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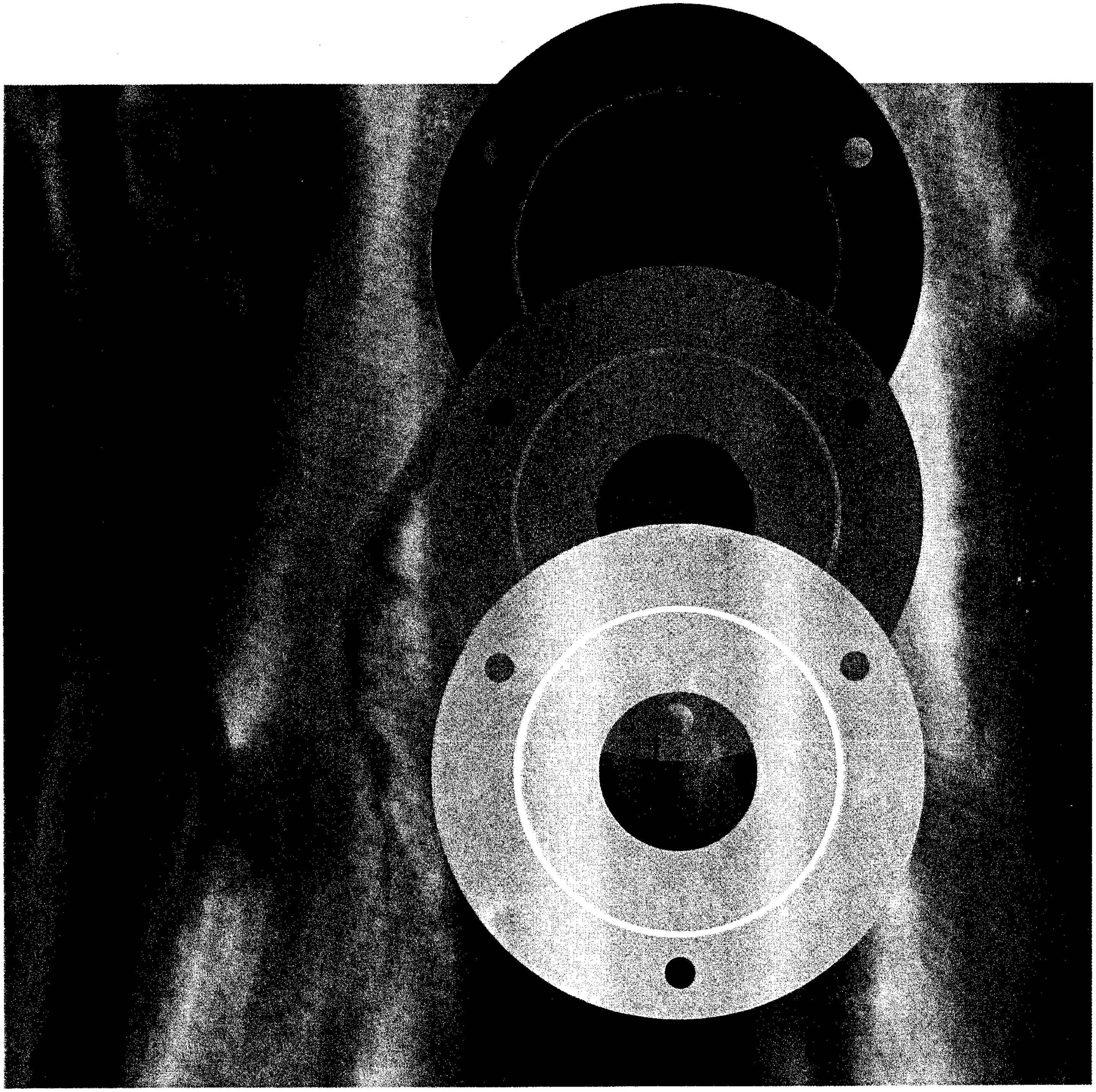
Degreasing

Occidental Chemical Corporation

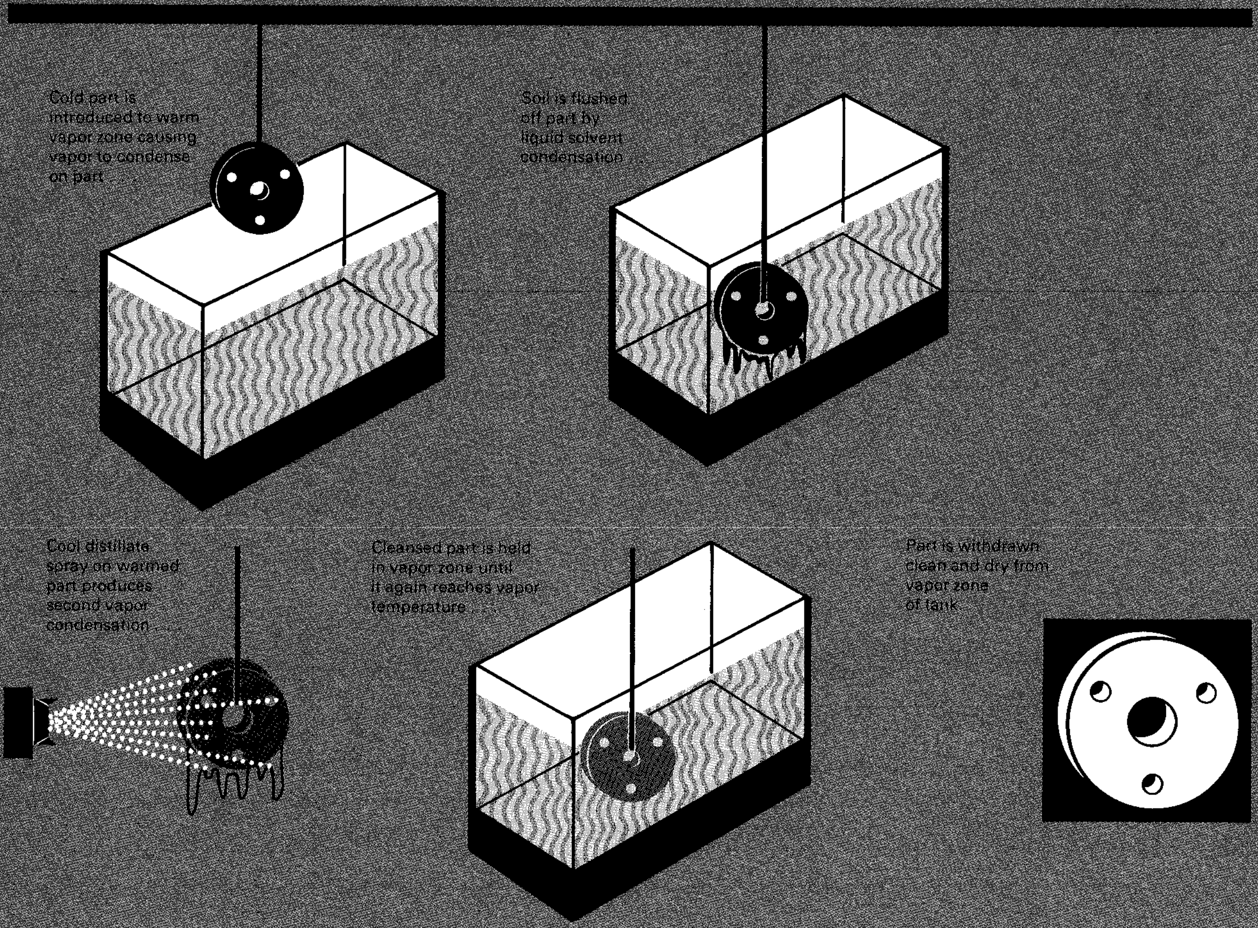
Vapor Degreasing Handbook



Vapor Degreasing with Occidental Chemical Chlorinated Solvents

Process Description

Vapor degreasing is a rapid and economical procedure for preparing clean, dry articles for subsequent finishing and/or fabrication. In its simplest form, a non-flammable chlorinated solvent is boiled to produce a vapor zone the height of which is controlled by condensing coils. Cold work introduced into the vapor condenses the vapor and the soil is flushed off by the liquid solvent condensate. The soil accumulates in the boiling sump and only pure vapor comes in contact with the work load. The work is held in the vapor zone until it reaches vapor temperature, at which time condensation stops. Vapor flushing is usually followed by pure distillate spray and/or liquid immersion. The cool, pure distillate reduces the temperature of the metal surface below the vapor temperature producing a second vapor condensation. When the work again reaches vapor temperature it is withdrawn from the vapor zone clean and dry.



1 Basic Considerations

Applications for Vapor Degreasing

Vapor degreasing quickly and thoroughly removes grease, oil, or similar substances used as lubricants or temporary protective coatings during metal fabrication, together with the dirt or solids adhering to the oil or grease films. The vapor degreasing process is applicable to any stage of manufacturing operations where clean, dry metal surfaces are desirable; for example:

Before Painting, Enameling, or Lacquering to provide a clean, dry surface and assure good adhesion of the finish.

Before Electroplating to remove mineral oils or buffing compounds prior to electrocleaning for subsequent electroplating.

Before Inspection to give a visually clean surface without the need for extensive rinsing or drying.

Before Assembly to give clean, dry parts, ready for immediate assembly and subsequent finishing.

Before Further Metal Work or Treatment to remove all traces of processing oils from surfaces in order to avoid smoking or non-uniform hardening during subsequent operations such as heat treating or welding.

Before and After Machining to remove oil, grease, and chips and to give a clean surface for subsequent machining.

Before Packing to prepare metal parts for wrapping and shipping, particularly in the case of polished, plated, or easily etched non-ferrous metal surfaces.

In Special Applications, such as the cleaning of glass and solvent resistant plastics, the drying of metal parts by displacing and flash-distilling the water from their surfaces, the heating of metal work prior to "black" (ultraviolet) light inspection.

Factors to be Considered when Choosing a Metal Cleaning Process

Type of Metal to be Cleaned

Vapor degreasing is adaptable to all commonly used types of metal. Since cleaning is by solvent action rather than chemical action, vapor degreasing simplifies cleaning on work containing dissimilar metals. It does not over-clean or under-clean areas, even where the metals differ in their chemical activity.

Size of Parts to be Cleaned

The vapor degreasing process will clean parts of any size—as small as a semiconductor or watch component, as large as a rocket engine. Metal strip and wire are being vapor degreased at speeds up to 150—200 feet a minute. Beaker-sized degreasers, or large conveyorized systems are all adaptable to the degreasing of tiny parts. A single tank occupying a comparatively small amount of floor space will vapor degrease massive parts. To clean the interior of a large tank, externally generated solvent vapors, conveyed through piping or flexible hose into the tank, condense on the walls to flush off soil and leave them clean and dry.

Shape of Parts

Due to the rapid penetrating action of solvent, the vapor degreasing process is excellent for cleaning parts containing recesses, blind holes, perforations, crevices, and welded seams. Examples include complicated and fragile stampings, screw machine parts, and polished pieces, such as castings or extrusions. Small parts can be handled in rotating baskets to prevent nesting and avoid dragout of liquid solvent from the degreaser. In extreme cases, ultrasonic energy may be used to supplement the solvent cleaning action.

Type of Soil to be Removed

Most lubricants used in metal fabrication are soluble in chlorinated solvents. The process effectively removes lubricants containing nonsaponifiable oils, with or without sulfurized or chlorinated components. In addition to dissolving the solvent-soluble soil, it effectively flushes away any adhering dirt, metal dust, chips, or other insoluble soil. For example, spraying parts immediately after they enter the vapor zone removes buffing and polishing compounds containing both greases and insoluble grits. However, when a long period of time elapses between buffing and degreasing, the compounds may oxidize or "set up" during storage. They may then require a predip in a chlorinated solvent-petroleum mixture prior to vapor degreasing.

Unless accompanied by sufficent oil or grease, vapor degreasing is not effective in removing insoluble contaminants such as metallic salts and oxides; sand; forging, heat-treat, or welding scale; carbonaceous deposits; and many of the inorganic soldering, brazing, and welding fluxes. Likewise, finger-prints resist vapor degreasing.

