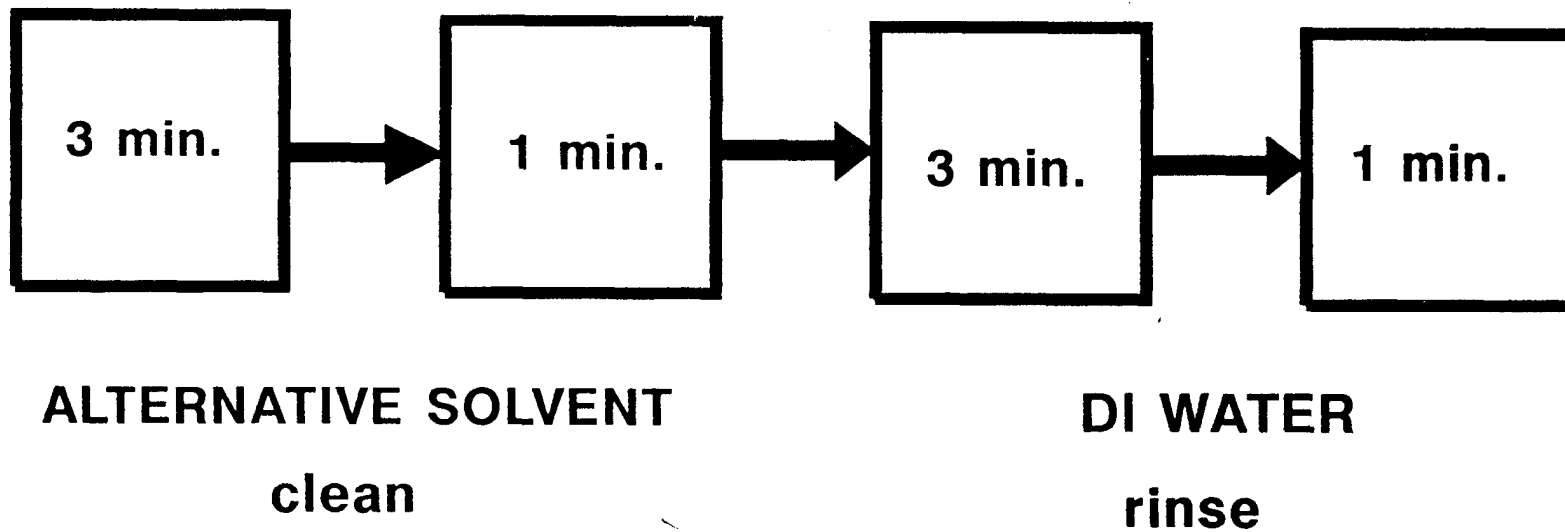
CFC ALTERNATIVES CLEANING and DEGREASING

- HYDROCARBONS ----- Synthetic
 - Mineral Spirits
 - Terpenes
 - Naphthas
- Natural
 - Limonenes
 - Terpenes
- SEMI-AQUEOUS ----- Surfactant / Solvent with Water
- AQUEOUS ----- Surfactant / Water with Water Rinse
- WATER SOLUBLE ----- Solvent Wash with Water Rinse
- COSOLVENT ----- Solvent A Wash; Solvent B Rinse
(Solvent B is fast drying)

Figure 2

ALTERNATIVE SOLVENTS OPERATING PROCESS

IMMERSION TANK CLEANING *

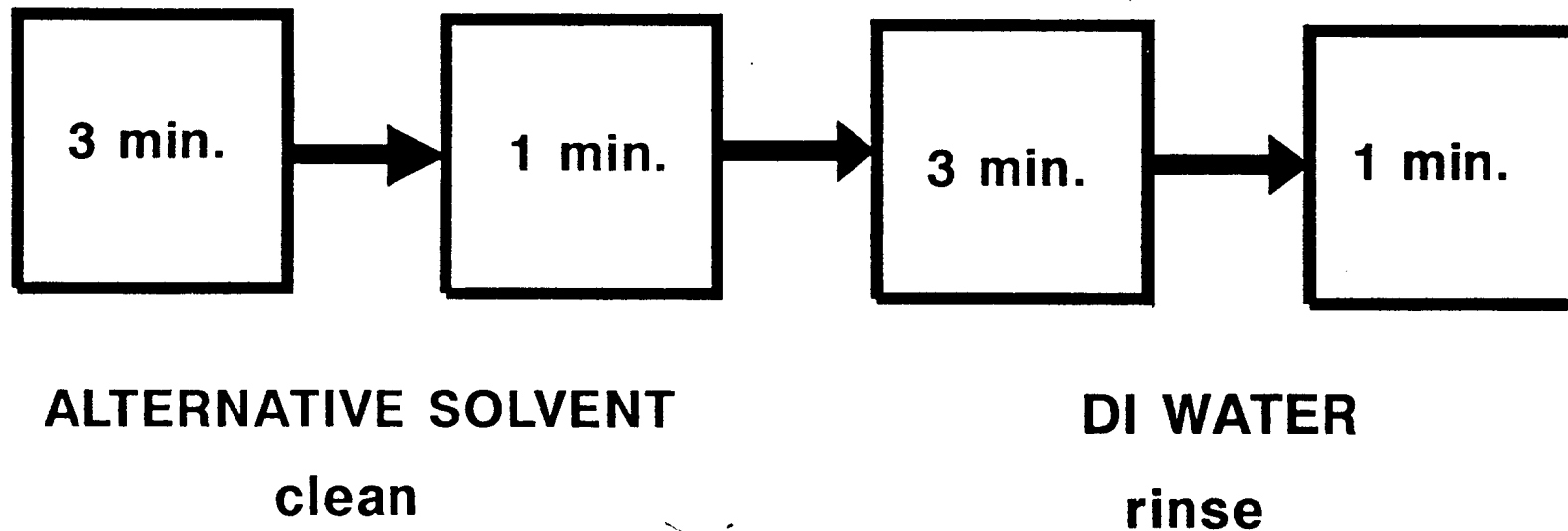


*
With Agitation

Figure 3

ALTERNATIVE SOLVENTS OPERATING PROCESS

IMMERSION TANK CLEANING *



*
With Agitation

Figure 3

IPA / COSOLVENT CLEAN AND DRY SYSTEMS

SINGLE STAGE OPERATION:

