



Property Risk Consulting Guidelines

A Publication of AXA XL Risk Consulting

PRC.9.2.5.1

SOLVENT VAPOR DEGREASING

INTRODUCTION

Solvent vapor degreasing is a common way to clean dirt, oil, grease, rust, scale, tarnish or other soils from metal parts. In this process, the solvent is boiled and a vapor zone maintained above the solvent. The parts to be cleaned are moved through the vapor zone where the vapor condenses on the parts, dissolves the soil, and drips back into the solvent tank. Variations of this process add stages where the parts are dipped in warm or boiling solvent, or are sprayed by warm solvent. Other nonporous materials, such as glass and plastics, can also be cleaned this way.

Overheating is the most frequent cause of losses in solvent vapor degreasing systems. Excessive temperatures can ignite residues or cause undesirable chemical reactions in degreasers using chlorinated solvents. The consequences of overheating are much more severe in vapor degreasers using flammable liquids. However, flammable liquids might replace chlorinated solvents if the phase-out of chlorinated solvents mandated by the United States Environmental Protection Agency leaves no alternative for a particular degreasing application.

This AXA XL Risk Consulting Guideline explains how to arrange, operate and protect vapor degreasing systems using chlorinated solvents, substitute solvents, or flammable solvents.

POSITION

Chlorinated Solvents

Safely operating chlorinated solvent vapor degreasers involves properly arranging the degreasers' control and heating systems. Other loss control measures, including separation and sprinklers, are also needed.

Control Systems

Provide normal and excess temperature controls to limit the liquid solvent temperature. Arrange the excess temperature controls to shut off the heat source when the maximum allowable temperature is reached. Locate heat sensing devices below the level of the lowest heating surface. Refer to Table 1 for maximum liquid solvent temperature settings.

Arrange solvent liquid level controls to shut off the heat source if the liquid level drops to less than 1½ in. (38 mm) above the top of the highest heating surface.

Detect abnormally high vapor level by monitoring the temperature 2 in. – 3 in. (51 mm – 76 mm) above the normal vapor level. Shut off the heat source if the temperature at this point exceeds the maximum vapor temperature shown in Table 1.

TABLE 1
Chlorinated Solvent Properties and Degreasing System Settings

Solvent	Boiling point °F (°C)	Maximum liquid solvent temperature setting °F (°C)	Maximum vapor temperature setting °F (°C)	Steam safety valve pressure relief setting psig (bar)	Maximum boiling temperature for 25% oil-contaminated solvent °F (°C)	Minimum acid acceptance for water-contaminated solvent %
Trichloroethylene C ₂ HCl ₃	188 (87)	240 (116)	160 (71)	15 (1.0)	195 (91)	0.03
Perchloroethylene C ₂ Cl ₄	250 (121)	295 (146)	190 (88)	60 (4.1)	260 (127)	0.01
Methylene Chloride CH ₂ Cl ₂	104 (40)	125 (53)	95 (35)	5 (0.35)	110 (43)	0.03
Trichloroethane (1,1,1) C ₂ H ₃ Cl ₃	165 (74)	190 (88)	130 (54)	15 (1.0)	175 (79)	0.03
Trichlorotrifluoroethane C ₂ Cl ₃ F ₃	118 (46)	130 (54)	105 (41)	5 (0.35)	125 (53)	N/A

Monitor cooling water flow with a flow switch or other device installed on the cooling water jacket. Maintain cooling water outlet temperature in a range above the dew point of the surrounding air (usually 90°F – 110°F [32°C – 43°C] is satisfactory). Shut off the heat source upon loss of cooling water flow or upon out-of-range cooling water temperature.

Arrange degreaser control systems to sound an audible alarm and turn on an indicator light upon detection of any adverse condition. Use dedicated electrical contacts suitable for operation under load to shut off the heat source in an emergency.

Heating Systems

Low pressure steam heat exchangers are the first choice for heating systems. Use this type of system wherever steam is available. Specify a minimum MAWP (maximum allowable working pressure) for the heat exchanger of 60 psig (4.1 bar) for perchloroethylene systems and 15 psig (1.0 bar) for all other systems listed in Table 1.

Provide a relief valve downstream of each steam pressure reducing valve. Size the relief valve the same as the incoming steam line and ensure that it can pass full steam flow at the pressure relief setting. See Table 1 for recommended pressure relief valve settings. Pipe the relief valve to a location suitable for safely discharging high pressure steam.