Amount of Soil to be Removed

A unique advantage of vapor degreasing is that cleaning costs and cleaning uniformity are relatively independent of the amount of soil removed. Rate of contaminant build-up in a vapor degreaser merely governs the frequency of solvent distillation and/or maintenance cleanouts. The quantity of soil removed does not materially affect solvent consumption.

End-Use of the Cleaned Work

The end-use of the cleaned work usually determines the degree of cleanliness required. Vapor degreasing produces a dry surface essentially free of organic contamination. Consequently, vapor degreased work is suitable for most finishing operations, without further treatment.

Exceptions are:

> Some parts, such as those of mild steel, may require application of a suitable rust preventative for protection during prolonged storage because there is no protective film remaining on the parts after vapor degreasing.
>
> Where complete freedom from all contamination is necessary, additional chemical cleaning is required.

Space Requirements

By eliminating the need for separate rinsing and drying stages, the vapor degreasing process permits the use of compact equipment occupying a minimum amount of space. The actual dimension of a vapor degreasing process is determined by the physical size and shape of the workload as well as the production rate required. Installation of the degreaser in a pit is common in plants with low-ceilinged work areas. Thus, vapor degreasing is particularly advantageous for locations with limited floor space, as in plant expansion, addition to an existing production line, or in new plants with high space costs.

Material Handling Methods

Any vapor degreasing process is capable of continuous operation and is adaptable to most conventional conveyor systems for handling metal work. Conveyorized automatic degreasers are manufactured for processing small parts, basketed work, sheet metal, fabricated parts, castings, etc. In addition, automatic load and unload features are available as well as racking means for avoiding solvent drag-out.

Cleaning Costs

Considering the relatively small cost cleaning plays in the total cost of metal-goods manufacture, the use of a second-rate cleaning process cannot be justified.

In those few cases where two or more processes promise satisfactory performance, a comprehensive cost analysis is necessary to determine which gives the lowest over-all cost. Too frequently, process selection rests on single cost comparisons. Investment, utilities, and maintenance costs are low for vapor degreasing, high for alkali cleaning. On the other hand, chemical costs for vapor degreasing are relatively high; for alkali cleaning they are low. Thus, considering only the chemical cost often leads to poor selection.

In evaluating costs for purposes of process comparison, it is essential that return-on-investment, depreciation, and reject-handling costs be determined as well as costs of materials, labor, and utilities. When all factors are taken into consideration, vapor degreasing will be the choice for a wide range of industrial cleaning needs.

Selecting Vapor Degreasing Equipment

In the selection of vapor degreasing equipment, one question must be answered before all others. That question is: Which of the vapor degreasing cycles is best suited to handle each specific cleaning problem? The importance of this analysis cannot be overemphasized. An error in choice of cycle may easily lead to the purchase of the wrong equipment resulting in waste of time, effort, and money.

Once the proper cycle has been determined, the engineer can then proceed to ask questions concerning the size and type of the equipment and the number of units required. Should the degreaser be conveyorized or manually operated? If conveyorized, what type of conveyor, i.e., monorail, cross-bar, or mesh belt? Should the unit be steam, gas, or electrically heated? Does the production flow call for the centralization of cleaning operations or for the distribution of units in scattered areas?

In answering such questions, technical representatives of solvent and equipment firms rely on their knowledge of the basic features and variations of the vapor degreasing method. Thus, in attacking the problem of equipment selection, a thorough understanding of these factors is fundamental.

Essentially there are three variations of vapor degreasing: 1) straight vapor, 2) liquid immersion-vapor, and 3) vapor-spray-vapor degreasing. In determining the best degreasing cycle, it is important that the essential features of all three be studied as they apply to the type of work to be cleaned and the contaminants to be removed.

Straight Vapor Degreasing

In the straight vapor method, cleaning results from the condensation of solvent vapors directly on the work. The clean condensate dissolves the contaminant and carries it away. This method or cycle is best suited for higher boiling solvents: Triclene® D, trichlorethylene, Perclene® D, perchlorethylene, and One-One-One Trichloroethane.

When contemplating the adoption of a straight vapor cycle, an important point to consider is the mass and gauge of the stock being cleaned. The weight and the specific heat of the work must be such that sufficient vapor is condensed to completely remove the oil or grease present. For example, heavy bars of metal may be satisfactorily degreased by simple vapor treatment, but this method is not satisfactory for small, thin sheets of metal where insufficient solvent vapor is condensed for adequate cleansing action.

Immersion-Vapor Degreasing

Immersion-vapor degreasing is preferred under any of the following conditions:

1. For closely nested work.
2. For excessive soil levels.
3. For light gauge work.
4. When ultrasonics are necessary.
5. For parts of intricate pattern.

Immersion in the boiling solvent enables rapid solution and removal of the contaminants. However, the work must be "cooled" in warm liquid to permit the characteristic final "vapor rinse" with clean condensate. This method is obviously impractical where the pieces handled are large and require an excessive volume of liquid solvent for immersion.

Vapor-Spray-Vapor Degreasing

The vapor-spray-vapor cycle is similar to straight vapor degreasing with the addition of a pure distillate rinse. This spray aids in physical removal of insoluble soil, provides additional liquid contact, and cools the part for a final vapor rinse.

This technique is recommended for:

1. Large parts such as cabinets and doors.
2. Removal of solvent insoluble soils such as buffing compounds.
3. Contamination levels too high for straight vapor cleaning.

The vapor-spray-vapor cycle does not lend itself to cleaning of closely nested work such as screw machine parts.

After choosing the proper cleaning cycle, selection of the proper equipment follows from a study of the size and shape of the work to be cleaned, utilities available, space and production requirements, and over-all process integration.

Proper Capacity

Adequate capacity is very important. Undersized degreasers are a poor investment since they result in high solvent costs and may give incomplete cleaning. The size and weight of the largest single work load contemplated (including supports) should be specified in order that sufficient heat will be provided to accommodate it. The hourly throughput and contamination level must also be considered in order to arrive at the necessary dimensions and capacity of the degreaser.

Utilities Selection

The source of heat utilized in heating the degreaser will be based on availability and relative cost to the user. If a plant has steam available, it is generally preferable. In gas-fired installations, outside air must be piped directly to the burner for combustion of the gas. Suitable flues must be provided to exhaust combustion gases to the outside of the building. All gas-fired and electrically heated degreasers are equipped with thermostats to prevent overheating of the liquid.

Manual or Automatic

Manually operated degreasers are usually preferred where the work flow is variable or the processes intermittent. Depending on the type of work to be cleaned, it may be necessary to tumble or rotate the parts to minimize "dragout" of the solvent.

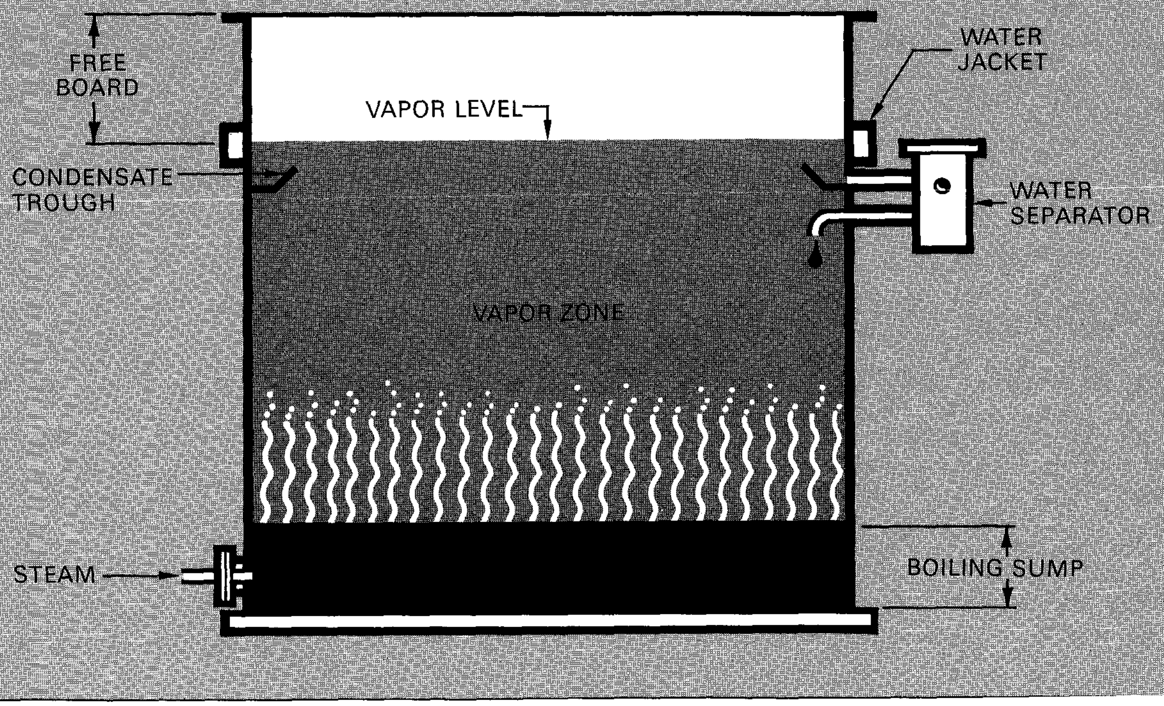
Cross-bar or belt-type conveyorized units are available for large volume vapor degreasing of parts in baskets or transfer boxes. In large plants, where work travels by mono-rail, belt, or roller systems, the appropriate degreasing cycle can be incorporated in the production line to permit continuous cleaning operations.

Auxiliary distillation units should be provided for all conveyorized machines and for large manual degreasers. The use of a centrally located still warrants consideration where several small manual degreasers are contemplated. The savings in solvent, maintenance, and cleanout costs resulting from auxiliary distillation usually offset the relatively small investment involved.

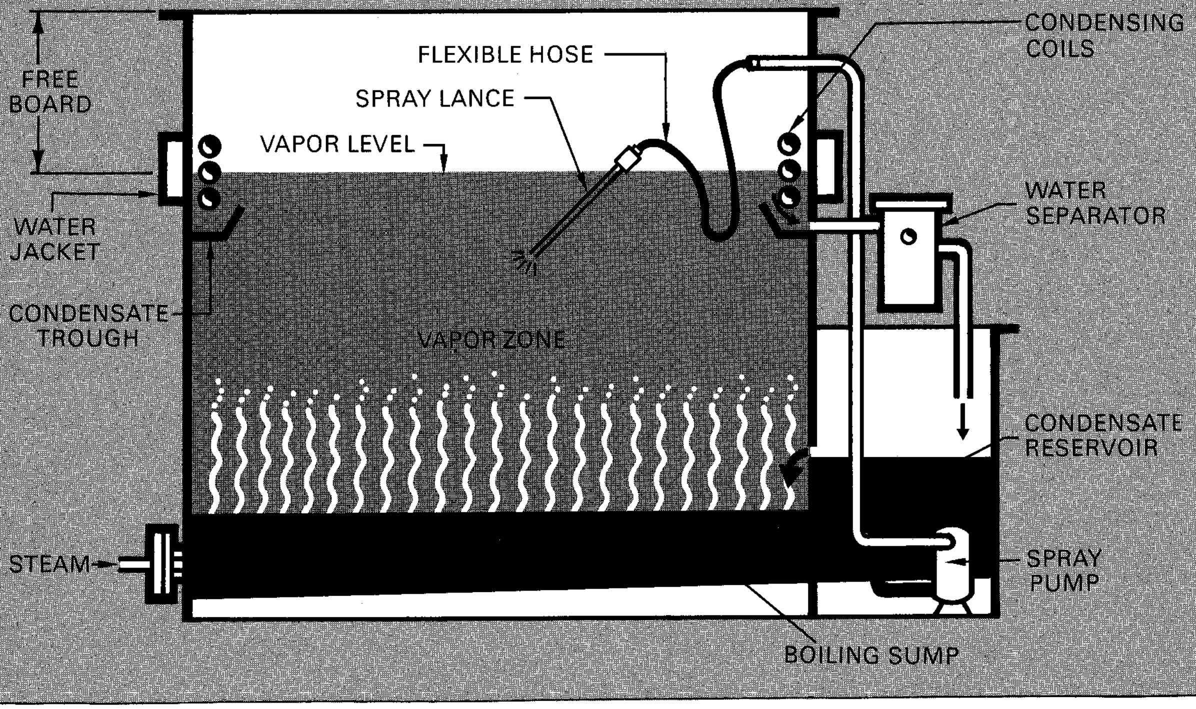
Heat Pump

Heat recovery vapor degreaser systems based on heat pump technology are available for use with low boiling point solvents. The system employs a refrigeration system for condensing, and uses the recovered heat from the coolant and from the compressor to boil the solvent. The only utility required is electricity. Some low boiling point solvents used in heat pump degreasers are trichlorotrifluoroethane, methylene chloride and their azeotropes, and blends with alcohols, ketones and esters. These offer a broad range of cleaning capabilities for specific applications. The cleaning of heat-sensitive parts and difficult cleaning jobs requiring polar solvents are typical examples. In all cases, where heat pumps are used, it is important to have enough available energy to maintain a constant distillation rate, even at 50 weight percent contamination of the solvent.