IN ONE PROCESS TANK -----

Clean in Boiling IPA / Cosolvent Blend

Rinse and Dry in IPA Vapors

TWO STAGE OPERATION:

IN #1 PROCESS TANK -----

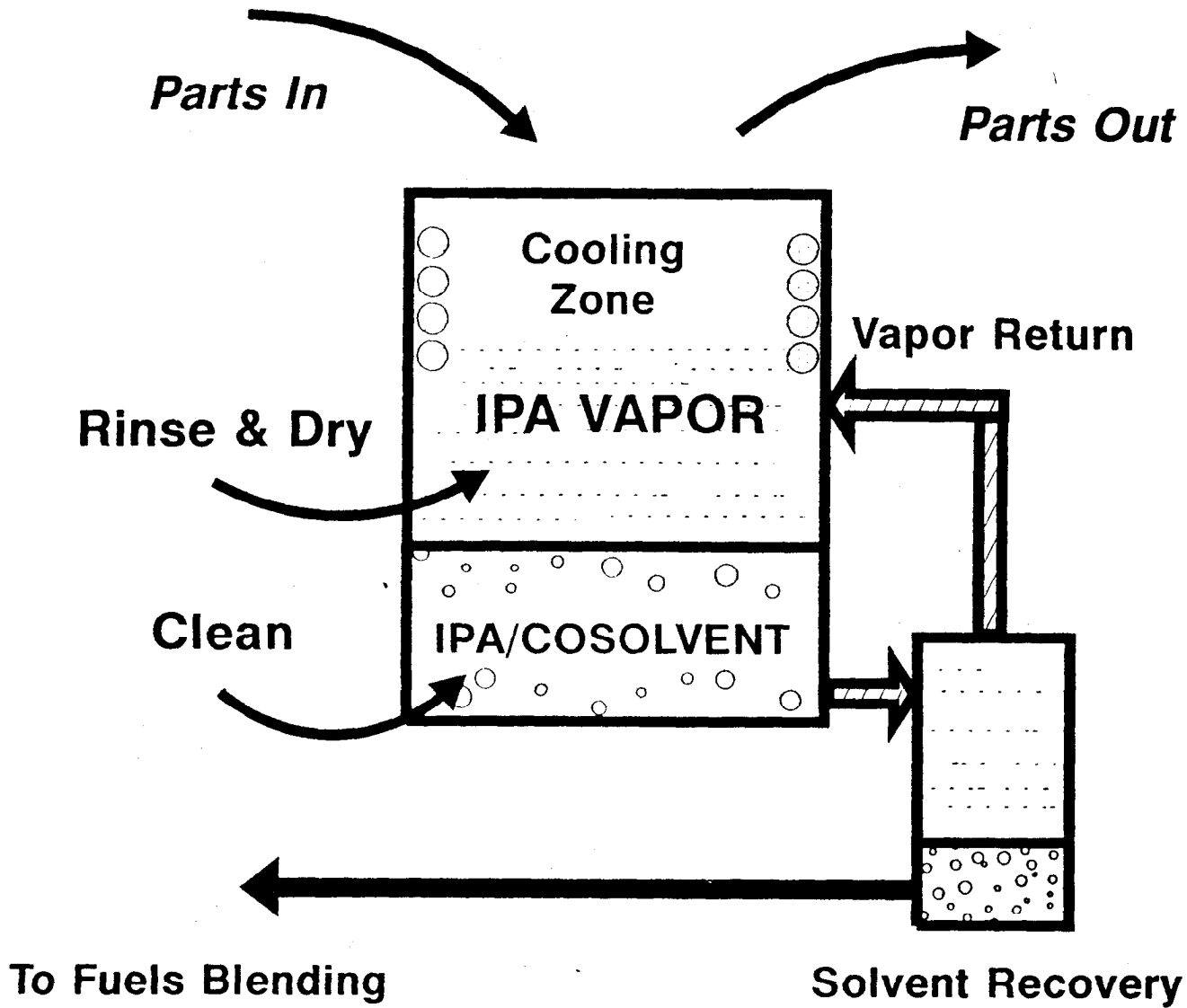
Clean in Cosolvent at Selected Conditions