Locate steam pressure reducing valves on 75 psig (5.2 bar) steam systems at least 15 ft (4.6 m) from degreasers’ heat exchangers. On 150 psig (10.3 bar) systems, locate these valves 35 ft (10.7 m) from heat exchangers.

Equip steam lines with safety shutoff valves suitable for steam service and listed by a nationally recognized testing laboratory as normally closed safety shutoff valves. Install these valves upstream of all pressure reducing valves and bypasses. Provide orifices in reducing valve bypasses to limit steam flow to within the relief valve capacity.

Electric immersion heaters are the second choice for heating systems. Use only low power, coil-type, electric immersion heaters. Do not exceed a heater power of 22 W/in.² (34 mW/mm²) for metal tanks. Use a heater power in the range of 12 W/in.² – 15 W/in.² (19 mW/mm² – 23 mW/mm²) for plastic or plastic lined tanks. See PRC.9.5.1 for more information on tanks with plastic components.

Direct combustion heaters firing gas or oil are the least desirable choice for heating systems. If using this type heater, locate air inlets and combustion exhaust away from any possible source of solvent vapors. Also be sure heater exhaust capacity is adequate.

Equip fuel lines to all fired heating equipment with safety shutoff valves listed by a nationally recognized testing laboratory. Provide combustion controls on all fuel fired equipment in accordance with pertinent NFPA 85, NFPA 86, and NFPA 87 and PRC.4.0.1.

Other Loss Control Measures

Locate degreasers in well-ventilated, well-separated areas with no unnecessary combustibles or other sources of ignition and no excessive drafts. Locate degreasers handling aluminum or magnesium parts in a separate room cut off by a barrier wall that is nonpermeable to gases and solvent vapors. Install self-closing doors, and keep them closed at all times.

Provide automatic sprinkler protection above degreasers in accordance with NFPA 13 and PRC.12.1.1.0 requirements for Ordinary Hazard, Group 2. Extend protection at least 10 ft (3.1 m) beyond degreasing equipment.

Provide a water separator for each degreaser.

Do not use chlorinated solvent vapor degreasers to clean parts coated with flammable liquids. Also, do not put flammable liquids in chlorinated solvent vapor degreasing equipment.

If degreasing operations are automated, limit conveyor speeds to a maximum of 11 ft/min (3.3 m/min) unless the equipment is designed to contain solvent liquid and vapor at higher speeds.

Alternative Nonflammable Solvents

The protection philosophy for degreasers using nonflammable liquids is the same as that for degreasers using chlorinated solvents, with differences being taken into account for the liquid's differing physical and chemical properties. For example, operating temperatures and conveyor speeds could be different. For aqueous and semi-aqueous solutions, water separators would not be needed. Also see **DISCUSSION**.

Although aqueous and semi-aqueous degreasing solutions are nonflammable, they often contain small amounts of flammable liquids. These liquids can become a loss prevention concern when the solvent is recovered.

The hazards of recovering flammable solvent include the additional pumps and piping that move solvent to and from treatment tanks, the fuel-fired equipment used in evaporators, and solvent holding tanks. In some cases, the solvent may even be distilled. PRC.9.6.2.1 addresses the hazards of distilling flammable liquids.

Flammable Solvents

Do not use flammable solvents for vapor degreasing unless no other cleaning method is satisfactory.

Minimizing the hazards of operating flammable solvent vapor degreasers involves properly arranging the degreasers' control, heating and electrical systems. Other loss control measures, including cutoffs, special extinguishing systems and sprinklers, are also needed. If considering a flammable liquid vapor degreasing system, submit plans and specifications to AXA XL Risk Consulting for review prior to installation.

Control Systems

Provide controls to limit the liquid solvent temperature. Arrange controls to shut off the heat source and admit cooling water to the boil sump cooling coils when the maximum allowable temperature is reached. Set the maximum allowable temperature at no more than 9% over the solvent boiling point in °F (5% in °C).

Arrange solvent liquid level controls to shut off the heat source if the liquid level drops to less than 1½ in. (38 mm) above the top of the highest heating surface.

Detect abnormally high vapor level by monitoring the temperature 2 in. – 3 in. (51 mm – 76 mm) above the normal vapor level. Shut off the heat source and cover the tank when the temperature at this point exceeds 9% of its normal operating temperature in °F (5% in °C).

Monitor cooling water flow with a flow switch or other device installed on the cooling water jacket. Monitor cooling water temperature at the water outlet from the condensate coils. Shut off the heat source upon low cooling water flow or high cooling water temperature.