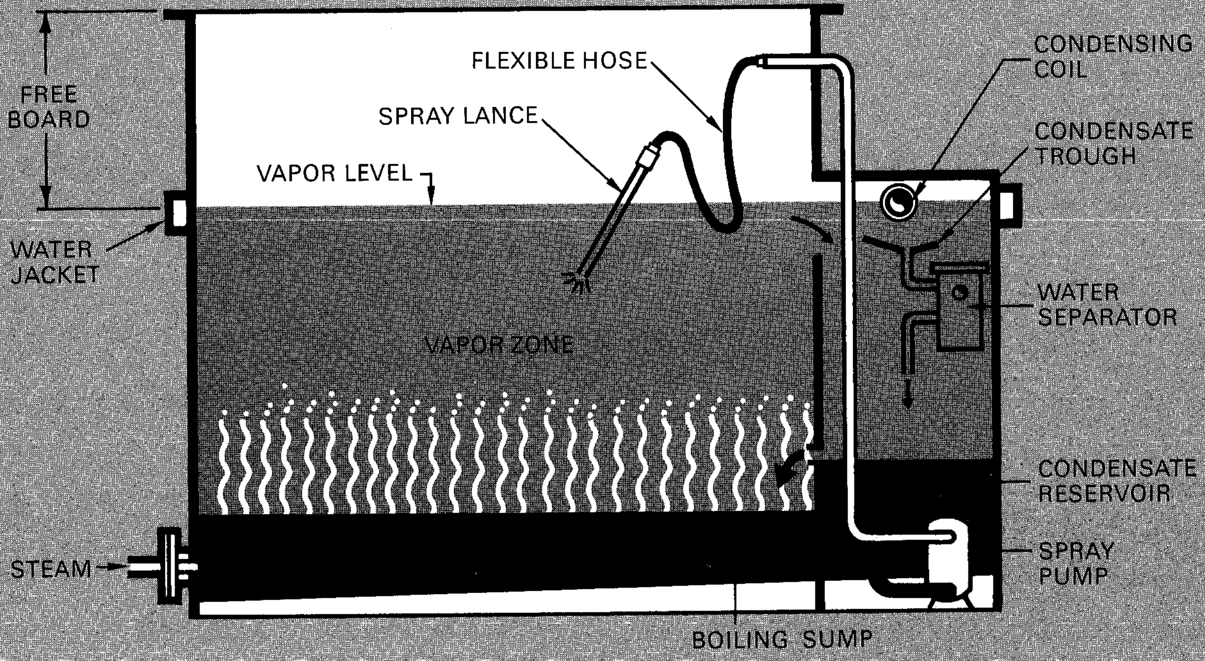
Vapor Only Degreaser



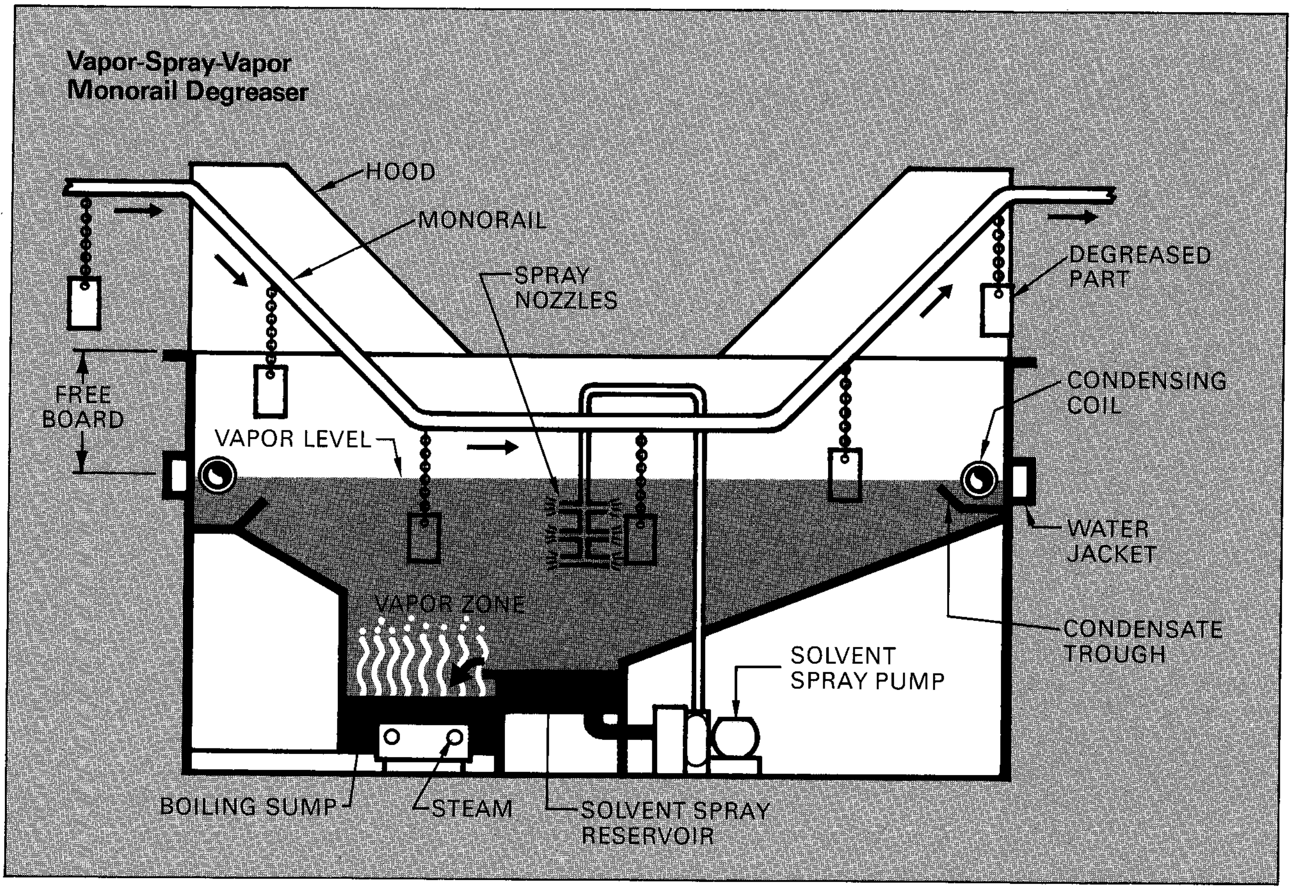
Perimeter Condensing Vapor-Spray-Vapor Degreaser



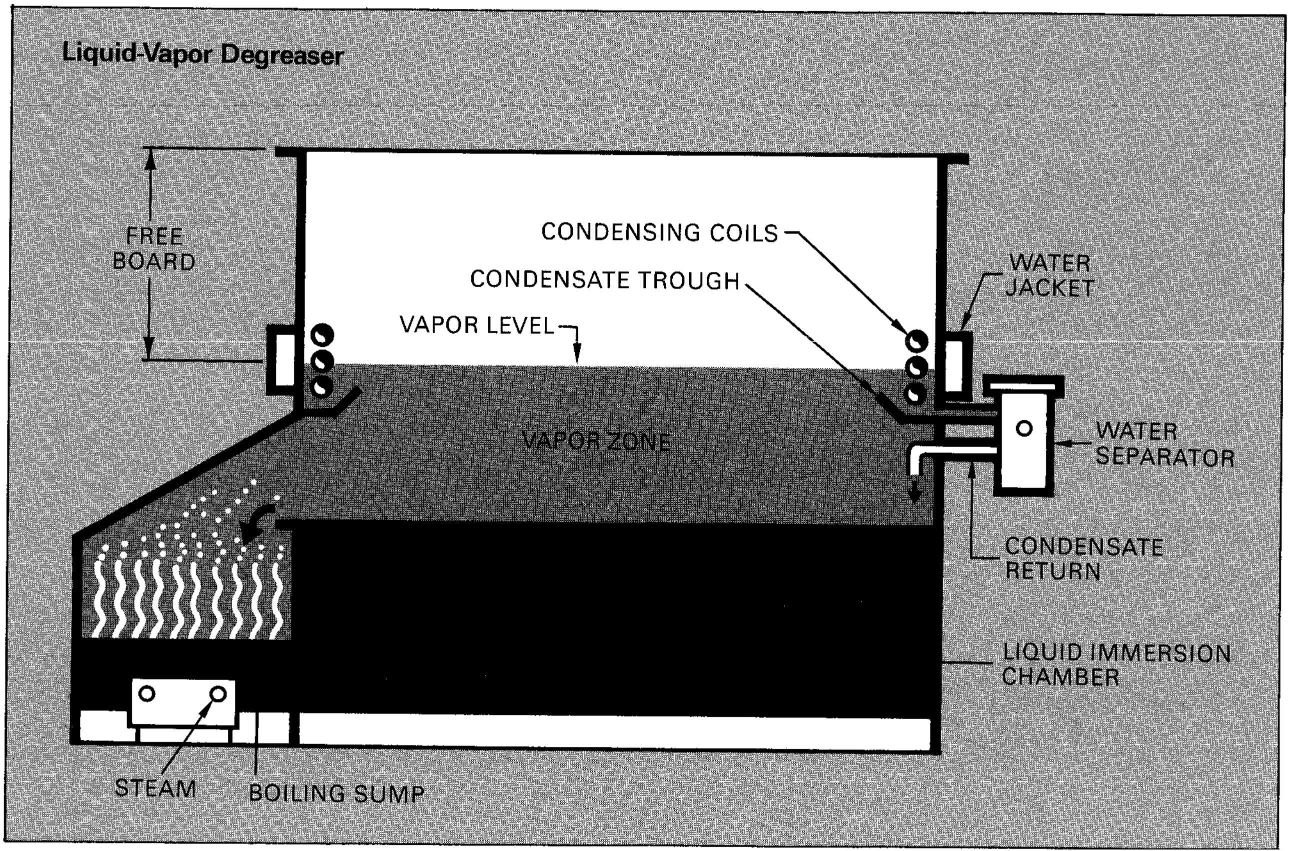
Offset Condenser Vapor-Spray-Vapor Degreaser