IN #2 PROCESS TANK -----

Rinse and Dry in IPA Vapors

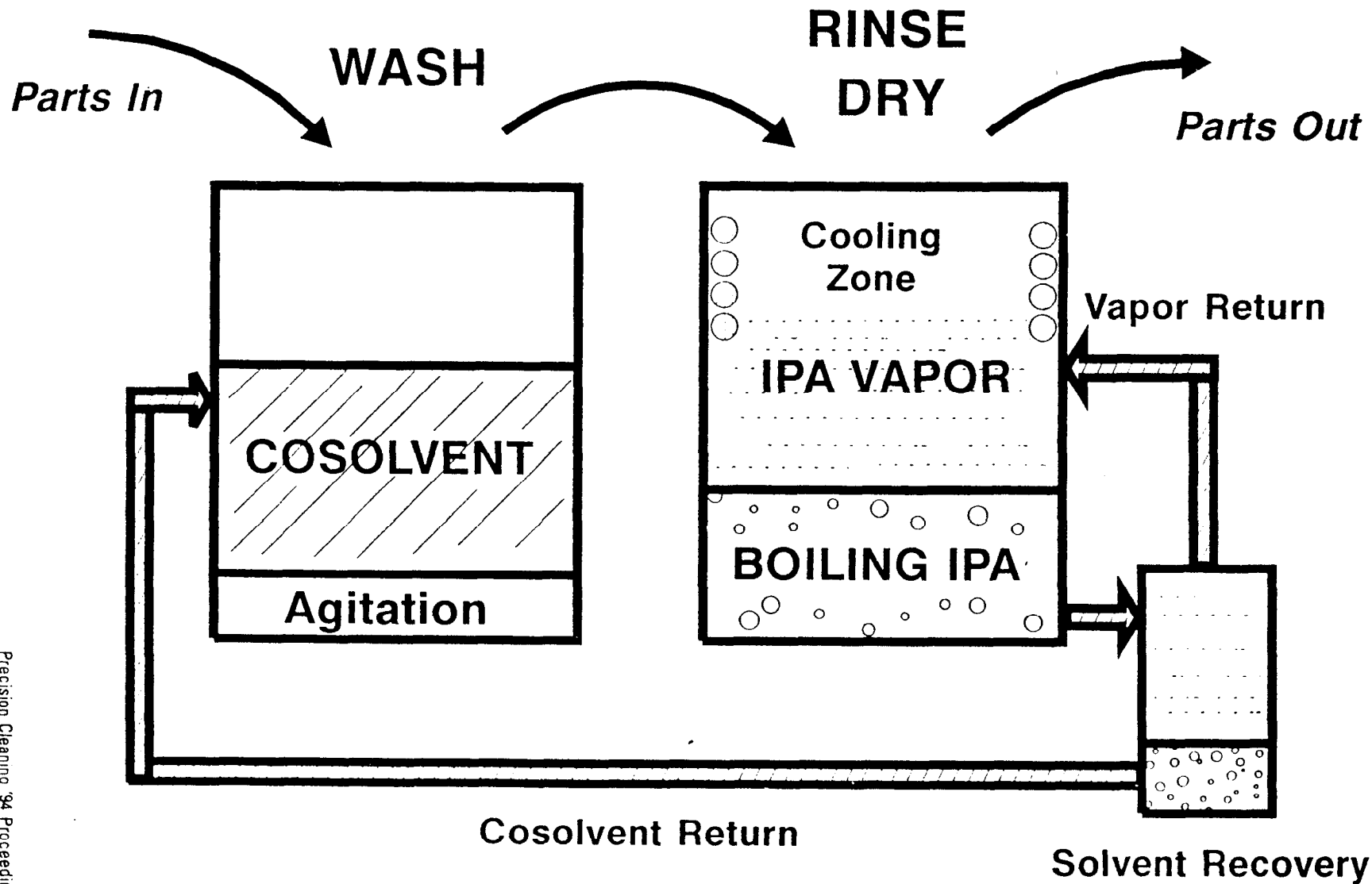
Figure 4

IPA / COSOLVENT CLEANING



Single Station Clean and Rinse System

IPA / COSOLVENT CLEANING



Two Station Clean and Rinse System

Figure 6

Two-Phase Solvent Precision Cleaning System

b y

Robert L. Polhamus

ABSTRACT

The emergence of aqueous and semi-aqueous chemistry as the accepted alternative to Ozone Depleting Substance (ODS) elimination is not able to supply the necessary answer to all cleaning problems. In some applications, water can be detrimental to the components or incomplete drying may result in product failure. The semi-aqueous and solvent/solvent processes may leave trace amounts of residue on components that make the parts unsuitable for some critical applications. Although water and detergent formulations along with semi-aqueous chemistries can provide a wide spectrum of cleaning options, the applications are equally diverse and, in some cases requires an application specific solution. A product and process that can combine the positive aspects of two chemistries while negating or controlling the negatives can offer an additional option in arriving at an optimum solution. The Alternative Cleaning Technology (ACT) has been developed to address this issue.

INTRODUCTION

The elimination of Ozone Depleting Substances (ODS) has created new opportunities for some users within different industries to reevaluate the way they were cleaning their components and how cleaning fits into an overall manufacturing strategy. With the rediscovery of water as a cleaning media and the reformulation of conventional aqueous detergents to more soil specific applications, aqueous cleaning is beginning to dominate applications that had been cleaned with solvents for many years. For those applications where water and detergent do not provide the necessary cleaning power, the development of semi-aqueous chemistry cleaning has filled a need. By carefully evaluating the properties of each of these options, a solution can be found that essentially guarantees the elimination of ODS from industrial cleaning. The limiting factors to full implementation of aqueous or semi-aqueous cleaning usually center around drying and waste handling. As better drying methods and waste management systems are developed these hurdles will also be eliminated.

However, one major obstacle still remains to the complete elimination of solvent cleaning with aqueous or semi-aqueous substitution. There are certain applications and materials to which water is detrimental. These are usually high precision needs where water will deteriorate the performance of the product by producing surface changes and

/or incomplete water removal can result in product failure. An example of this is a high precision bearing where during cleaning, rinsing, and subsequent drying., the presence of water could produce a fine oxide layer thick enough to result in product failure. In medical applications, the use of water in cleaning or rinsing could lead to the deposit of harmful organisms on the components making them unusable for their intended purpose. Many such examples exist. These applications still rely on solvent cleaning due to the inability of water to produce the desired results.

NON-WATER CONTACT CLEANING

One option for non-water contact cleaning is to use hydrocarbon immersion cleaning with single or multiple solvent immersion rinsing. In this process, a dirty part is immersed in a hydrocarbon bath where the soils are solubilized in the cleaning agent. The product is then removed from this bath and placed in subsequent immersions for rinsing. These baths may either be the same as the cleaning chemistry, although less contaminated, or may be a different chemical capable of removing the cleaning hydrocarbon. After achieving the proper level of rinsing, the hydrocarbons are evaporated from the surface. This process, although suitable for some applications, will not satisfy the complete range of needs. In some instances the hydrocarbon will leave behind a small amount of residual material which is often unacceptable in the strictest cleanliness requirements. Many of these products recommend air drying and, due to the evaporation rate, this process can be somewhat time consuming and may not meet the demands of high volume throughput. There are also restrictions to hydrocarbon emissions in some geographies and the capture and reclaim of these materials can pose some technical difficulties.