Supervise degreaser ventilation. If ventilation fails, controls should shut off the heating source, cover the tank, admit cooling water to the boil sump cooling coils and shut down incidental electrical equipment, such as ultrasonics and conveyors.

Monitor solvent vapor concentration beneath the boil sump. Arrange controls to sound an alarm at 15% LEL; and to shut off heat, cover the tank, admit cooling water to the boil sump cooling coils and increase ventilation at 25% LEL.

Hard wire all safety alarms and interlocks independently if using a programmable logic controller. Arrange degreaser control systems to sound an audible alarm and turn on an indicator light upon detection of an adverse condition. Use dedicated electrical contacts suitable for operation under load to perform all safety functions.

Electrical Equipment

Use one or more of the following means to eliminate electrical ignition hazards in degreasers and degreaser rooms.

- Locate ordinary electrical equipment in electrically unclassified areas only.
- Use electrical equipment listed by a nationally recognized testing laboratory for Class I, Groups C and D locations as appropriate for the area classification.
- Purge or pressurize electrical equipment in accordance with NFPA 496.
- Use intrinsically safe electrical equipment complying with ANSI/UL 913.

Heating Systems

Use only hot water heat exchangers as the heat source. Specify a minimum MAWP for the heat exchanger of the highest possible hot water pressure, or the highest expected pressure downstream of a relief valve, if one is provided. Locate water heaters and their controls in separate rooms from degreasers. Equip hot water lines with safety shutoff valves suitable for hot water service and listed by a nationally recognized testing laboratory as normally closed safety shutoff valves. Provide combustion controls on water heaters in accordance with pertinent NFPA standards and PRC.4.0.1.

Other Loss Control Measures

Locate degreasers in well-ventilated rooms cut off from all other parts of the facility by 2-h rated fire barrier walls with 1½-h rated fire doors. Design ventilation for 1 cfm/ft² (0.3 m³/min/m²) of floor area. Provide explosion venting, curbing and drainage to a safe location. Install explosion venting as specified by NFPA 68. Arrange the drainage system in accordance with NFPA 30 and PRC.8.1.0.

Properly ground all vapor degreasing equipment. Use only conductive metal tanks, pumps, valves, and piping.

Protect degreasers with special extinguishing systems, such as water spray, foam, CO₂ or dry chemical. Actuate extinguishing systems with supervised heat or flame detection systems. Monitor the systems with control panels listed by a nationally recognized testing laboratory for release device service. Refer to the appropriate NFPA 11, NFPA 12, NFPA 15, NFPA 16, and NFPA 17 and AXA XL Risk Consulting Guidelines.

Avoid auxiliary hazardous operations outside degreaser enclosures. Most degreasers condense, collect and reuse solvent within the enclosure, but sometimes external stills or rinse tanks are added. Separately protect all such operations. Include cutoffs, degreaser enclosures, adequate ventilation, vapor monitoring, safety controls and interlocks, proper electrical equipment and special extinguishing systems in the protection scheme. Contact AXA XL Risk Consulting's local Field Servicing Office for guidance.

Provide automatic sprinkler protection in degreaser rooms. Design the system in accordance with NFPA 13 and PRC.12.1.1.0 requirements for Extra Hazard, Group 2.

Limit conveyor speeds to minimize vapor loss outside degreasing enclosures. Provide interlocks to shut off the heat source and the conveyor if there is any resistance to movement in the conveyor exceeding normally expected levels.

Management Programs

Incorporate all the necessary procedures and practices pertaining to vapor degreasing operations into the facility's written management programs for loss prevention and control. Follow the guidance given in *OVERVIEW* (PRC.1.0.1). Pay particular attention to the following programs:

- **Smoking Regulations** - Do not permit smoking near vapor degreasing equipment.
- **Impairments** - Do not operate solvent vapor degreasers when protection in the area is impaired.
- **Maintenance** - Strictly adhere to preventive maintenance schedules. Confirm that degreasers are properly maintained by reviewing records and taking action when the maintenance program is not followed.

Routinely test control panel alarms and indicator lights, degreasing system safety interlocks, and special extinguishing systems. Inspect the immersion heater, temperature sensors, and solvent level sensors for corrosion or other damage. Repair or replace all parts as necessary.

Put all inspection, testing and maintenance procedures in writing and incorporate them into the facility's training programs. Incorporate manufacturers' maintenance recommendations into the degreaser maintenance schedule. Report and correct all deficiencies.