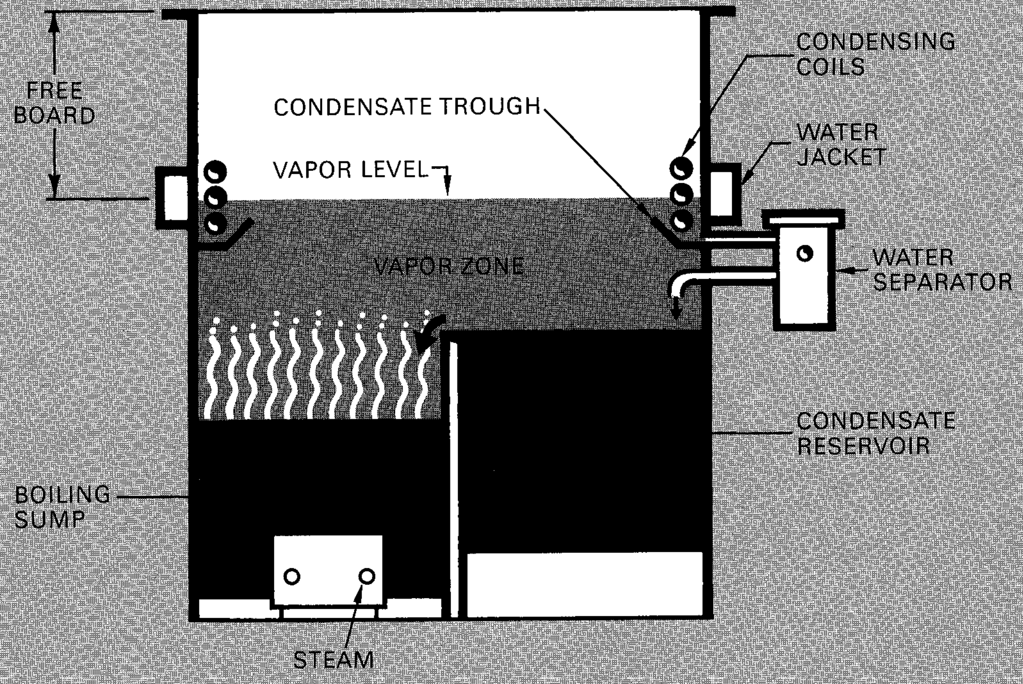
Vapor-Spray-Vapor Monorail Degreaser



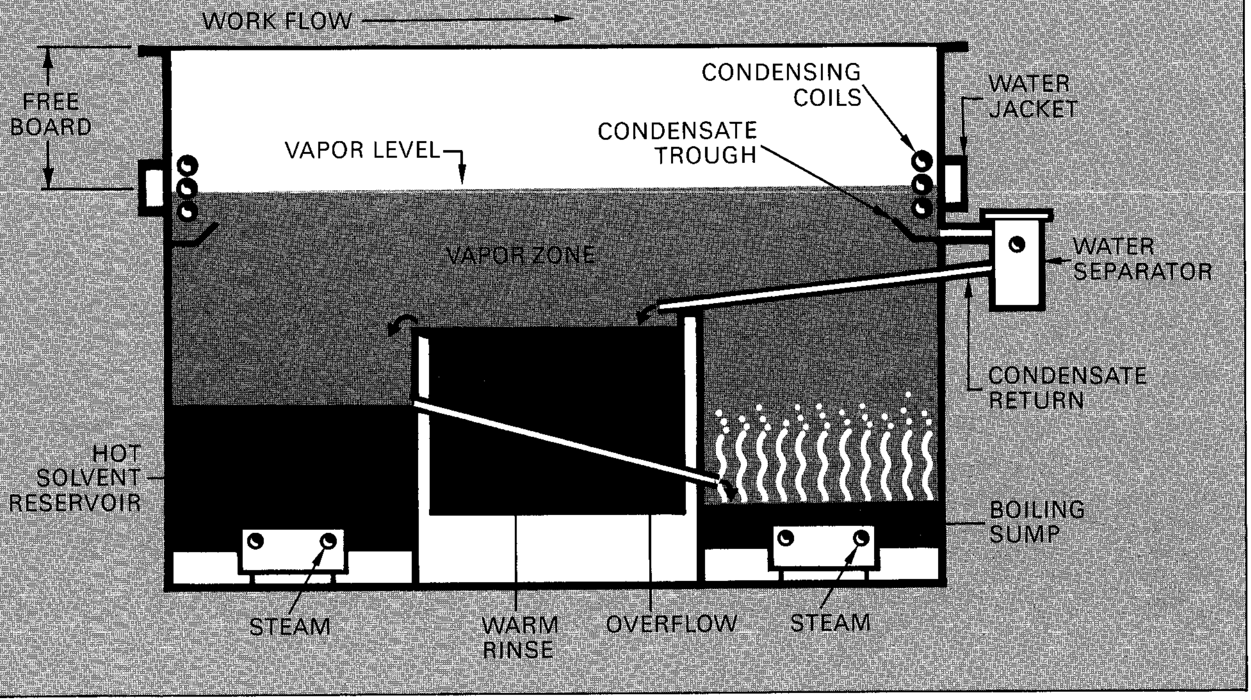
Liquid-Vapor Degreaser



Liquid-Liquid-Vapor Degreaser
2 Compartment



Liquid-Liquid-Vapor Degreaser
3 Compartment



Selecting A Vapor Degreasing Solvent

For years Triclene® D trichlorethylene has been recognized as the "standard" for vapor degreasing. In fact, successful development and refinement of the vapor degreasing process was based on, and made possible by, the use of this versatile solvent.

Federal and State regulations enacted in order to meeting national air quality standards have prompted the use of alternate solvents not considered as detrimental to air quality—namely, Perclene® D perchlorethylene, M-Clene D® methylene chloride, and One-One-One Trichloroethane.

Experience gained using alternate solvents has revealed their technical advantages. Thus, the best choice for vapor degreasing may be any of the four solvents depending upon the individual requirements of the application.

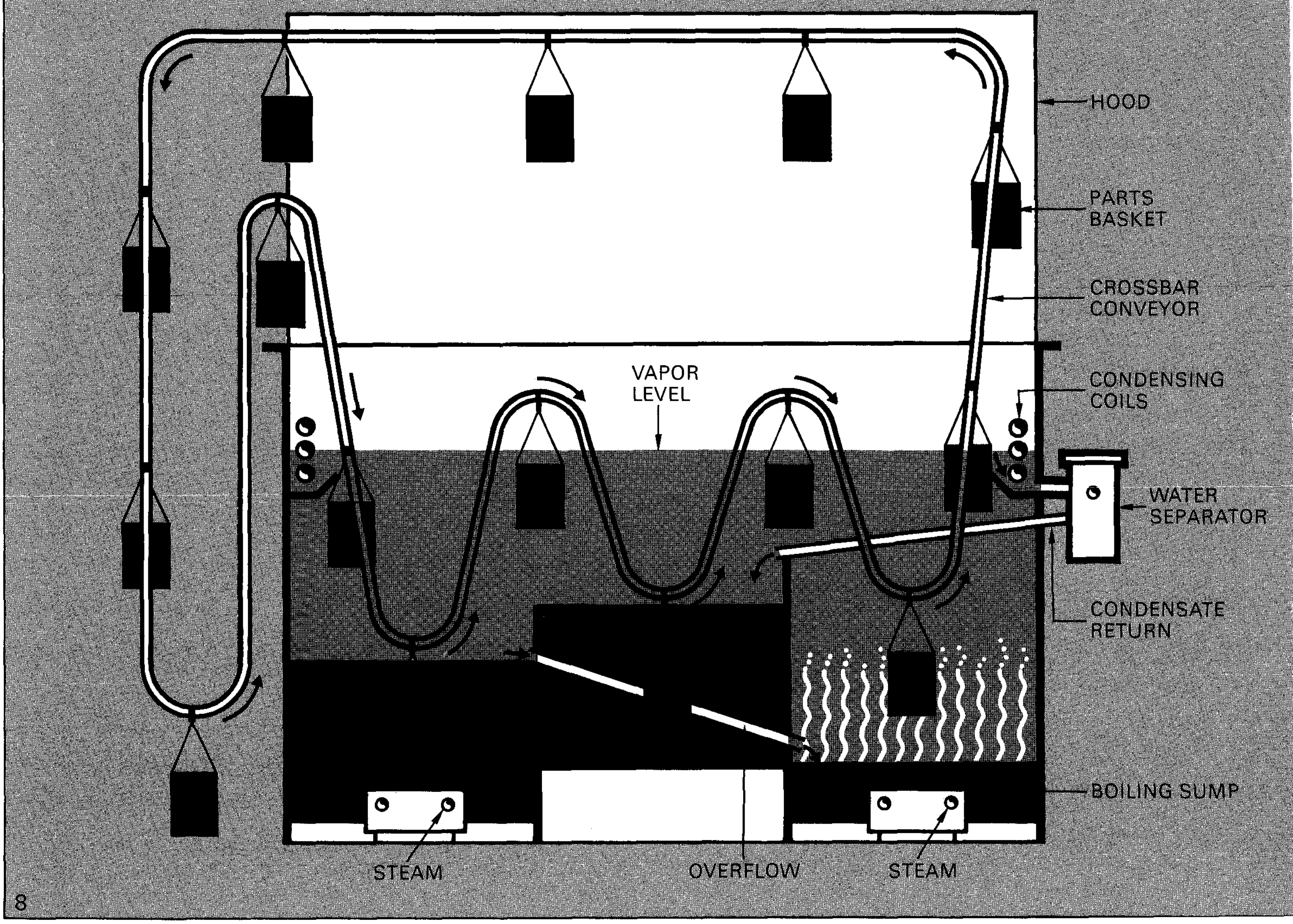
While the four solvents vary in properties, they all possess the following six characteristics necessary for vapor degreasing service.

Nonflammable—Triclene D, Perclene D, M-Clene D, and One-One-One Trichloroethane are all nonflammable. They have no flash or fire point.

High Vapor Density—Solvent vapor must be heavier than air.

Toxicity—With Proper ventilation, each of the four chlorinated solvents can be used.

Liquid-Liquid-Vapor Crossbar Degreaser



SOLVENT	SOLVENT VAPOR DENSITY	
	AIR=1	LBS./CU. FT. (At the boiling point)
Triclene D	4.54	0.278
Perclene D	5.83	0.320
M-Clene D	2.93	0.206
One-One-One Trichloroethane	4.58	0.285

Suitable Boiling Point and Low Heat Requirement—A vapor degreaser should be able to operate on utilities normally available in a plant. This permits use of Perclene D (250°F boiling point) on one extreme and M-Clene D (104°F boiling point) on the other. All four chlorinated vapor degreasing solvents have a significantly lower heat requirement than water.

SOLVENT	BOILING POINT °F	SPECIFIC HEAT (at 20°C) Btu/Lb/°F	LATENT HEAT OF VAPORIZATION Btu/lb.
Triclene D	188	0.225	103
Perclene D	250	0.205	90
M-Clene D	104	0.280	142
One-One-One Trichloroethane	165	0.258	102
Water	212	1.000	972

Stability—All chlorinated solvents must be stabilized for vapor degreasing use. Occidental Chemical's vapor degreasing grade solvents, tested under simulated use conditions, gave the following results:

CONDITION	M-CLENE D	PERCLENE D	TRICLENE D	ONE-ONE-ONE TRICHLOROETHANE
Wet Steel Storage	G	G	G	P
Oxidation	E	G	E	E
Hydrolysis	E	E	G	P
Polymerization	E	E	G	F
Pyrolysis	E	E	G	F