The chemical properties that have made ODS desirable cleaning chemicals centered around; adequate solubility for the soils encountered, low toxicity, non-flammability, and reclaimability. These characteristics, in conjunction with relatively low usage cost and a simple process, allowed these chemicals to become a dominant factor in a wide range of cleaning applications. It does not appear that in the near future there will be substances available that can combine all of these characteristics. However, a process has been developed that incorporates two chemicals that , when their properties are combined, produce a suitable replacement.

The Alternative Cleaning Technology (ACT) process utilizes a two phase system with liquids of different physical properties. One liquid provides the cleaning power whereas the second liquid is used to rinse the cleaning chemical and is subsequently dried off the surface. Much of the development work on this process has utilized isopropyl alcohol as the primary cleaning agent and a fully fluorinated hexane, referred to as a perfluorinated chemistry (PFC), as a rinsing, drying, and inerting agent.

THE ACT CLEANING PROCESS

The cleaning power of isopropyl alcohol is well documented, but due to its flammability, it has not achieved wide acceptance. The perfluorinated materials have been

around for quite some time and their low toxicity and chemical properties has allowed them to be acceptable in various applications. And although their physical properties mimic those of ODS, their lack of cleaning power has made them unsuitable for cleaning, in general. By combining these two materials in the same system, we are able to achieve a high level of cleaning power while producing a safe, effective, environmentally compliant process.

The ACT process is very similar to the conventional vapor degreasing process. The equipment consists of a two sump design where the left hand sump produces a vapor blanket and the right hand sump provides immersion in pure distillate chemical for precision cleaning.

Unlike the single liquid vapor degreasing process where the boil sump and immersion sump are comprised of the same chemical, in this system the alcohol and PFC remain distinct due to their immiscibility. The alcohol, being much less dense than the PFC, forms an upper layer in each sump with the PFC on the bottom. The beneficial PFC properties of having a higher density and lower boiling point are the key to the process.

In the boil sump, the PFC material is boiled and percolates through the alcohol level to produce a high density vapor blanket above both sumps. The boiling point of the PFC is around 50 deg. C. The boiling point of the isopropyl alcohol is around 82 deg. C. The vapor blanket is composed of approximately 90% PFC and 10% alcohol. At this concentration the vapor is non-flammable. Since the vapor has displaced all atmosphere above the sumps we have eliminated the flammability hazard of using alcohol at elevated temperatures.

The vapor blanket is contained by a primary cooling coil that operates at a temperature significantly below the boiling point of the PFC. Cold water or direct expansion refrigeration can be used to condense the vapors. The vapor condensate is captured in a condensate trough and fed into a distillate reservoir. In the reservoir, the alcohol and PFC liquid fractions separate with the alcohol rising to the top. Once the reservoir is filled, the liquid volume overflows back into the immersion sump. Since the alcohol is concentrated in the upper layer, it flows back into the sump leaving the reservoir full of PFC.

The reservoir overflow enters the immersion sump where the alcohol and PFC exist in separate layers. The PFC sinks to the bottom, and through a standpipe, is returned to the boil sump. The alcohol level overflows a weir separating the boil and immersion sumps and carries soils removed in the immersion sump into the boiling sump. This completes the distillation/purification cycle that maintains a clean immersion sump.

The cleaning process is similar to the conventional degreaser in that the product is introduced into the area above the boil sump for a pre-clean vapor rinse or can be immersed directly into the boil sump for boiling agitation cleaning. Although the PFC is boiling and the alcohol is not, the PFC vapors that pass through the alcohol create a strong

rolling action that will remove a significant amount of soil. After pre-cleaning in the boil sump, the product is transferred to the immersion sump where ultrasonics or other forms of agitation are applied to accomplish the required cleanliness level. After immersion the product is removed to the vapor zone where pure distillate is used to flush off any drag-out from the immersion sump. Drying takes place and the product is removed from the unit.

Although this basic process description is similar to that of conventional vapor degreasing, all similarity ends there. Due to the nature of the two-phase chemical system and a need to control drag-out emissions to minimum levels, there are several process parameters and equipment features that are unique to this process.

EQUIPMENT DESIGN

The ACT equipment depicted in the BASIC SYSTEM DESIGN schematic has several features designed to control vaporous emissions that are not usually found on conventional vapor degreasers. Past industry data has shown that liquid drag-out caused by low vapor zone residence times and rapid transportation of product in and out of the machine are the largest source of losses. In some instances over 70% of losses can be contributed to these factors. The next largest source is usually vapor loss at the vapor/air interface through atmospheric air exchanges in the freeboard area. Finally, the last common source of emissions is the drag-out produced by a micro layer of condensate on the product surface. The ACT design addresses these aspects.

The ACT system is designed with two independent internal lift mechanisms to move the product vertically within the unit. These are illustrated in the schematic. This eliminates the operator from the process and allows slow controlled motion to reduce vapor blanket collapse. In addition, since this step is automated, an operator no longer needs to perform the tedious task of suspending the parts baskets in the various process areas. This allows extended residence times in the vapor zone that are often cut short when manual operation is involved. Automation of the process has shown to contribute significantly to emission reduction. An external hoist is capable of performing this same function, however, the internal hoist provides an additional benefit. The internal hoist allows the cover to be closed for the duration of the processing. Since there is no robot arm to interfere with the cover, the ACT cover is closed and pneumatically sealed during the entire cleaning process. By sealing the lid there exists further insurance against emission losses caused by process parameters such as spray and vapor collapse. The closed lid also reduces the opportunity for air exchanges within the freeboard area, further reducing emissions.

In order to control the vaporous emissions at the vapor/air interface, a super cooled freeboard area has been built into the system. This chiller operates at -20 deg C, creating an extremely cold blanket of air above the vapor zone. The location of the chiller plate is depicted in the schematic. Due to the low temperature there is very little solubility

for PFC vapors and they fall back down into the vapor zone. This temperature is also adequate for trapping the vast majority of alcohol vapors that may rise up.