Monitor dissolved oil content of degreasing solvent by noting the solvent boiling point. Remove the solvent and clean all sludge from a degreaser whenever the solvent boiling point exceeds the recommended maximum temperature. Do this for chlorinated solvents when oil content reaches 25% by volume. Refer to Table 1 for the solvent boiling points corresponding to 25% oil content.

Measure chlorinated solvent acid acceptance once each shift. Replace the solvent and clean the degreaser when the acid acceptance falls below acceptable levels. Do not add sodium or potassium hydroxide to alleviate acidity. Refer to Table 1 for minimum acid acceptance values.

Restore all stabilizers and additives to the solvent when replacing it.

- **Employee Training** - Provide employee training in the degreasing process and equipment. Most suppliers of degreasing equipment provide training programs. Have all employees expected to operate or maintain the equipment attend these programs. Management should then direct the development of operator and maintenance training programs for periodic use in their facility.

Instruct operators to adhere to process design parameters. Provide written information on normal and emergency operations; the degreasing solvent, including the MSD sheets; the nature of the soil being removed and its effect on the process; inspection, testing and maintenance activities; system design load; and proper system settings.

- **Pre-emergency Planning** - Train the emergency response team to respond to emergencies involving the degreaser operations.
- **Materials Evaluation** - Evaluate all materials involved in degreasing operations. Re-evaluate whenever there is a change in solvents, materials being cleaned or soils being removed.
- **Hot Work** - Do not permit hot work near degreasing operations unless the equipment has been shut down and cleaned of all solvents and residues.
- **Hazard Evaluation** - Evaluate the compatibility of all materials and the process settings being used. Re-evaluate whenever there is a change of any kind, including size or weight of parts, speed of processing, or new production method for the parts. Also evaluate all changes to degreasing solvents and methods for storing, dispensing, cleaning or recovering them.

- **Housekeeping** - Maintain good housekeeping near degreasing operations. Routinely check for improper storage of combustible materials, residue buildup, leaks and other adverse circumstances.

DISCUSSION

Vapor degreasers contain a solvent boil sump and vapor zone within a ventilated, open-top enclosure. Parts are degreased by passing them through the vapor zone. Condensate coils control vapor level, and the freeboard retains residual vapors. Many degreasers also contain dip tanks, ultrasonic cleaning tanks, solvent hold tanks and dryers. Degreasers may hold from five to a few hundred gallons of solvent. A simplified sketch of a vapor degreaser is shown in Figure 1.