E=EXCELLENT G=GOOD P=POOR F=FAIR

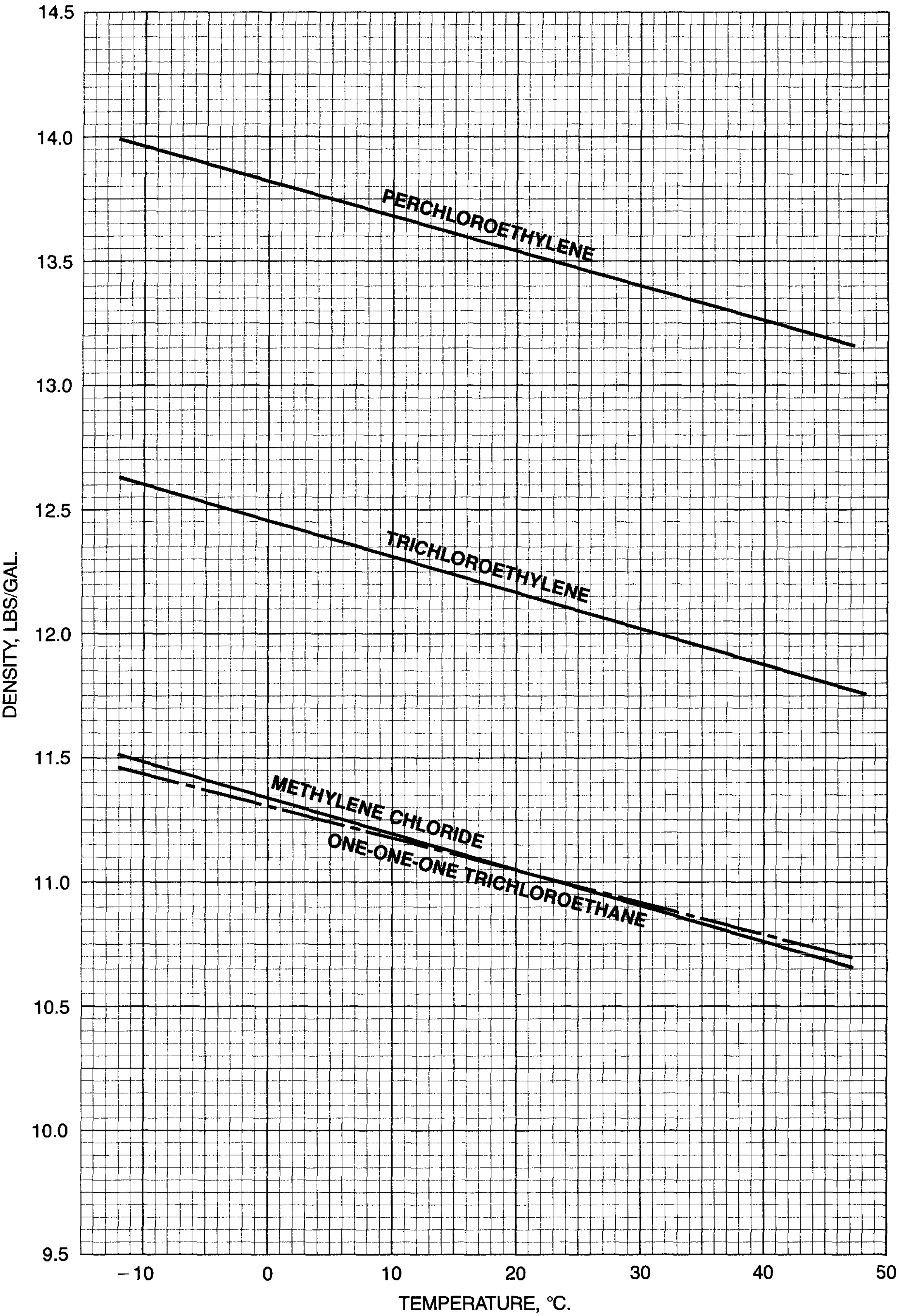
Compatibility and Solvency—Vapor degreasing solvents must not attack the workload being cleaned. And they must quickly and effectively dissolve the soil. Some soils are soluble only at very high temperatures (waxy drawing lubes), while others (some fluxes) may be heat-set when exposed to Triclene D or Perclene D vapors. Likewise, the work may be heat distorted, or in the case of some plastics, dissolved or softened if the incorrect solvent is chosen. It is strongly suggested that the compatibility and solvency be evaluated using the actual workload and soil before committing to any vapor degreasing solvent. OxyChem's technical service is available for assistance in carrying out such evaluations.

Physical Properties of Chlorinated Solvents

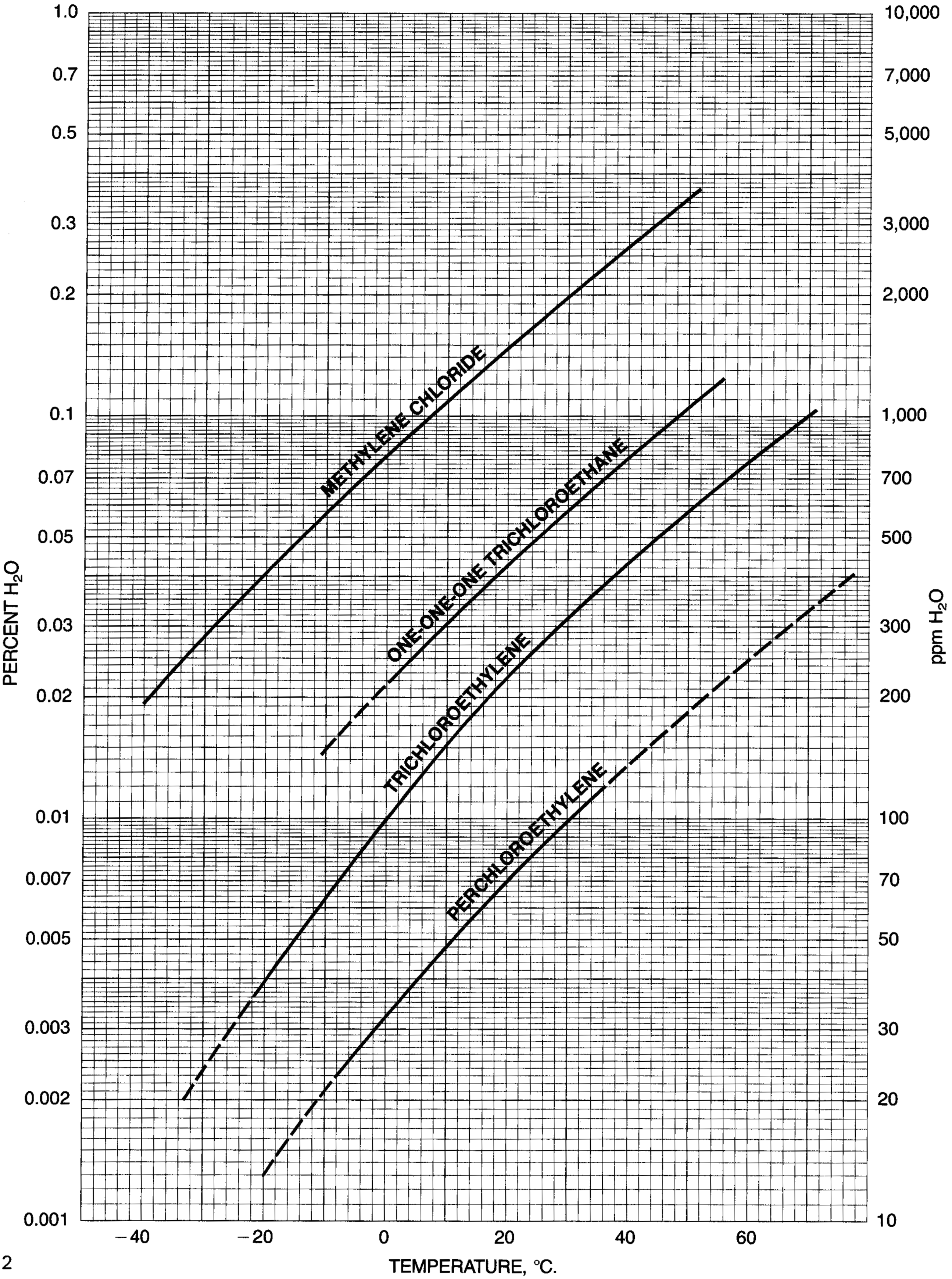
	Perchlorethylene	Trichlorethylene	1, 1, 1,-Trichloroethane	Methylene Chloride
Chemical Formula	$CCl_2:CCl_2$	$CHCl:CCl_2$	CH_3CCl_3	CH_2Cl_2
Molecular Weight	165.85	131.40	133.42	84.84
Boiling Point: °C. and °F.	121.0; 250	86.9; 188	74.1; 165	39.8; 104
Critical Pressure (Atmos.)	39.3	49.5	39.8	60.9
Critical Temperature: °C. and °F.	347; 657	271; 520	277; 530	245; 473
Coefficient of Cubical Expansion: Avg./°C., Liquid	0.00102	0.00117	0.00125	0.00137
Applicable Range: °C.	0 to 25	0 to 40	0 to 30	0 to 40
Dielectric Constant: Liquid	2.365 (25°C.)	3.42 (16°C.)	7.0 (25°C.)	9.1 (20°C.)
Vapor B.P.				1.0082 (40°C.)
Diffusity in Air: sq. cm./sec. @ 25°C., 1 atmos.	0.067	0.073	0.078	0.091
Explosive Limits in Air—Lower	None	14.5 (100°C.)	8.4 (100°C.)	15.5*
Percent by Volume—Upper	None	18.4 (100°C.)	16.5 (100°C.)	66.4*
Evaporation Rate: Ether = 100	12	30	37	62
Carbon Tetrachloride = 100	39	84	100	147
Flammability	Non-Flammable	Non-Flammable	Non-Flammable	Non-Flammable
Flash Point Open Cup: °C. and °F.	None	None	None	None
Freezing Point: °C. and °F.	-22.4:-8.3	-86.4:-123.5	-36.9:-34.4	-96.7:-142
Heat of Formation: Kg-cal/mol—Liquid	3.0	1.0	-30.6	28.6
—Vapor	-6.0	-7.0	-38.2	21.7
Ignition Temperature: °C. and °F.		410; 770	485; 905	662; 1224
Kauri Butanol Value	90	130	124	136
Latent Heat of Vaporization (B.P.)—Cal/gm	50.1	57.2	56.7	78.7
—BTU/pound	90.2	103.0	102.0	141.7
Refractive Index—Liquid N 20 D	1.5044	1.4782	1.435 (25°C.)	1.4244
—Vapor (0°C.)	1.002009	1.001784	-	1.001055 (25°C.)
Solubility (25°C.), g/100 gms—In H_2O	0.015	0.11	0.07	1.32
—H_2O In	0.0105	0.032	0.05	0.198
Specific Gravity: 25°C./25°C.	1.620	1.455	1.322	1.322
Pounds/Gallon: 25°C. (77°F.)	13.48	12.10	10.98	11.00
Specific Heat: (Cal/gm/°C or BTU/lb/°F.)				
—Liquid, 20°C.	0.205	0.225	0.258	0.280
—Vapor (CP, 1 atm.)	0.146 (100°C.)	0.156 (80°C.)		0.155 (40°C.)
Specific Resistivity: ohms/cm	1.8×10^{13}	6.6×10^{9}	7.3×10^{9}	-
Steam Dist. Point (1 atm): °C. and °F.	87.8; 190	73.3; 164	65; 149	37.8; 100
Ratio of Solvent/Water by Weight	5.32 to 1	13.4 to 1	21.2 to 1	66.3 to 1
Surface Tension in Air: Dynes/cm: 20°C.	32.3	31.6	25.5	28.2
Thermal Conductivity —Liquid, 20°C.	0.0732	0.0801	0.0797	0.0920
BTU/hr. (sq. ft.) (°F./ft.)—Vapor, B.P.	0.00505	0.0482	0.00523	0.00438
Vapor Density —gm/liter	5.22	4.45	4.58	3.30
(B.P., 760 mm.)—lbs./cu. ft.	0.320	0.278	0.285	0.206
Specific Gravity (Air= 1)	5.83	4.54	4.55	2.93
Vapor Pressure (20°C.) mm. Hg	14.4	57.8	104.5	352.1
Viscosity (Centipoises—liquid—20°C.)	0.88	0.58	0.79 (25°C.)	0.425
—vapor	0.0099 (60°C.)	0.0103 (60°C.)		0.0109 (40°C.)
Water Azeotrope: °C. and °F.	87.8; 190	73.3; 164	65; 149	37.8; 100
Water—Weight Percent	15.8	7	4.5	1.5

* Only in pure oxygen under pressure.