The last area of emissions to be addressed is the micro layer of condensate trapped on the product surface. In a conventional degreaser, the final vapor rinse is done to flood off drag-out from the immersion sump and to vaporize liquid condensed on the surface. During this rinse/dry phase the condensation of vapor on the parts causes the part temperature to approach the boiling point of the liquid. Since the temperature of the parts cannot reach the boiling point of the fluid, eventually an equilibrium between condensate and vapor is established producing a microscopic layer of liquid which remains on the surface. When the product is removed from the system, this liquid generally flashes off very quickly in either the freeboard of the degreaser or outside the machine. In most cases, this material is lost to the atmosphere.

The ACT system has been designed with the ability to superheat the parts to raise their temperature above the boiling point of the PFC helping to eliminate this micro layer. During the cleaning process, the parts are immersed in the alcohol level within the immersion sump. After the cleaning is performed the parts are removed from the sump coated with alcohol. The alcohol is not volatile enough at the vapor blanket temperature to quickly or adequately dry the parts. PFC condensate from the condensate reservoir is sprayed onto the parts to displace the alcohol from the surface. As shown in the schematic, the spray takes place within the vapor zone just above the liquid level in each sump. The liquid spray is immediately followed by a superheated vapor that condenses on the parts and heats the parts to a temperature above the PFC boiling point. This significantly reduces the micro layer of PFC condensate found on the surface. After going through several cycles of liquid and superheated vapors, the parts are raised into the freeboard area where any trace amounts of liquid flash off. These vapors immediately fall back down into the vapor zone where they are contained. Since the cover has been closed and sealed during this entire step, there are no air exchanges within the freeboard area that could contribute to PFC rich atmosphere being removed from the unit.

Due to the inclusion of the aforementioned design and process features, the overall emissions of the unit can be maintained at a very low level. Actual process losses will depend on part configuration and adherence to good procedures, but should be controlled within environmental and operational cost considerations.

FUTURE CONSIDERATIONS

The ACT system has been designed around specific chemical properties and is not dedicated to a particular chemical. Other chemicals can be used as cleaning agents as long as they have the properties of, being less dense than PFC, are essentially immiscible in PFC, and have a boiling point higher than PFC. If a flammable chemical is chosen its vapor pressure at the boiling point of PFC must be low enough to produce a non-flammable concentration. Volatile Methyl Silicone chemistry is an example of a product that meets

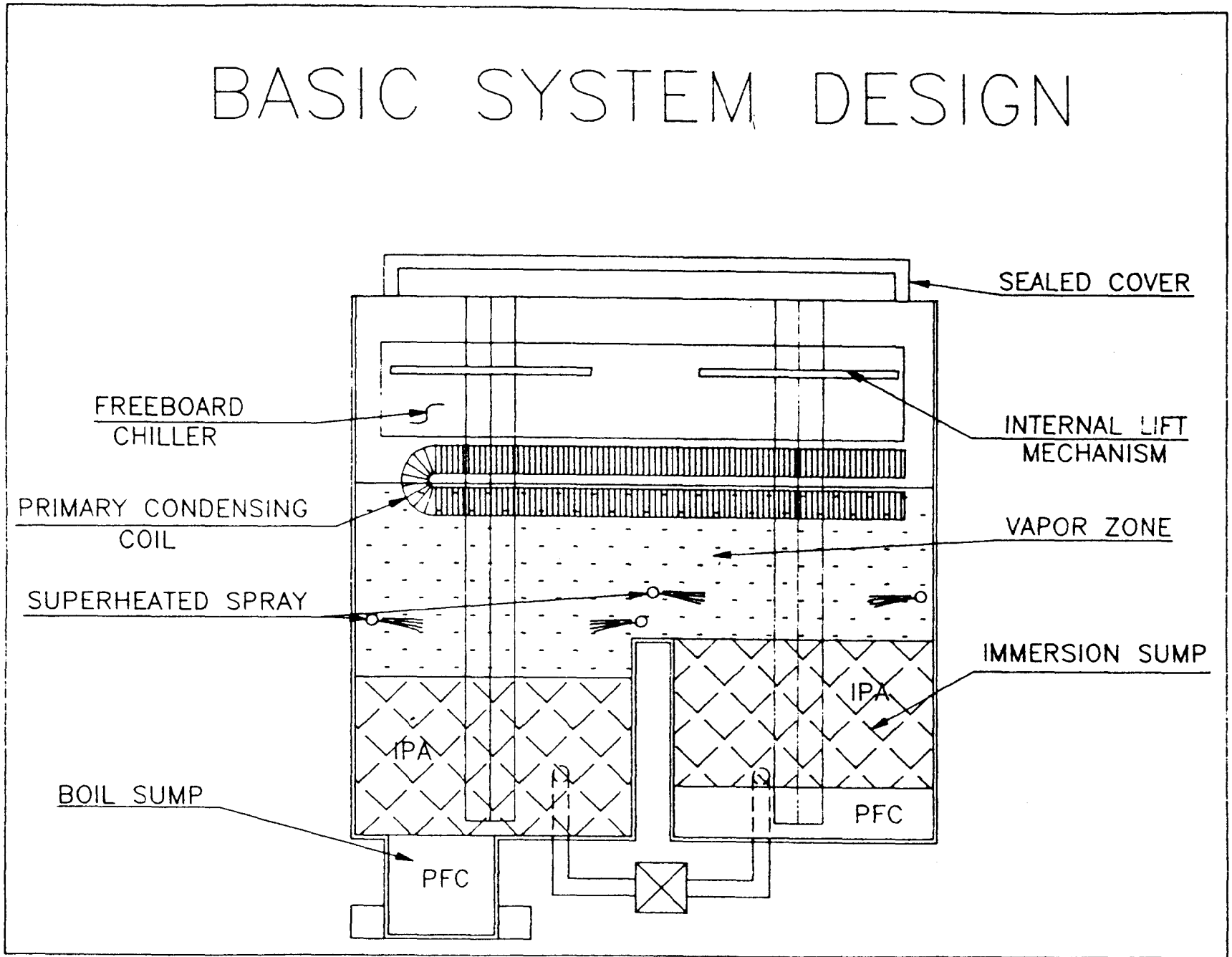
this criteria. As the process is explored and developed, other solvents will be found that perform within this process,

Next generation chemicals are being developed now that may replace the PFC in the system. These chemicals will require the characteristics of, high liquid density, low toxicity, non-flammability, preferably low boiling points and heat of vaporization. Improved environmental compatibility will also be a desired characteristic. Although PFC have Global Warming potential over which to be concerned, the controlled usage within this process makes them acceptable substitutes for ODS. Future chemistries with even better environmental compatibility will enjoy the benefits of this technology.