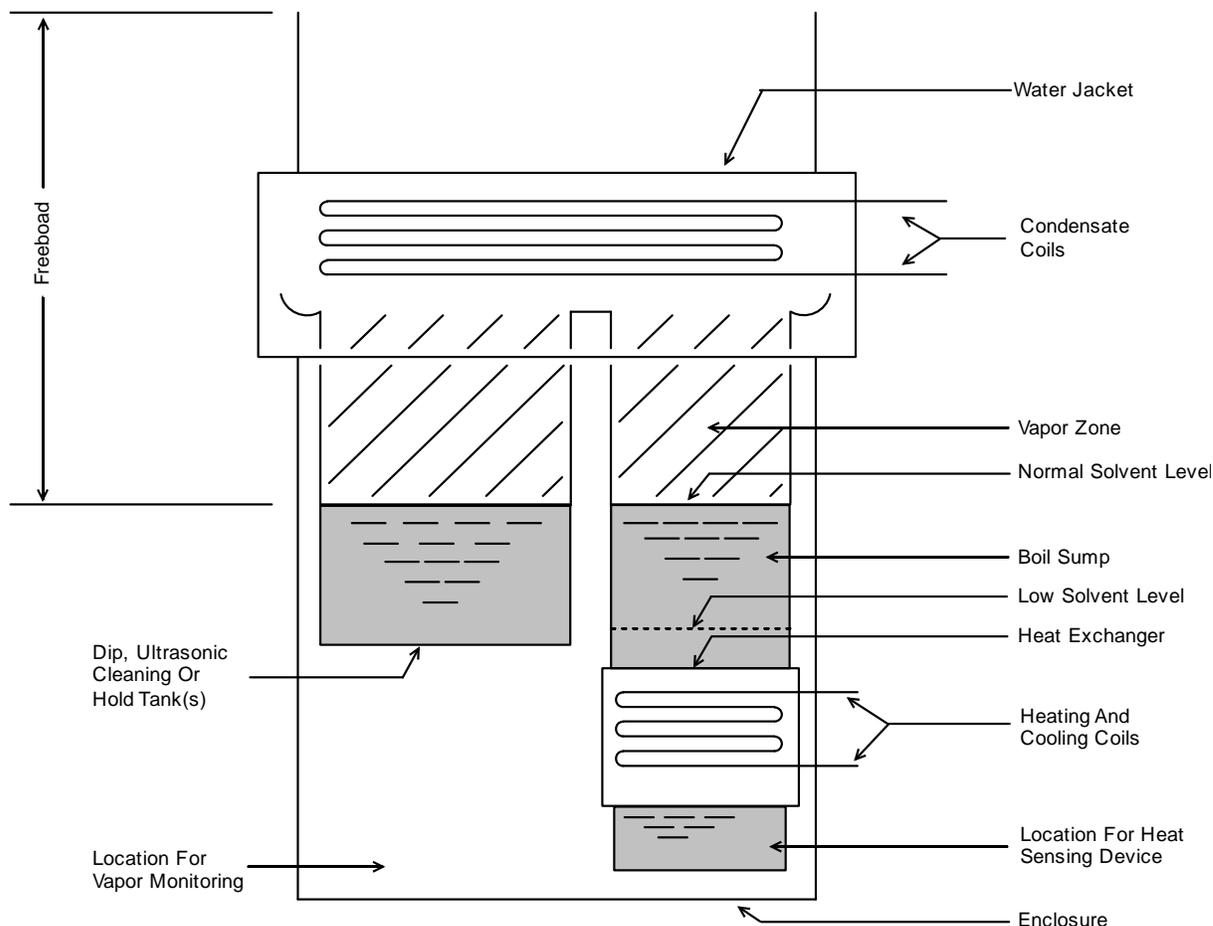


Figure 1. Simplified Sketch of a Vapor Degreaser.

Degreasing prepares parts' surfaces for further processing. Parts may be degreased before inspection, testing, assembly, or finishing operations, such as electroplating, anodizing, galvanizing, rust proofing and painting.

While becoming less common, solvents frequently used for vapor degreasing are chlorinated hydrocarbons. The most common of these are:

- Trichloroethylene ("tri," "trike," "tri-chlor," or "TCE").
- Perchloroethylene, also known as 1,1,2,2 tetrachloroethylene ("per," "perc," or "per-chlor").
- Methylene chloride, also known as methane dichloride or dichloromethane ("meth").
- 1,1,1 trichloroethane, also known as chloroethene or methyl chloroform.

- Trichlorotrifluoroethane, also known as Freon 113 or HCFC 113.

Sometimes flammable liquids are used as degreasing solvents. Among these liquids are acetone, cyclohexane, ethyl lactate, isopropyl alcohol, kerosene, naphtha, n-butyl acetate, and xylene. Azeotropes of these liquids are also used for degreasing.

Chlorinated Solvent Degreasing

Solvent Characteristics

Chlorinated solvents are almost ideal fluids for vapor degreasing because of their unusual combination of properties. These properties include:

- Excellent ability to dissolve fats, oils and other common soils requiring removal.
- Low latent heats of vaporization. Large amounts of liquid can be converted to vapors with minimal energy input and the vapors readily condense on the cold parts being cleaned.
- Dense vapors. They are easy to retain in open tanks with little vapor loss.
- Chemical stability.
- Noncombustibility.

The primary disadvantage of chlorinated solvents is that they are part of a class of chemicals now believed to contribute to ozone depletion. Two of the chlorinated solvents commonly used in vapor degreasing - 1,1,1 trichloroethane and trichlorotrifluoroethane - are considered Class I Ozone Depleting (OD) Substances. The Montreal Protocol halted world production of Class I OD Substances at the end of 1995. Although these substances may still be used, supplies are difficult to replenish and taxes on their use are high.

For these reasons, many facilities using the Class I OD chlorinated solvents have changed to Class II OD chlorinated solvents. The three most common Class II OD solvents are trichloroethylene, perchloroethylene and methylene chloride. There are no known problems changing from one chlorinated solvent to another in existing equipment. Changing from one solvent to the other usually requires changing only the process and shutoff temperature set points. However, stricter EPA fugitive emissions standards may require other changes to degreasing equipment in conjunction with the change of solvent.

According to the Montreal Protocol, production of Class II OD Substances must cease in 2030. Until then, facilities may continue to use the Class II OD solvents. In the meantime, several companies are trying to develop comparable substitutes with no ozone depletion potential.