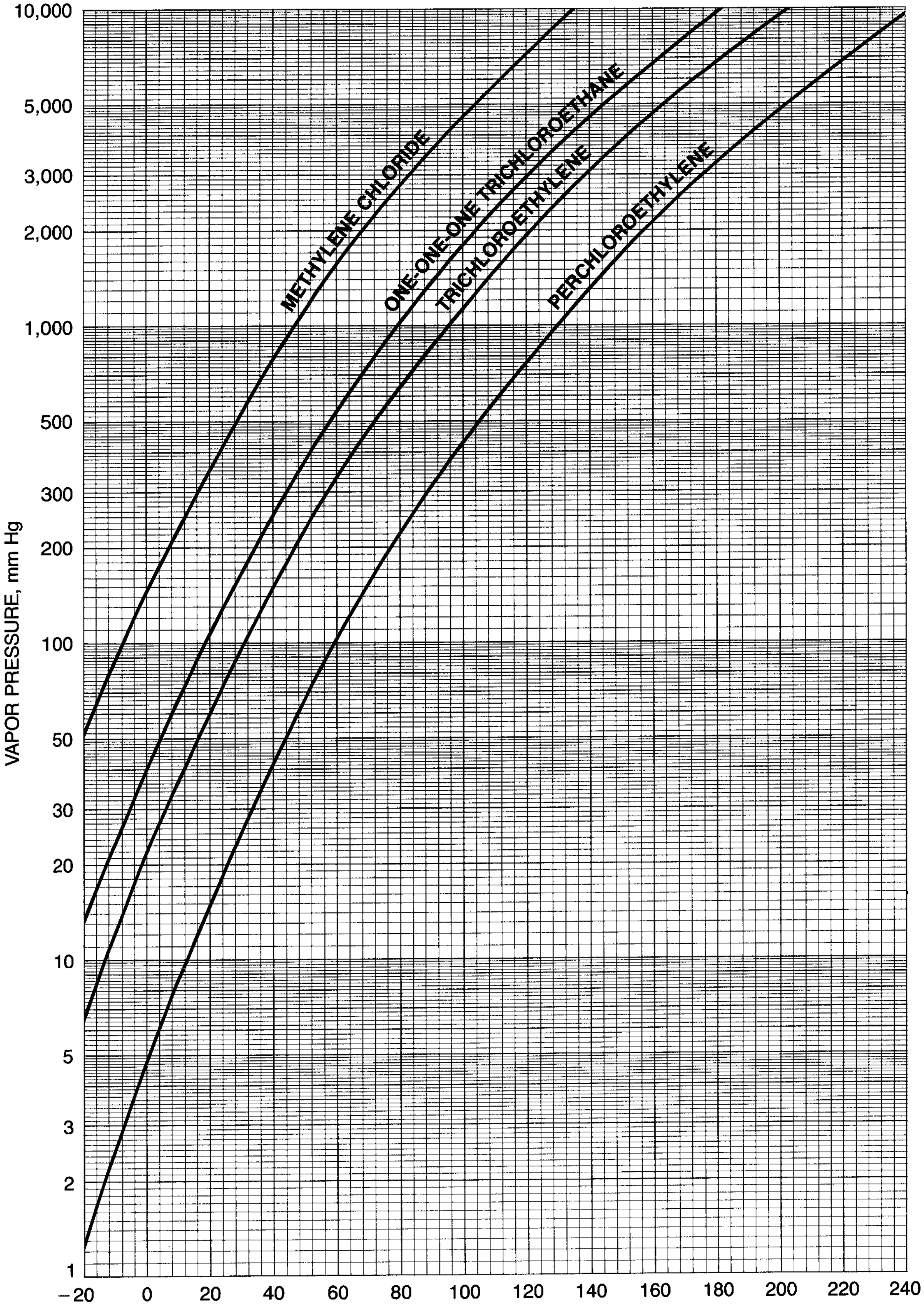
Density of Chlorinated Solvents as a Function of Temperature



Solubility of Water in Chlorinated Solvents



Vapor Pressure of Chlorinated Solvents



2 Comparative Advantages And Limitations of Vapor Degreasing Solvents

One-One-One-Trichloroethane

ONE-ONE-ONE-TRICHLOROETHANE behaves like trichlorethylene in vapor degreasing due to a similar boiling point and has become the solvent of choice in most degreasing applications. However, it is more sensitive to water and aluminum. Stability problems can develop in stress applications of One-One-One-Trichloroethane. Therefore good housekeeping and quality control procedures are important.

Advantages of One-One-One-Trichloroethane

Lower Part Temperature—The boiling point of One-One-One-Trichloroethane is 23°F lower than trichlorethylene. Parts are noticeably cooler on exit from the degreaser but are not cool to the touch. Associated with the cooler part temperature is less vapor flushing which may make spraying or a liquid dip essential.

Easy Conversion—Due to its 165°F boiling point, One-One-One-Trichloroethane performs well in degreasers designed for trichlorethylene. Modifications are minimal in stainless steel equipment. Easy compliance with EPA restrictions on trichlorethylene can be achieved if there is not a stress condition which will cause stability problems.

Limitations of One-One-One-Trichloroethane

Unstable with Water—One-One-One-Trichloroethane should not be used if water based lubes are removed from the workload or if there is excessive water in the system. One-One-One-Trichloroethane has a strong affinity for water and even with a properly operating water separator, it is difficult to keep the degreaser dry. Equipment life will be seriously shortened in wet One-One-One-Trichloroethane service.

Aluminum Instability—In addition to the hydrolytic instability of 1,1,1-trichloroethane, depletion of those inhibitors which prevent reaction with aluminum can cause a "run-away" acid-forming reaction. Such a reaction can have disasterous effects; deterioration of the degreaser and its associated equipment; corrosion of surrounding structural steel and equipment; and even fire and/or explosion. The conditions which lead to this "run-away" reaction may go unnoticed for some time. The final reaction may take place in as little as 10 minutes. Chemical reactions such as the ones described above are most common when the work being processed is aluminum or zinc. Good housekeeping and quality control procedures can reduce the risk of this reaction occuring.

Maximum 75—80% Recovery—One-One-One-Trichloroethane cannot be steam stripped due to its hydrolytic instability. Further it is not advisable to exceed 200°F in the still or thermal decomposition may result. One-One-One-Trichloroethane sludge having a boiling point of 200°F contains 20-25% solvent which cannot be recovered.

Perclene D

PERCLENE D is the highest boiling vapor degreasing solvent (BP 250°F).

Advantages of Perclene D

"Fail Safe"—Refers to the inherent stability of the perchlorethylene molecule. If the stabilizers used in Perclene D are depleted, a runaway reaction with aluminum will **not** occur. To various degrees, this aluminum catalyzed breakdown can occur with 1,1,1-trichloroethane, trichlorethylene, and methylene chloride, if the stabilizers are depleted.

Increased Vapor Flushing—A metal workload condenses solvent vapor until it reaches the temperature of the vapor. At this point, condensation or flushing ceases and cleaning is complete. Once the workload has reached the temperature of the vapor, there can be no additional cleaning regardless of how long the work is kept in the degreaser. Thus with Perclene D (BP 250°F), 75% more vapor flushing is obtained than with trichlorethylene.

Better Cleaning—Cleaning tests and field studies have shown Perclene D typically cleans better than all other chlorinated solvents. This is due to increased vapor flushing and the higher boiling point. Oil and greasy soils are more fluid and more soluble at higher temperatures. Many buffing compounds contain a waxy binder that is only solvent soluble at higher temperatures when it is molten. Cleaning effectiveness must be checked with the specific workload and soil.

Drying Solvent—All four chlorinated vapor degreasing solvents physically combine with water at a temperature lower than their boiling point. This physical combination of solvent and water (called an azeotrope) has a specific composition and boiling point. Perclene D is the best drying solvent of the four because its high boiling point (250°F) drives water off the workload rapidly. Its azeotrope also contains the most water (15.8% vs. 7.0% for trichlorethylene which is the next best).

Usable with All Materials of Construction—Corrosion strip tests and field experience have shown Perclene D suitable for use in mild steel and galvanized as well as stainless equipment.

Limitations of Perclene D

May Require Added Heat Input-As will be discussed in the next section, "Equipment Design Guidelines," a minimum of 60 psig steam pressure and possibly a larger steam coil are required. With electric or gas, there may be need for additional elements or a larger orifice. Immersion-vapor degreasers are most easily converted to Perclene D.

High Part Temperature—This is a limitation which seldom can be compensated for, if it is a problem. Refrigerated tunnels following the degreaser have been used with limited success. At 250°F, heavier gauge parts are still hot to the touch after 45 minutes of cool-down time. On the other hand, light gauge parts (like finned tubing) cool in nearly the same time as with trichlorethylene.

Hot Work Area—Perclene D degreasers must be insulated to provide greater comfort and safety: however, radiant heat from the workload cannot be eliminated.

Effect of Temperature on Workload—The higher temperature of 250°F may or may not be harmful to the workload. This must be checked in a cleaning test prior to use of Perclene D.

M-Clene D

M-CLENE D is at the other end of the spectra from Perclene D. But its low boiling point of 104°F gives it unique vapor degreasing properties.

Advantages of M-Clene D

Cool Parts—A workload that is cool to the touch after vapor degreasing (104°F) is a *unique* advantage of M-Clene D.

High Production Rate—Continuous workload capability of the vapor degreaser is calculated using the following formula:

$$\text{Lbs./Hr. that can be cleaned} = \frac{\text{Maximum Heat Available}}{\text{Specific Heat of Metal Cleaned} \times \text{Temperature Rise of Work in Vapor Degreaser}}$$

Thus, production rate is proportional to the heat available divided by the temperature rise (ΔT). The ΔT for M-Clene D is 30°F at 74°F room temperature. With trichlorethylene, it is 114°F. Hence a four-fold increase in production rate can be achieved with M-Clene D over trichlorethylene.

Excellent Recovery—Recovery of 97% is possible with conventional distillation equipment without steam stripping. This is due to the large difference in boiling points between M-Clene D and oil. With steam stripping, it is possible to recover and reuse oil. Sludge from a M-Clene D still is amazingly free flowing. Still cleanout normally does not require removal of the cleanout door. At the lower temperature, sludge is not baked on the steam coils.

Unsurpassed Stability—At 104°F, reactions proceed much more slowly than at 188°F, the boiling point of trichlorethylene. Thus when a stabilization system equal to that of Triclene D is tailored to methylene chloride, the result is unsurpassed stability. M-Clene D has successfully replaced trichlorethylene in applications where acidity problems existed.

Operator Comfort—M-Clene D offers the greatest operator comfort of all chlorinated vapor degreasing solvents.

Does Not Heat Set Soils—As discussed with Perclene D, some workoads (and soil) are heat sensitive. M-Clene D will not cause heat related problems.

Suitable for Heat Recovery Systems—M-Clene D can be used in degreaser systems based on heat pump technology. These systems use the heat recovered from the refrigerated condensing coolant to boil the solvent.

Limitations of M-Clene D

Requires 70°F (max.) Inlet Cooling Water—This utility may or may not be available. Well water is ideal. City water in many northern states is likewise sufficiently cool. Cooling tower water can normally be used during the winter, spring and fall months, but an alternate source of colder water is required for the summer. If cool water is not available, a recirculating chilled water system must be used. Chiller sizing is covered in the section on "Equipment Design."

May Require More Condensing Area—The latent heat of vaporization for M-Clene D is nearly half again as great as trichlorethylene. Thus, additional condensing surface area may be needed when converting a trichlorethylene degreaser.

Vapor Cleaning Not Sufficient—While high production rate is an advantage, the corresponding disadvantage is proportionately less vapor flushing. Particularly in summer months with high ambient temperatures there is seldom enough vapor flushing to remove all the soil. Thus a spray or liquid dip is necessary. This may be difficult with a large bulky workload.

High Melt Soils Are Not Removed—M-Clene D cleans largely by solvency, while the higher boiling vapor degreasing solvents clean through a combination of solvency and heat. A cleaning evaluation is strongly recommended before going ahead with M-Clene D. Results have in many cases been better than trichlorethylene, but in several instances M-Clene D has proven totally inadequate.

Triclene D

TRICLENE D was the *standard* of the industry and the solvent to which others are compared. It has a moderate boiling point of 188°F which provides considerable vapor flushing, yet the workload is not excessively hot on exit from the degreaser. Utility requirements are satisfied with low pressure steam (15 psig) and city or cooling tower water. With the development of the Triclene D stabilization system, acidity problems are rarely encountered.

The use of Triclene D is restricted in some areas by the local Environmental Protection Agency (EPA). This legislative topic is covered in Section V.

The general properties of Triclene D make it acceptable, but not necessarily the best choice, for nearly all vapor degreasing applications.