CONCLUSIONS

There remain some critical industrial applications where the aqueous and semi-aqueous cleaning process is unacceptable. Many of these applications still rely on Ozone Depleting Substances (ODS) in their manufacturing process. Utilization of a two-phase system incorporating a cleaning solvent and an inert rinsing/drying agent will provide necessary cleaning while eliminating ODS from the process. Proper equipment design and management will produce an environmentally compliant process in the near term while next generation solvents are being developed. Equipment design parameters will be compatible with the chemical properties of next generation solvents allowing the process to be implemented in the present with applicability to the future.

BASIC SYSTEM DESIGN



REMOVING THE IMPERFECTIONS FROM CHEMICAL CLEANERS

Dr. David Zimmerman

ABSTRACT

Recognition and acceptance that there is no perfect world, no absolute in the chemical specialty cleaners, brings with it a need to understand and explore what it takes to make "things" work. As our ability to develop and accumulate information on hazardous materials, toxic substances, air pollutants, carcinogenicity, global warming, ozone depletion, volatile organic compound emissions, clean water demands etc., so increases the gray areas of the unknown.

It is therefore, critical to appreciate that most decisions have in their formation a strong element of negotiation and compromise. To see imperfections must not halt the process of accretion. The proper use of imperfections is to move one focus in a new direction and to provide a better perspective in putting together a solution.

Gaining this perspective demands we can put our hands on data and facts we did not know or overlooked in our prior days of "cloudless skies."

INTRODUCTION

Chemical manufacturers, some of which never sold and serviced cleaning compounds prior to 1989, are now promoting products, making claims, using carefully couched hyperbole or highly structured statistics and tests to prove they are producing major breakthroughs in replacing methyl chloroform and chlorinated fluorinated compounds. The data is interesting but is it germane?

The amount of data which can now be generated may not apply to the cleaning requirements but it is certainly impressive. The "how to" separate the associated from the extraneous needs to be done. To be convinced by the weight of the facts -- by the sheer numbers -- may look good on paper in the support document files but may prove of no or limited value as it allies to a specific job and of getting it done. Today the job to be done covers the effectiveness, efficiency of the product: that it conforms to the regulations and restrictions: that it is economical and it is safe or safer to people, places and things. Forty-five year old technology is being presented with the latest scientific argot as a new concept. Older products are being redrummed, relabelled and of course renamed. All being presented to ride-out, to overcome the shock waves of the Montreal Protocol.

With a firm and secure awareness of what is being offered and a positive knowledge of what needs to be done and how replacements of MCF and CFC's are in the market, you may not need to reinvent the wheel, but only to respoke it.

All Chemical Cleaners are manifestly imperfect. There are no exceptions. Cleaners may be corrosive, hazardous, toxic, ozone depleting, global warming, carcinogenic, flammable and for all practical purposes relatively innocuous. In performance they may be successful, almost acceptable and not at all. They may remove the contaminant and destroy the substrata.

The key for the elimination of imperfections is obvious: it is necessary to fit all the pieces together, soil, substrate, application, chemical and desired results into an acceptable and viable, workable fit.

SOILS

The soils to be removed are varied, simple, complex, even exotic. Full ranging. The oils and greases may be petroleum based, animal, vegetable, metallic, synthetic, compounded, organic, inorganic, paints, carbons, resins, fluxes, rouges etc., etc. Chart I provides an overview of some soils and the difficulty of removing them.

No specific method or chemical treatment is indicated in the removal process. The very composition of some soils, active or inert, bonded to the surface or held by oil or grease, will determine ease of displacement.

CHEMICAL CLEANERS

The broad overview of chemical cleaners is generically categorized in Chart II. These are broad classifications and no attempt has been made to distinguish them. Chart II will separate cleaners in their respective genus. To assist in identification current language has now decided to employ more space-age designation. Today, alkalis are indicated as aqueous, solvents as non-aqueous, solvent emulsions as semi-aqueous/microemulsions.

ALKALI/AQUEOUS CLEANERS

There is some pertinency in this new nomenclature. Alkalis or aqueous cleaners are water based and should be rinsed to avoid leaving any residue. Water based chemical cleaners will not dry rapidly. Unless heated and hot water or steam rinsed, they may provide a rust growth area, a staining or *even* some residue. Yes, even in those situations which

require absolute chemical cleanliness, AQUEOUS CLEANERS CAN fulfill the requirement. It, obviously, may entail specialized surfactants, a superior balanced formula and D.I. rinses. Looking back at aqueous products and the almost infinite variety of ingredient combinations possible and therefore the great variety of soil removals and applications, what are the imperfections or inhibitions!

Aqueous products require more sophisticated equipment, more stages in the system, greater attention to waste stream minimization and reduction, closer scrutiny of substrata, the possibility of degradation, and increased physical plant space. The imperfections of aqueous cleaners are, usually clearly apparent: however their advantages also carry high visibility. The balance is important.

A quick overview of aqueous cleaning points up relative inexpensive product cost. Potentially safer, non-regulated, non-reportables, more employee oriented, easy to use, greater variety, more acceptable locally disposable. These positive attributes should be compared to their need for more initial expense: added cleaning and rinsing stages, greater control to insure proper level of predetermined cleanliness of finished parts and when in production systems the time required to complete the application. Aqueous cleaners have been used for a very long time and there are early references to the use of water--unfortunately we are not given any specifics on the degree of cleanliness achieved.