Potential Problems

In degreasers using chlorinated solvents the loss prevention problem is the sludge, not the solvent itself. The sludge consists of the oils and greases being removed from the parts. The main causes of fire in degreasers using chlorinated solvents are low solvent level and excessive sludge accumulation. Either of these conditions may cause the sludge to overheat and ignite. Solvent level controls and frequent cleaning control these conditions.

Improper temperature settings can cause overheating. The temperature settings recommended in Table 1 are from ASTM D3698 and should be appropriate for most applications. The recommended vapor temperature settings are from *Economical And Efficient Vapor Degreasing With Chlorinated Solvents From Dow* a Dow Chemical Company brochure. Using stabilizers may permit higher operating temperatures.

Overheating may also result if superheated steam reaches steam heat exchangers. This potential is minimized by locating steam pressure reducing valves an appropriate distance from the heat exchanger.

Vapor control in chlorinated solvent degreasers is primarily an economic and environmental issue, but it is a loss prevention concern as well. Solvent vapors escaping from degreaser tanks can damage paint or coatings on structural members and can contaminate mechanical and electrical process

equipment. Degreasers handling aluminum or magnesium parts could emit corrosive fumes and hydrogen gas.

Other problems with degreasers can arise from unwanted chemical reactions in the solvent. Overheated solvent can break down, generating gaseous hydrogen chloride which combines with moisture to form hydrochloric acid. The presence of certain contaminants in the solvent can cause reactions releasing corrosive and toxic fumes. The addition of sodium or potassium hydroxide to the solvent to neutralize acidity may result in the formation of dichloroacetylene, which can violently decompose or even explode. Aluminum and magnesium from parts being cleaned can sometimes react with the solvent. Aluminum and magnesium residues may react to form chlorides, which can subsequently initiate a Friedel-Crafts reaction. Zinc can also participate in reactions.

Because water contributes to many chemical reactions and can corrode degreaser components, it is important to keep moisture from condensing in the solvent. Keeping the temperature of the cooling water above the dew point of the surrounding air inhibits moisture condensation. Water separators remove moisture that does condense.

The perception that chlorinated solvents are noncombustible is not entirely true. The Bureau of Mines Report RI 6190 points out that trichloroethylene-air mixtures are flammable at atmospheric pressure between 30°C – 82°C (86°F – 180°F). However, no known losses have been solely and directly caused by such a mixture igniting. Furthermore, adding stabilizers usually raises the flash point well above normal operating temperatures.

More information on chlorinated solvent vapor degreasing is available in ASTM D2942, ASTM D4079, ASTM D4080, ASTM D4126, ASTM D4376, and ASTM D4757.

Status of Chlorinated Solvents

Most industries have now phased out Class I OD solvents. But some industries have not yet found suitable replacement solvents or cleaning processes for precision cleaning needs. These industries include semiconductor, medical and aerospace workers.

The U.S. EPA requires that alternative solvents and cleaning processes be used wherever possible. It has published updates to the Montreal Protocol, as well as many papers on acceptable alternative solvents and cleaning methods.¹ Where none of these alternates meet precision cleaning needs, it allows special use exemptions. To meet these exemptions, the user must install additional process controls to further reduce solvent use and emissions, and must provide tight enclosures around process equipment. Both these measures can involve extensive process adjustments.

The following sections discuss alternative solvents and cleaning methods, and potential ways to reduce the need for cleaning. See the U.S. EPA references for more detailed information.

Alternative Solvents

The U.S. EPA lists the following acceptable alternative solvents for vapor degreasing:

- Hydrochlorofluorocarbons (HCFCs)
- Volatile Methyl Siloxanes
- Perfluorocarbons
- Alcohol With Perfluorocarbons
- Perfluoropolyethers
- Hydrofluoroethers
- Trans-1,2-dichloroethylene
- Heptafluorocyclopentane
- Straight Organic Solvents

HCFCs are Class II OD substances still permitted under the Montreal Protocol, and as such will be phased out as the Class I OD substances already have been. The U.S. and other developed nations

must reduce consumption and production of HCFCs by 90% by 2015 with a 100% phaseout by the year 2030.

Volatile Methyl Siloxanes are low molecular weight silicones that can have flash points anywhere between 30°F and 135°F (-1°C and 57°C).

Perfluorocarbons and perfluoropolyethers are Class II OD substances still permitted under the Montreal Protocol, subject to narrowed use limits. In some cases where perfluorocarbons alone do not provide sufficient cleaning, mixtures with alcohol do. Alcohol alone is suitable for many uses in the semiconductor industry. Using alcohol, with or without perfluorocarbons, requires the standard protective measures taken for flammable liquids.