3 Equipment Design Guidelines

Heat Balance Calculations

A vapor degreaser (or still) is a heat balance machine. Heat input to vaporize the solvent equals heat removed by the condensing coils plus radiation losses. When a workload is introduced, heat is also removed through increasing the temperature of the metal and producing condensate. The amount of heat input should be sufficient to handle the instantaneous heat requirement of the workload in a batch type operation. When the vapor degreaser is idling (no workload), condensing coil capacity must be sized so as to remove the heat.

$$\text{Total Heat Requirement} = \text{Heat For Workload} + \text{Heat For Condensate Production} + \text{Heat Losses}$$

Heat for the workload is calculated as follows:

$$\text{Heat For Workload} = \text{Specific Heat Of Metal} \times \text{Lbs. of Metal Cleaned per Hour} \times \text{Temperature Rise In Vapor Degreaser}$$

For example, a properly operated trichlorethylene degreaser cleaning 2,000 pounds of steel per hour (maximum of 200 lbs. per load) when the ambient temperature is 70°F will require the following heat:

METAL	SPECIFIC HEAT, Btu/lb./°F
Steel	0.117
Copper	0.092
Aluminum	0.230

$$\text{Heat for Workload} = .117\,\frac{\text{Btu}}{\text{Lb.}} \times 2000\,\frac{\text{Lb.}}{\text{Hr.}} \times (188-70) = 27{,}600\ \text{Btu/Hr.}$$

For a batch type machine, the size of the individual load should not exceed 1/10th of the total hourly workload since ten workloads per hour is a practical minimum.

Therefore, the maximum weight of an individual load determines the hourly heat requirement.

Heat for condensate production depends upon how much clean solvent is required. Normally, 60 gph of condensate for each 10 sq. ft. of solvent vapor-air interface is adequate to maintain sufficient volume for spray or a clean immersion reservoir.

Thus, for a degreaser 3′ x 7′ in top dimensions, 126 gph of condensate should be generated. If this degreaser has a spray pump discharging 180 gph and the spray will be used continuously, the condensate production rate must be increased accordingly.

Heat requirement to produce condensate is calculated as follows: (Refer to solvent physical properties table on p. 9 for specific and latent heats.)

$$\begin{array}{c}\text{Heat to Convert}\\ \text{Solvent Liquid to Solvent-Vapor}\\ \text{At the Boiling Point}\end{array} = \begin{array}{c}\text{Lbs./Hr.}\\ \text{Of Condensate}\end{array} \times \text{Latent Heat of Vaporization}$$

$$\begin{array}{c}\text{Heat to Raise Condensate}\\ \text{To Solvent Boiling Point}\end{array} = \begin{array}{c}\text{Lbs./Hr.}\\ \text{Of Condensate}\end{array} \times \begin{array}{c}\text{Specific Heat}\\ \text{Of Solvent}\end{array} \times \begin{array}{c}\text{Temperature Difference Between}\\ \text{Solvent Boiling Point and}\\ \text{Condensate Reservoir}\end{array}$$

$$\begin{array}{c}\text{Total Heat Requirement}\\ \text{To Produce Condensate}\end{array} = \begin{array}{c}\text{Heat to Raise Condensate}\\ \text{To Solvent Boiling Point}\end{array} + \begin{array}{c}\text{Heat to Convert}\\ \text{Solvent Liquid to Solvent Vapor}\\ \text{At the Boiling Point}\end{array}$$

For example, for a trichlorethylene degreaser with a condensate reservoir temperature of 120°F, the heat requirement for producing 126 gph of condensate is:

$$\begin{aligned}\begin{array}{c}\text{Heat to Raise Condensate}\\ \text{To Solvent Boiling Point}\end{array} &= 126\,\frac{\text{Gal.}}{\text{Hr.}} \times 12.2\,\frac{\text{Lb.}}{\text{Gal.}} \times .225\,\frac{\text{Btu}}{\text{Lb. }^\circ\text{F}} \times 188\text{—}120^\circ\text{F}\\ &= 126 \times 12.2 \times .225 \times 68\,\frac{\text{Btu}}{\text{Hr.}}\\ &= 23{,}500\,\frac{\text{Btu}}{\text{Hr.}}\end{aligned}$$

$$\begin{aligned}\begin{array}{c}\text{Heat to Convert}\\ \text{Solvent Liquid to Solvent Vapor}\\ \text{At the Boiling Point}\end{array} &= 126\,\frac{\text{Gal.}}{\text{Hr.}} \times 12.2\,\frac{\text{Lb.}}{\text{Gal.}} \times 103\,\frac{\text{Btu}}{\text{Lb.}}\\ &= 126 \times 12.2 \times 103\,\frac{\text{Btu}}{\text{Hr.}}\\ &= 158{,}000\,\frac{\text{Btu}}{\text{Hr.}}\end{aligned}$$

$$\begin{array}{c}\text{Total Heat Requirement}\\ \text{To Produce Condensate}\end{array} = 23{,}500 + 158{,}000 = 181{,}500\,\frac{\text{Btu}}{\text{Hr.}}$$

Heat Losses due to conduction and convection can be almost eliminated with Perclene D, Triclene D, and One-One-One-Trichloroethane by using insulation. They are negligible with M-Clene D even when the degreaser is uninsulated.

Thus for the 3′ x 7′ uninsulated vapor degreaser, using trichlorethylene, radiation losses are about 1520 Btu/Hr. This assumes a 1 foot solvent depth and 3 foot vapor depth.

SOLVENT	Btu/Hr./100 Sq. Ft. HEAT LOSS EXPERIENCED FROM UNINSULATED SURFACE	
	Vapor Zone	Boiling Sump
Perclene D	2300	4600
Triclene D	1100	2100
One-One-One-Trichloroethane	800	1600

Boiling Sump	2(1 x 7)	+	2(3 x 3)	+	(3 x 7	=	41 sq. ft.	x 21	=	860
Vapor Zone	2(3 x 7)	+	2(3 x 3)			=	60 sq. ft.	x 11	=	660
							Total Heat loss, Btu/hr.			1,520

Thus the total heat requirement for this operating degreaser equals 210,620 Btu/Hr. This amount of heat must be supplied by the heating source. The condensing coils must be capable of removing the same quantity of heat since this will be necessary when the degreaser is idling (no workload).

These values assume zero air movement at the tank wall. As the amount of air movement increases, heat loss to the surrounding area will increase substantially.

Heating Sources and Requirements

Most vapor degreasers are heated by steam or electricity. At one time, gas was a popular heat source; however, safety requirements are obsoleting its use. Forced hot water can be used for M-Clene D.

Steam provides an even, controllable heat. The driving force is the temperature difference between the steam and solvent boiling point. Normally, it is at least 50°F.

Once the desired operating steam pressure is determined, coil area requirement is calculated using the following formula:

SOLVENT	Suggested Steam Pressure, psig	Steam Temperature °F
M-Clene D	0—15	212—250
One-One-One-Trichloroethane	2—15	220—250
Triclene D	6—15	230—250
Perclene D	55—75	305—320

Degreaser Heat Requirement, Btu/Hr. = Heat Transfer Coefficient × Steam Coil Area × Driving Force °F

The heat transfer coefficient, U, has been determined experimentally. It varies depending upon solvent used, soil concentration and condition of the steam coil.

For example, to produce 210,620 Btu/Hr. for a 3′ x 7′ trichlorethylene degreaser a steam coil area of 22.6 sq. ft. is required when 15 psig steam is used and solvent contains 30% oil.

SOLVENT	HEAT TRANSFER COEFFICIENT, $\frac{\text{Btu}}{\text{Hr.—°F—Ft.}^2}$	
	Clean Solvent*	Solvent Plus 30% Oil
M-Clene D	300	200
One-One-One-Trichloroethane	200	175
Triclene D	175	150
Perclene D	150	100

*The above values are for a clean, noncorroded or scaled steam coil.

$$210{,}620\ \frac{\text{Btu}}{\text{Hr.}} = 150\ \frac{\text{Btu}}{\text{Hr.—°F—ft.}^2} \times A \times 62\text{°F}$$

$$22.6 = A$$

Steam coil is normally fabricated from black iron pipe (Schedule 10 or 40) in 1¼, 1½ or 2″ IPS.

STEAM COIL SIZE, IPS	SQ. FT. OF AREA PER LINEAR FT.
1¼″	0.435
1½″	0.497
2″	0.622

Electric Heating is convenient for smaller vapor degreasers. Immersion type elements with a watt density of 20-watts per sq. in. or less are used. Higher watt density elements can cause thermal decomposition of the solvent.

Sizing electrical heating is simple since 1 KWH produces 3400 Btu/Hr. Thus, the 3′ x 7′ trichlorethylene degreaser would require 62 KWH for 210,620 Btu/Hr.

Electrical elements are available in 3, 4, 6, 7.5 and 9 KWH ratings. Seven 9 KW elements would be selected to provide the necessary heat for the 3′ x 7′ degreaser using trichlorethylene.

$$\frac{210{,}620\ \frac{\text{Btu}}{\text{Hr.}}}{3{,}400\ \frac{\text{Btu}}{\text{Hr.}}} = 62\text{ KW}/9 = 7\text{–}9\text{ KW elements}$$

Gas Heating is accomplished by installing a 4 to 6 in. diameter tube in the boiling sump. This tube should be U-shaped and extend for the full length of the boiling sump. Its ends protrude through a removable cleanout door. The gas burner is installed at one end of the tube and the other end is attached to a chimney flue. The burner should be sized to produce twice the calculated Btu requirement of the degreaser, since heating efficiency can be as low as 50% when the U-tube becomes fouled. When it is clean, the burner can be adjusted to produce a smaller flame.

Federal, state, local or insurance company regulations may require safety shut-off controls on direct gas heated degreasers. Local gas companies should be consulted to assure selection of the proper controls and that they are correctly installed. OSHA requirements for gas heat are detailed in Section IV.

Condensing Sources and Requirements

Condensing coils must be sized to remove all heat supplied by the steam, electricity or gas. Location of the coils determines the vapor depth. The OSHA requirement for freeboard, which is the distance between the vapor line and degreaser lip (see page 29), must be observed.

Condensing coils may be installed around the perimeter of the degreaser or may be off-set at one end. A trough under the coils catches the condensate. This trough is piped to the solvent-water separator, then to the condensate reservoir. Condensing coils may be made of copper, galvanized steel* or stainless steel. Finned tubing is a desirable way of obtaining the necessary surface area where there is a space limitation.

Degreasers and stills designed to run on Perclene D, Triclene D or One-One-Trichloroethane should also be equipped with a cooled jacket at the vapor line level. This jacket should be on all four sides of the degreaser or still, but it need only be 2″ in height. Its purpose is to cool the sidewalls above the vapor-air boundry. Hot sidewalls in the freeboard area cause thermal currents which increase solvent losses.

Calculations for condensing coil size parallel those for the steam coil, as follows:

$$\begin{array}{c}\text{Degreaser Heat}\\ \text{Removal Requirement}\end{array} = \begin{array}{c}\text{Heat Transfer}\\ \text{Coefficient}\end{array} \times \begin{array}{c}\text{Condensing}\\ \text{Coil Area}\end{array} \times \text{Driving Force}$$

Driving Force is the difference between the solvent vapor temperature and the mean coolant temperature in the condensing coil. It is obtained using the following equation:

$$\text{Driving Force} = \frac{(\text{Solvent B.P.} - H_2O\text{ Temperature in}) - (\text{Solvent B.P.} - H_2O\text{ Temperature out})}{\ln \dfrac{(\text{Solvent B.P.} - H_2O\text{ Temperature in})}{(\text{Solvent B.P.} - H_2O\text{ Temperature out})}}$$

Example Cases:

DRIVING FORCE, °F	SOLVENT B.P., °F	H_2O IN, °F	H_2O OUT, °F	SOLVENT
154	250	70	120	Perclene D
90	188	70	120	Triclene D
73	165	70	110	1,1,1-Trichloroethene
28	104	70	80	M-Clene D

The actual heat transfer coefficient (U) for condensing coils is 250 Btu/hr.—°F—ft². Using a U of 125 Btu/hr.—°F—ft² allows operation with the vapor line at mid coil level.

Thus, in the previous example, for the 3′ × 7′ degreaser on trichlorethylene with inlet water of 70°F and outlet water of 120°F, 19 sq. ft. of condensing surface is necessary to remove 210,620 Btu/Hr.

$$210{,}620\,\frac{\text{Btu}}{\text{Hr.}} = 125\,\frac{\text{Btu}}{\text{Hr.}-{}^\circ\text{F}-\text{ft}^2} \times A \times 90^\circ\text{F}$$

$$19\text{ sq. ft.} = A$$

---

*Not recommended for One-One-One-Trichloroethane or where water hardness will cause rapid internal scaling.