SOLVENT CLEANER/DEGREASERS

SOLVENTS as cleaners appeared as a strong follow-in to the Industrial Revolution. Once civilization went from hand manufacture to industrial or machine manufacture solvents became a cleaning factor. Their progressive utilization--was accelerated by the discovery of oil and its fractionated issues and the concept of the industrial production line.

From a directed phase, solvents are the antithesis of aqueous cleaners. Solvents do not chemically change soils. They dilute or solubilize. They thin out oils/greases to the edge of finitude. The growth of solvents as chemical cleaners continued with the discovery and the use of the chlorinates. First came carbon tetrachloride which maintained its front runner position for many years in spite of its deadly nature especially when inhaled by any individual who enjoyed alcoholic beverages.

CHLORINATED/FLUORINATED (HALOGENATED) SOLVENTS

Methyl chloroform or 1,1,1-trichloroethane, a by-product of the polyvinylidene chloride manufacture quickly supplanted carbon tet when it was introduced as a cleaner about 45-50 years ago. By the late 1940's and early 1950's trichloroethylene, perchloroethylene and the chloro-fluorohydrocarbons were already in the marketplace. In those early Camelot days trichloroethylene was the product of choice for vapor degreasing. "Perk" was insinuating itself as the dry cleaning solvent for wool clothing and the CRC's had made air conditioning and aerosol (pressured) containers a necessary accessory to an upscaled life style.

The chlorinates, including the fluorinates, quickly became the ultimate in the solvent cleaner market. And why not? Non-flammable, fast drying, no residue, high threshold limit values and low boiling ranges made them the products of choice. To the larger volume user their higher opening cost could be offset by distillation and recycling. They were known as the "Safety Solvents", a misnomer which persisted for more than 20 years.

Some of the same desired characteristics of the chlorinates and fluorinates actually became their Armageddon. The vast, unprecedented use of these solvents soon became a cause for technological inspection and review. Human health issues, clean air and clean water examinations revealed serious problems.

Still, it is important to recognize that these specialized solvents established a benchmark of cleaning that is virtually unsurpassed. Examination reveals:

The CFC, to include HCFC and HFC.

- are non-flammable
- adequate but not superior cleaners as calculated via K.B. values (KB).
- no residue
- adequate human acceptability
- recyclable
- extreme fast drying
- non-reactive to most substrata of the chlorinates
- non-flammable
- superior cleaners (high KB)
- no residue
- recyclable
- range from very fast drying to moderate

The imperfections became clear as technology made clean air, clean water and human contact an accessible determinate. The CFC's were ozone depleters and global warmers. MCF was a declared ozone depleter. Trichloroethylene, according to some agencies, was a suspected human carcinogen as was "Perk" and together with methylene chlorine were classified with lowered TLV's. Industry and solvent users viewed these products with apprehension, With Industry reacting to all the issues, ecological, environmental and public pressure the search was on to find substitutes.

PETROLEUM DERIVATIVE SOLVENTS

During this period the petroleum derivatives fell under scrutiny. The aromatics (the benzene, cyclic ring, naphthalenes) became human and disposal problems. The aliphatic solvents fared somewhat better but the flash point and/or slow drying restricted precision cleaning. It appeared that solvents had reached a difficult and vulnerable position. The preferred solvents with their fine tuned characteristics for cleaning were oppugned and the less effective, non-critical solvent cleaners were relegated to shop work.

The hunt was on or as Sherlock Holmes would exclaim "The game's afoot." Longer and more intensive focus on alkali or aqueous cleaners was made and, at the same time testing procedures were developed to examine the semi-aqueous or solvent-emulsion cleaners.

SEMI-AQUEOUS/SOLVENT EMULSIONS

Solvent-emulsions had been marketed for than 50 years with some degree of success. *Combining some of the advantages of solvents with aqueous (alkali) ingredients produced synergistic cleaners which removed the more difficult soils and could be rinsed free. The early semi-aqueous products primarily united either aromatic or aliphatic solvents with emulsifiers, coupling agents, surfactants and alkali boosters. They performed, were adequate and were acceptable. As the ban on aromatics took hold variations were formulated. Terpenes, paramethadienes were introduced carrying, what appeared to be, better ecological and environmental acceptance. Aliphatics were now being surrounded by complex organic solvents, a variety of surfactants, alcohols and other additives to enhance cleaning.

A significant breakthrough came with the discovery and the utilization of biodegradable solvents in the semi-aqueous compounds. Approximating the cleaning ability of the aromatics these new products would rinse adequately to meet critical cleaning criteria.

SUMMARY/OBSERVATIONS/SUGGESTIONS

AQUEOUS CLEANERS

- All water based.
- Alkaline - caustic or non-caustic, usually with boosters, buffers, inhibitors plus glycol ethers, inorganic solvents to contend with various soils and substrates.
- Water dilutable and rinsible.
- Work more efficiently on removal of animal and vegetable oils/greases. Clean broad range of soils.
- For critical cleaning results thorough rinse required.
- Cost/gallon of solution is low-to-moderate.
- Cost of time, equipment, added space due to rinse stages is moderate to high.
- Cost of waste disposal relatively low.
- Depending on formula should meet clean air regulations, VOC and be non-ozone depleting.
- Usual long tank life. Drag-out is usual loss.
- Drying Time: evaluation necessary.

SOLVENTS

- Fluorinates
 - Clean air problems.
 - Government limitation.
 - Producers are eliminating.
 - Not really an option.
- Chlorinates
 - MCF - being eliminated.
 - Others - Tri, Perk, etc.
 - Severely limited by government and public.
 - From a performance point of view, somewhat viable.
 - Depending on geographic location. Leaves no residue.
 - Not all substrata safe.
 - Low TLV - people problem.
- Aromatics
 - Considered hazards, toxic.
 - Flammable.
 - Strong odor.
 - Costly disposal.
 - Slow drying.
 - May attack some sub-surface.
 - Very limited acceptability.

- Aliphatics
 - Flammable
 - Reportable VOC possible
 - Speed of drying directly related to flammability.
 - Not easily disposable.
 - Not efficient nor effective cleaners.
 - Usually requires additional steps e.g. manual wipe/brush.
 - Not acceptable for critical cleaning.