Hydrofluoroethers including HFE-7000, 7100 and 7200 are non-flammable and have no ozone depleting potential. They may be blended to target specific cleaning applications and will not mix with water. They are mild cleaners that may be suited for critical cleaning operations.

- Trans-1,2-dichloroethylene is not an ozone depleting substance, however it is flammable, with a flash point between 36 – 39°F (2 – 4°C).
- Heptafluorocyclopentane (HFCPA) also has no ozone depleting potential and has no flash point below its boiling point. It may be a suitable alternative cleaning agent for precision, electronics and metals applications.

Straight organic solvents include ketones, alcohols, ethers and esters. These are almost always flammable.

The U.S. EPA requires control of vapor emissions for almost all degreasing solvents. In addition, all flammable degreasing solvents require the protective measures described under POSITION.

Alternative Cleaning Processes

Alternative processes to vapor degreasing use:

- Aqueous Solutions;
- Semi-Aqueous Solutions;
- Pressurized Gases;
- Supercritical Fluids;
- Gas Plasma;
- Ultraviolet Radiation/Ozone;
- CO₂ Snow;
- Mechanical Action;
- Ultrasonic Radiation.

As with chlorinated solutions, a concern with aqueous and semi-aqueous solutions is with the buildup of sludge that is being removed from the parts being cleaned. In addition, semi-aqueous solutions might contain small amounts of flammable liquids that become more concentrated as the solution is used. Aqueous solutions also require additives resulting in higher treatment and disposal costs and need larger and more energy intensive equipment to operate.

Common gases pressurized for degreasing include air, CO₂ and nitrogen. Rare gases like helium, neon, argon and xenon are also used. Supercritical fluids are gases pressurized above their critical temperature and pressure. Operating in this region improves the cleaning ability of many gases. Gas plasma cleaning uses ionized gases to combine with the contaminants being removed. This process usually takes place inside a vacuum chamber.

The UV/Ozone process is simple and inexpensive, and it can remove thin organic films from many types of surfaces. It works by exposing the surface to UV light in the presence of ozone. Contaminant molecules are dissociated by absorbing the UV wavelength light. CO₂ snow cleans parts by the momentum transfer between the snow and the contaminant molecules. This process works very well in many applications, is inexpensive, and generates no waste or residue.

Methods of mechanical cleaning include spraying, power washing, agitation, brushing and shot blasting. These methods can be used to clean fairly durable parts. They are usually not suitable for precision cleaning operations. Ultrasonic radiation works in a similar manner by vibrating soil off the parts being cleaned.

Reducing The Need For Cleaning

Sometimes redesigning the manufacturing process can eliminate cleaning steps. Examples of such redesign include:

- Changing to a low-solids flux for soldering;
- Soldering under an inert atmosphere, removing the need for flux altogether;
- Eliminating the need for soldering;
- Making the parts with a higher tolerance to soil.

Many processes are not amenable to such redesign; for processes that are, the potential savings can be substantial.

Flammable Solvent Degreasing

Vapor degreasing with a flammable liquid uses the liquid above its flash point and the vapor above its upper explosive limit. Because this is very hazardous, other cleaning alternatives should be explored before choosing this method. Even if none of the Class II OD chlorinated solvents are suitable for a particular degreasing application, there are many other safe cleaning agents and methods that can be tailored to achieve the desired level of cleanliness in virtually any application. Some of these agents are:

- Alternative chlorinated and fluorinated solvents. These include HCFC's, however, these are being phased out with a 90% reduction by the year 2015 and 100% by 2030. HFC's such as HFC-365mfc and HFE's including HFE-7000, 7100 and 7200 are acceptable alternatives under the U.S. EPA's Significant New Alternatives Policy (SNAP) Program.²
- Semi-aqueous emulsions of terpenes, petroleum distillates, alcohol or other solvents in water.
- Acid or alkaline aqueous solutions.

Other methods for cleaning parts include mechanical and heat cleaning. Examples of mechanical cleaning are brushing, shot blasting, spraying, agitation or ultrasonic cleaning.

Often, cleaning processes use several stages and combine mechanical and/or heat cleaning with custom tailored cleaning agents to achieve the desired results. Stages for dewatering with oil based mixtures and for oven drying are commonly added to the cleaning process.

