ADVANCED VAPOUR DEGREASING WITHOUT OZONE DEPLETING SOLVENTS

ABSTRACT

An advanced vapour degreasing process has been developed which offers the ease of use, fast drying, and excellent cleaning performance of conventional vapour degreasing, but which does so *without* ozone-depleting or significant global warming solvents.

This paper describes the fundamentals of this new **co-solvent** or **AVD** cleaning technology, and outlines its advantages and disadvantages relative to existing CFC solvent alternatives. Given its potential to provide customers with non-ozone-depleting, non toxic chemical compositions which offer improved cleaning characteristics together with competitive economics, and the opportunity to continue to use a vapour degreasing process.

INTRODUCTION

The process uses non-flammable, low-toxicity chemicals which do not contain chlorine . Its performance is at least as good or better than that obtained with the ozone-depleting substances commonly used in vapour degreasing. *There appear to be fe*w, if any, vapour degreasing *applications not technically suited for the proces*s.

Like semi-aqueous cleaning, the process uses separate materials for dissolving the soil and then rinsing the solvent plus soil from the parts. But unlike semi-aqueous cleaning, it **avoids** the use of **water** and its numerous associated problems, such as difficulty in drying and its tendency to promote corrosion.
The process involves the use of two solvents, an organic to dissolve soils and a fluorinated

rinsing agent removes the organic solvent and dissolved soil from the part. Organic solvent and rinsing agent are physically mixed in the boiling sump of the vapour degreasing equipment. Rinsing agent vapours are condensed and returned to the clean (rinse) sump, from where rinsing agent condensate overflows back into the boil sump. Following immersion in the rinse liquid, parts are held in the vapour for final rinse.

Many manufacturers need vapour degreasing or an equivalent process to produce **clean, dry parts** without using water. There are a number of cleaning tasks presently undertaken with ozone-depleting solvents in vapour degreasers (for example; in certain precision cleaning applications), for which there has not been a viable non-ozone depleting alternative **until now**. By way of specific example, some types of parts cannot be exposed to water for fear of damaging the parts, eg; they may be prone to rust. In other cases, there may be no practical way to remove the water, eg; it may become trapped in small blind holes or other capillary spaces, or parts may become “nested” in groups and trap water between adjacent parts.

Further, many **small volume batch cleaning operations are ideally suited for vapour degreasing** - it is often difficult and expensive to use cleaning processes that involve water in low-volume batch processes.
This is particularly important for smaller manufacturing operations where it may be difficult to justify or afford the expense of cleaning equipment using water and the associated water treatment systems which will be required to provide sufficiently clean water for disposal or recycle. Many of these applications were moving toward the use of HCFC-141b or HCFC-123, and were left in difficult circumstances when it became clear in mid 1991 that **these products would not be suitable for use as cleaning solvents.**

A NEW VAPOUR DEGREASING PROCESS

For quite some time, many companies have been working to identify a practical replacement for the ozone-depleting solvents used in vapour degreasing processes. Most of these efforts, especially by the traditional solvent manufacturers, have focused on finding molecules that **combine all of the favourable attributes of CFC-113 and/or 1,1,1-trichloroethane (methyl chloroform**), but which have low or no ozone depletion potential.

It is not necessary to combine all of the desirable attributes into a single molecule - it is only necessary to have **a process that performs in the same way** as traditional vapour degreasing.

Two appropriately chosen types of materials, each having properties complementing solvents used in vapour degreasing cleaning applications by means of an essentially drop-in process. Cleaning solvent typically has low vapour pressure and high boiling point, along with good solvency properties. Rinsing agent typically has high vapour pressure and low boiling point, but has no need for good solvency. The cleaning agent and rinsing agent may be either soluble or substantially insoluble in each other. **Azeotropic behaviour between the cleaning and rinsing agents is not necessary.**

DESIRABLE PROPERTIES

CLEANING AGENT	RINSING AGENT
. good solvency for the soils	. low toxicity;
of interest:	
. good materials compatibility	. low viscosity
. low viscosity	. low heat of vaporization
. low toxicity	. an appropriate boiling point for the task at hand
. non flammability	
Low vapour pressure	
. chemical stability; and	. good chemical stability;
. properties such that the	. non flammability;
. cleaning agent is not a hazardous waste.	. good materials, compatibility; and
	. zero ozone depletion.

Successful cleaning agents, including several products commonly used in semi-aqueous cleaning processes, and a variety of rinsing agents, including a number of materials which might ordinarily not be thought of as suitable for use in vapour degreasing processes have been successfully trialed

VAPOUR DEGREASING, BUT NO O.D.P.

This simple, fast, safe and effective process represents a **major advance** in non-ozone-depleting cleaning . There are many manufacturers currently using vapour degreasing who can benefit from this technology.
Selective solvency can be achieved by the selection of the cleaning agent formulated to **precisely meet** the particular cleaning need at hand.
Cleaning Temperature can be altered within limits to facilitate the removal of previously difficult to remove soils or protect temperature sensitive materials of construction.
The cleaning agent selected will ordinarily have low volatility. Consequently, worker exposure to cleaning agent is low, further aiding in providing safety in operation.
Typically, printed circuit boards can be defluxed to give **ionic** contamination results similar to those obtained with **1,1,1-trichloroethane or semi-aqueous cleaning.** Metal parts can be cleaned to at least meet the same standards met by conventional vapour degreasing processes.