SEMI-AQUEOUS CLEANERS

- Contain various percentages of water.
- Water dilutable--but cleaning diminished.
- Water rinse needed to give clean surface.
- May have a reportable VOC.
- Cost in use less than chlorinates.
- Competitive to top range alkaline cleaners.
- Requires testing on sub-surface to determine safety.
- May have low flash point
- Should be able to provide better features of solvent and aqueous cleaning.
- Long tank life.
- Check disposal.

There are new products being brought to market. Some are variations which would fit directly into the above three essential categories. In spite of the hyperbole, they bring very little new advances in the technology of cleaning, let alone precision cleaning. There are innovative technologies--new solvents: solvents with superior penetrative talent: solvents with higher flash points and moderately fast drying time; solvents with excellent, critical cleaning and not reportable RVOC. Now available are semi-aqueous products suitable for elevated temperatures: semi-aqueous compounds with no odor, no flashpoint, no R.V.O.C., no regulatory reportables. Semi-aqueous formula with high level cleaning performance and just about all subsurface safe are currently in the marketplace.

New equipment is being developed to employ these new products to their fullest capacity. Integrated - whole system units are available or on the drawing board to accommodate these new releases. Working with full knowledge of what needs to be accomplished--time, space, application, surface, subsurface with attention to ecology, environment and plant interior which includes OSHA as well as EPA--is the function, the job, of the cleaning user. The supplier or suppliers should be selected from those who can fill in the blanks. The wheel has been invented--now let's get from here to there where industry needs to be.

CHART I

SOIL CLASSIFICATIONS

EASY TO REMOVE - LIGHT	MODERATE TO HEAVY		DIFFICULT TO REMOVE
LUBES-PRESERVATIVES Mineral Oils Lube Greases	Palm Oils Petroleum Based	Lanolin "Cosmolene" Fatty Oils Waxes Metallic Greases	Asphalt Tars Crater Compound
OILS-CUTTING, STAMPING Soaps Emulsions	Soluble Oils Mineral Oils & Additives Sulfurized Oils Synthetic Oils Light Grinding Oils	Insoluble Oils Dye Emulsions Sulfurized Fatty Oils	Fatty Acid Soaps
ABRADING COMPOUNDS Buffing Compounds Animal - Vegetable Fats Tallow Petrolatum	Glues	Tripoli Hot Melt Glues	Solid Buffing Compounds-Rouges Stearates Silica Powder
COATINGS-CARBON-OXIDIZED OILS Oil Enamels Alkyds Air Oxidized Oils	Varnishes Zinc Chromatic Primer Gums Carbonized Oils Carbonized Fats Oilless Ena	Resins Carbonized Oils Carbonized Fats Oilless Ena	Cured Epoxy Epoxy Resins Polyurethanes Cured Phenolics
SOLIDS-ADHERED Grime Light Rust Bloom Dry Dirt	Shop Soil Rust Bloom Dry Dirt	Hardwater Scale Phosphate Coatings Heavy Rust Salt	Mill Scale Silicates Heat Scale

14 - 7.1		7+	6.9 - 0
ALKALIS	SOLVENTS	SOLVENT EMULSION	ACID
1. Caustic 2. Non-Caustic 3. Additives Organic Solvents Buffers Inhibitors Chelates	1. Chlorinated 2. Aliphatic 3. Aromatic 4. Ketones/Esters 5. Alcohols 6. Fluorinated 7. Mixtures * Water	1. Aromatic 2. Aliphatic 3. Chlorinated, Benzene All above with Emulsifiers Detergents Water and/or Organic solvents Mineral seal oils Coupling agents 4. Non-petroleum based	1. Highly corrosive Hydrochloric Sulfuric Nitric Hydrofluoric 2. Corrosive Phosphoric 3. Additives Detergents Organic solvents
SAPONIFICATION	SOLUBILIZE or DILUTE	SOLUBILIZE and EMULSIFY	CHEMICAL REACTION
<u>Removes</u> Oils, greases (especially animal and vegetable) Shop soils Grime, dirt Lubrication greases and oils Paraffin, waxes, inks, resins, adhesives Rust, scale, carbon, soot, phosphate coatings, stains	<u>Removes</u> Oils, greases (especially petro- leum or mineral) Tars, asphalt, pitch, inks, resins, preserva- tive coats, lattices, rubber waxes, finishes carbon Paints, plastics, fluxes, photoresists release agents	<u>Removes</u> Oils, greases, tars, asphalt, pitch, inks, preservative coats Grime, dirt, shop soils, soot, sludge, oxidized oils, light carbons "Crater" & "Cosmolene" Boiling oils, lubricants Some paints, waxy deposits	<u>Removes</u> Light oils Rust, scale, lime deposits, mineral residue, protein, milkstone Some atmospheric soils, inert soils Oxides Cement Heat bloom Flyash

Cleaning Options Using Terpene Solutions

Ross Gustafson

Abstract

In this session attendees will learn how to use formulated terpene products as a substitute for ozone depleting substances in cleaning operations. Several different types of cleaning procedures will be discussed including wipe cleaning and dip tank applications. These processes can be used on parts ranging from small valves or machine parts to large body panels.

Introduction

The final phase-out date for the use of chlorinated solvents is rapidly approaching. Many manufacturers are still looking for effective alternative solvents for these chemicals in their cleaning applications. The use of terpenes, as an alternative, has been widely documented and accepted.

Terpenes are a broad class of naturally occurring chemicals generally derived from plants. The two major classes are pine terpenes from the pulp and paper industries and citrus terpenes from citrus fruit juicing operations. Typical terpenes are compounds such as d-Limonene and pinene and terpene alcohols such as terpineol, Isoprene is the essential building unit common to all terpenes, which are structural variations of a number of isoprene units joined together in unique configurations.

d-Limonene has been used for a number of years in cleaning formulations and is proven to be an effective chlorinated solvent replacement. Depending on how the product is formulated, d-Limonene cleaners can be used full strength or diluted in water.