Protection requirements for solvent vapor degreasers using flammable liquids are based on controlling both liquid and vapor phases and on eliminating all possible sources of ignition. A hard wired control system should automatically shut down the heat source, increase ventilation, close the tank lid, admit cooling water to the boil sump cooling coils, and shut down incidental electrical equipment, as appropriate for the adverse condition detected. Only trained operators should run degreasing systems. The operators should keep the systems within design parameters. Proper operation and conscientious maintenance of vapor degreasers is essential to prevent losses. No changes should be made to the process without equipment manufacturers and process designers thoroughly reviewing them.

Solvent vapor degreasers using flammable liquids generally operate below 1% LEL outside the vapor zone. Therefore, shutdown at 25% LEL is not too low for this process.

REFERENCES

1. EPA/625/10-85/001, *Environmental Regulations And Technology – The Electroplating Industry*, September 1985, United States Environmental Protection Agency, Washington, DC.

REFERENCES (Cont'd.)

EPA/625/7-90/007, *Guides To Pollution Prevention – The Printed Circuit Board Manufacturing Industry*, June 1990, United States Environmental Protection Agency, Washington, DC.

EPA/625/R-93/016, *Guide To Cleaner Technologies – Alternatives To Chlorinated Solvents For Cleaning And Degreasing*, February 1994, United States Environmental Protection Agency, Washington, DC.

EPA/625/R-93/017, *Guide To Cleaner Technologies – Cleaning And Degreasing Process Changes*, February 1994, United States Environmental Protection Agency, Washington, DC.

The Montreal Protocol On Substances That Deplete The Ozone Layer, March 2000, The Ozone Secretariat. Available at www.unep.ch/ozone/mont_t.htm

Substitutes in Non-Aerosol Solvent Cleaning Under SNAP as of September 28, 2006, United States Environmental Protection Agency, Washington, DC. Available at www.epa.gov/ozone/snap/solvents/solvents.pdf

Substitutes In Electronics Cleaning As Of September 28, 2006, United States Environmental Protection Agency, Washington, DC. Available at www.epa.gov/ozone/snap/solvents/lists/electron.html

Substitutes In Metals Cleaning As Of August 25, 2003, United States Environmental Protection Agency, Washington, DC. Available at www.epa.gov/ozone/snap/solvents/lists/metals.html

Substitutes In Precision Cleaning As Of August 25, 2003, United States Environmental Protection Agency, Washington, DC. Available at www.epa.gov/ozone/snap/solvents/lists/precisio.html

Significant New Alternatives Policy (SNAP) Program, June 16, 2010, United States Environmental Protection Agency Washington, DC. Available at www.epa.gov/ozone/title6/snap/snap.html www.epa.gov/ozone/snap/index.html

2. EPA/625/10-85/001, *Environmental Regulations And Technology – The Electroplating Industry*, September 1985, United States Environmental Protection Agency, Washington, DC.

EPA/625/7-90/007, *Guides To Pollution Prevention – The Printed Circuit Board Manufacturing Industry*, June 1990, United States Environmental Protection Agency, Washington, DC.

EPA/625/R-93/016, *Guide To Cleaner Technologies – Alternatives To Chlorinated Solvents For Cleaning And Degreasing*, February 1994, United States Environmental Protection Agency, Washington, DC.

EPA/625/R-93/017, *Guide To Cleaner Technologies – Cleaning And Degreasing Process Changes*, February 1994, United States Environmental Protection Agency, Washington, DC.

The Montreal Protocol On Substances That Deplete The Ozone Layer, March 2000, The Ozone Secretariat. Available at www.unep.ch/ozone/mont_t.htm

Substitutes in Non-Aerosol Solvent Cleaning Under SNAP as of September 28, 2006, United States Environmental Protection Agency, Washington, DC. Available at www.epa.gov/ozone/snap/solvents/solvents.pdf

Substitutes In Electronics Cleaning As Of September 28, 2006, United States Environmental Protection Agency, Washington, DC. Available at www.epa.gov/ozone/snap/solvents/lists/electron.html

Substitutes In Metals Cleaning As Of August 25, 2003, United States Environmental Protection Agency, Washington, DC. Available at www.epa.gov/ozone/snap/solvents/lists/metals.html

Substitutes In Precision Cleaning As Of August 25, 2003, United States Environmental Protection Agency, Washington, DC. Available at www.epa.gov/ozone/snap/solvents/lists/precisio.html

Significant New Alternatives Policy (SNAP) Program, June 16, 2010, United States Environmental Protection Agency Washington, DC. Available at www.epa.gov/ozone/title6/snap/snap.html www.epa.gov/ozone/snap/index.html