High temperature greases and waxes can also be removed using the process. Cleaning speed has generally been excellent. The parts emerged clean and dry.

In general, rinsing agent choice is not significantly constrained by choice of cleaning agent, since rinsing agent solvency is not required. These materials have all of the advantages of CFC's (very low toxicity, non-flammability, convenient boiling points, excellent materials compatibility, etc.), but without the disadvantage of being ozone depleters. In fact, their ozone depletion potential is zero. Their only disadvantage is that they are relatively expensive and, like CFC's and 1,1,1-trichloroethane, they have the potential to contribute to global warming. However, emissions from properly designed equipment have proven to be so low that even relatively expensive materials can be used economically. Further, low emissions help to minimise any possible concerns with respect to global warming potential.

Hydrofluorocarbons and hydrofluoroethers demonstrate desirable physical properties and solvent characteristics as rinsing agents in conjunction with appropriate cleaning agents. Both are candidates for a results similar cleaning / drying systems when **matched** with **economical equipmen**t.

ENVIRONMENTAL IMPACT

Cleaning processes by their nature produce waste streams and other environmental emissions. These can be divided into emissions which affect air, water or ground, and the emissions may be gaseous, liquid or solid.

In all cleaning processes, the removed soil must go somewhere, and it usually winds up mixed with some amount of the cleaning solvent. A principal difference among the various cleaning methods involves the relative volume of waste produced, and its ultimate disposition. One of the reasons that vapour degreasing (with ozone-depleting solvents) has been widely accepted is that the vapour degreasing process produces clean, dry parts quickly and reliably, and (especially when combined with a solvent recovery still) it generates a **minimum volume of waste** requiring disposal #. Of course, due to the design of conventional vapour degreasing equipment, and due to the characteristics of the solvents used in conventional vapour degreasing, there are significant gaseous emissions . Vapour degreasing does not utilise water, so there are no concerns with respect to aqueous discharge.

On the other hand, aqueous cleaning does not give rise to significant gaseous emissions (except for harmless water vapour), unless one looks at the bigger picture and considers the impact of generating the relatively enormous amounts of energy required in aqueous cleaning (principally for the drying step). But in aqueous cleaning, the soil (and the chemicals used to remove the soil from the parts being cleaned) is carried away in very large quantities of water, which is normally loaded with caustic. Consequently, large amounts of clean water are required, and large volumes of contaminated wastewater are generated. Disposal of this wastewater is often the most difficult problem associated with aqueous cleaning.

Semi-aqueous cleaning gives a lesser water disposal problem, but at the cost of sometimes substantial VOC emissions from the semi-aqueous cleaning product.
While wastewater from both aqueous and semi-aqueous cleaning can be recycled for re-use, the capital cost of equipment to accomplish this task is a very significant barrier in many applications, especially for alkaline detergent cleaning. Large, sophisticated companies may decide to implement wastewater reclamation equipment but most smaller operations discharge the rinse water to drain or pay to have it hauled away.

By contrast, the **co-solvent** process produces only two small volume sources of emissions. First, the rinsing agent and agent/soil mixture are separated under the influence of gravity, when an immissible rinsing agent is used, in a closed vessel immediately adjacent to the process equipment. The still-clean rinsing agent (which is not contaminated at all during process operation) is recycled back to the equipment. # Spent (soil-loaded) agent is then either processed to recover useable cleaning agent or sent our for disposal, usually by fuel blending to recover the high energy value present in hydrocarbon cleaning agents. This constitutes the only waste product stream.

The only other source of emissions from the process is the small amount or rinsing agent vapour that unavoidably escapes during operation. Compared to losses experienced with conventional vapour degreasing, rinsing agent losses are very low, usually about **6 to 20 times less**. This low loss rate is due to both the **careful design of equipment** as well as to the inherent properties of the materials used as rinsing agents.

These exceptionally low volumes of waste products and vapour emissions help make the process both environmentally and economically attractive.

Some typical parts of soils which can successfully be cleaned.

PARTS	SOILS
. gyroscope assemblies	. fingerprint oils
. fine wire bonded hybrid circuits	. flux residues
. porous ferrite cards	. high viscosity
. contact lenses	. dampening oils
. honeycomb structural materials	. polishing agents
. fuel injector components	. grinding agents
. miniature ball bearings	. cutting oils
. highly polished metal parts	. cutting fines
. mirror finished parts	. particulate
. coils	. silicone oils
	. buffing compounds
	waxes

PROCESS ADVANTAGES

The process offers a number of advantages relative to other alternatives for ozone-depleting solvents used in vapour degreasing. These advantages include.

- zero ozone depletion potential
- non-flammable materials
- essentially non-toxic ingredients
- minimal waste volumes
- low energy use
- simple, convenient materials recycle
- economical operation
- excellent cleaning performance
- high productivity
- modest capital cost
- suitable for use in both small and large units
- simple and easy to use
- no hazardous materials involved
- broad applicability
- small equipment footprint
- does not use water.

SUMMARY

The process offers **all** of the **advantages** often associated with **vapour degreasin**g, such as the ability to clean a wide variety of soils quickly and reliably, and parts that emerge completely dry. Just as importantly, it avoids the disadvantages of aqueous processes, such as difficult drying and water disposal. The **cleaning performance** obtained to date is **equal to or better than** that available with conventional **vapour degreasing**