The length of condensing pipe or tube required can be determined knowing the sq. ft. per lineal ft. of standard sizes used in degreasers.

NOMINAL SIZE	O.D. INCHES	SQ. FT./ LINEAL FT.
½" IPS	.840	.220
¾" IPS	1.050	.275
1" IPS	1.315	.344
½" Tube	.50	.1309
¾" Tube	.75	.1963
1" Tube	1.00	.2618

The water flow necessary is calculated using the following formula:

$$\begin{matrix}\text{Degreaser Heat} \\ \text{Removal Requirement}\end{matrix} = \begin{matrix}\text{Specific} \\ \text{Heat of Water}\end{matrix} \times \begin{matrix}\text{Water} \\ \text{Flow Rate}\end{matrix} \times \begin{matrix}\text{Water Temperature} \\ \text{Rise in Coils}\end{matrix}$$

Using the Example:

$$210{,}620\,\frac{\text{Btu}}{\text{Hr.}} = 1\,\frac{\text{Btu}}{\text{Lb.}} \times \text{Water Flow Rate} \times 8.3\,\frac{\text{Lbs.}}{\text{Gal.}} \times (120-70)$$

$$\frac{210{,}620}{8.3 \times 50}\,\frac{\text{Gal.}}{\text{Hr.}} = \text{Water Flow Rate}$$

$$507\,\frac{\text{Gal.}}{\text{Hr.}} = \text{Water Flow Rate}$$

***Water Chillers* or *Direct Refrigeration* may be used in place of tap or cooling tower water. In these cases, the compressor must be sized to remove the calculated Btu/Hr. heat input. Heat pump technology can also be used to recycle the heat recovered from the coolant. See page 4 for more information.**

Safety Controls

A vapor degreaser and still must be equipped with a freeboard safety vapor level control and sump safety temperature control. In addition, on electrical and gas heated equipment, a low solvent level shut-off and safety temperature control are necessary for the boiling sump.

Both the freeboard and sump safety controls are electrically wired to a heat input shut-off switch. In the case of steam or gas, this is a solenoid valve. The sensing bulb for the freeboard safety control is placed 2–3 inches above the condensing surface. The sensing bulb for the sump control is immersed in the boiling solvent about 3 inches away from the heating element.

SOLVENT	Solvent B.P. °F	Safety Settings, °F	
		Sump	Freeboard
Perclene D	250	265	185
Triclene D	188	200	160
One-One-One-Trichloroethane	165	172	130
M-Clene D	104	115	95

The functional temperature range for safety controls is selected to match the solvent being used.

Water Separators

Water enters a vapor degreaser through condensation of atmospheric moisture, or drag-in of water on the workload (such as with water based lubricants). It gives the vapor a cloudy appearance. A dry vapor is perfectly colorless. Water in a vapor degreaser increases corrosion. Water also contributes to higher losses because the cloudy white vapor has a lower density than that of dry solvent.

A water separator operates on the principle of gravity separation. Water forms a minimum boiling azeotrope with any of the chlorinated vapor degreasing solvents at elevated temperatures. In the vapor degreaser (or still), this azeotrope is boiled by the heating source, then condensed on the cooling coils. In the water separator, there is sufficient hold time in combination with cooling coils to allow the temperature to drop below the azeotrope boiling point. Below this point, the solvent and water become two separate phases. Water floats on the top.

During distillation, live steam is normally injected to strip out solvent when oil concentrations exceed 40–60% (This should *not* be done with One-One-One-Trichloroethane due to its hydrolytic instability). Thus the water separator is very important on a still.

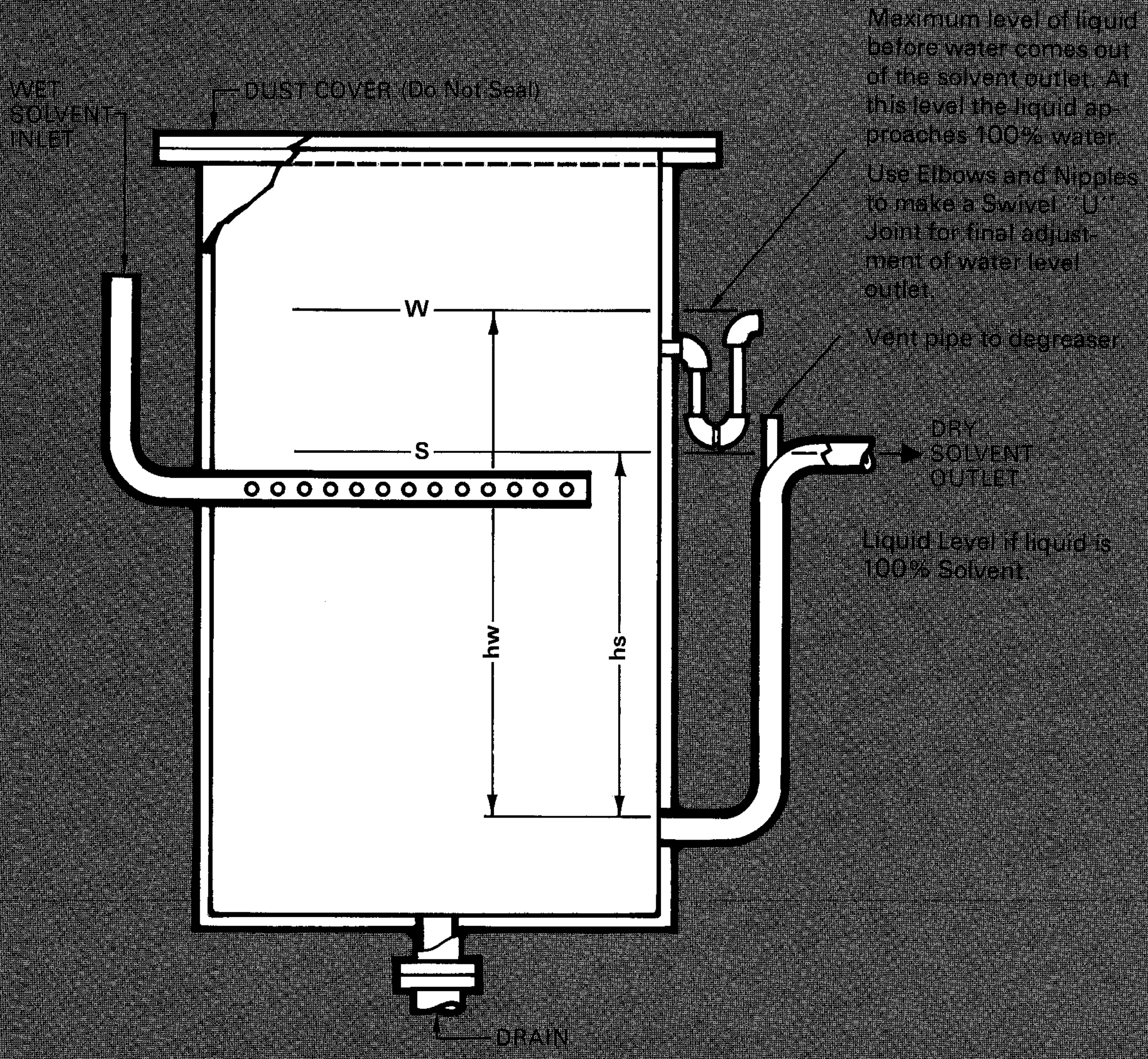
Design of a water separator is critical. Many water separators do not work because the inlet and outlets are not positioned properly. Location of these pipes varies with the solvent being used. The sketch on page 24 illustrates these points.

SOLVENT	Solvent B.P. °F	Solvent-Water Azeotrope	
		% Water, By Wt.	B.P. °F
Perclene D	250	15.8	190
Triclene D	188	7.0	164
One-One-One-Trichloroethane	165	4.5	150
M-Clene D	104	1.5	100

The size of the water separator depends upon the amount of condensate produced. A three minute solvent hold time in the separator is recommended for all solvents except One-One-One-Trichloroethane where a five minute hold time is suggested. Thus, if 2.1 gpm of condensate is produced (as is the case in the example 3′ x 7′ degreaser), the water separator should have a volume of 6.3 gallons for Triclene D. While smaller separators work, their efficiency is increased significantly with size.

A water separator should contain internal cooling coils to keep the operating temperature as low as practical. The temperature must be lower than the azeotrope boiling point in order for the separator to work. A loop or two of finned tubing extending from the top to bottom is suggested.

Solvent-Water Separator



Maximum level of liquid before water comes out of the solvent outlet. At this level the liquid approaches 100% water.

Use Elbows and Nipples to make a Swivel "U" Joint for final adjustment of water level outlet.

Vent pipe to degreaser.

Liquid Level if liquid is 100% Solvent.

1) Wet solvent must be higher than water overflow or water will back up into the degreaser.

2) Water overflow must be between levels "W" & "S". If higher than "W" the water will come out the Solvent Outlet.

3) hs times specific gravity of solvent = hw

Examples,

If hs = 10"
then hw = 16.2" (for "Perclene D")
= 14.6" (for "Triclene D")
= 13.2" (for "One-One-One)
= 13.2" (for "M-Clene D")

Auxiliary Equipment

Stills are used to increase recovery of the chlorinated solvent. In principle and operation they are an idling open top degreaser. Design requirements are the same as for the degreaser, with the exception of the heat. Heat input should be increased by a multiplier of 1.5 to compensate for the poor transfer obtained at higher oil concentrations. This amount of heat is not needed (and may be too much for the condensing coils to remove) when the solvent is clean. Thus, it is suggested that stills be equipped with two heating elements—wherein only one would be used until the solvent becomes heavily contaminated at which time both would be utilized.

A still can be operated batch-wise or continuously. In continuous operation solvent is feed to the still from the degreaser boiling sump and the distillate returns to the condensate reservoir. A float controls a pump, thereby keeping a constant level of solvent in the still.

Steam stripping (as discussed in the section on water separators) is necessary for economical recovery of Perclene D and Triclene D. It must not be used with One-One-One-Trichloroethane due to the hydrolytic instability of this solvent. Excellent recovery of M-Clene D can be accomplished without steam stripping due to the large difference in boiling points between the solvent and oil.

Refrigerated Freeboard Devices—Under certain conditions (typically degreasers with a high freeboard and intermittent workload), a refrigerated coil in the freeboard area will reduce solvent losses. These devices are powered by a 1—5 ton compressor depending upon the size of the degreaser. Since refrigerated freeboard devices act as a dehumidifier of the freeboard zone, they should be equipped with a separate trough to collect the water-solvent mixture and rapidly divert it to a water separator. Depending upon the manufacturer, refrigerated freeboard devices operate in the −10 to +40°F temperature range. A refrigerated freeboard device *does not control* the vapor line and must not be considered as a condensing source in the heat balance calculations.

Carbon Adsorption is a means for removing solvent vapor from air. Exhaust ducts from the degreaser are directed to a bed of activated carbon. The carbon adsorbs the solvent and clean air is emitted to the atmosphere. When one bed of carbon is loaded, the degreaser exhaust is directed to a second bed and the first bed is desorbed. Desorption is accomplished through live steam stripping. The water-solvent azeotrope is driven off and directed to a water separator.

Carbon adsorption efficiency is highest with Perclene D, secondly Triclene D, then M-Clene D. Normally it is not used with One-One-One-Trichloroethane due to its hydrolytic instability.

SOLVENT	SOLVENT RECOVERY		
	Recovery Without Steam Stripping		Recovery With Steam Stripping
	Max. °F	Recovery %	
Perclene D	265	40	95
Triclene D	213	60	95
One-One-One-Trichloroethane	200	70	Do Not Use
M-Clene D	185	95+	Not Needed

Equipment Suppliers

Vapor Degreaser Manufacturers

Baron-Blakeslee, Inc.
2001 N. Janice Avenue
Melrose Park, IL 60160
312-450-3900

Branson Ultrasonic Corporation
Eagle Road
Danbury, CT 06484
203-796-0400

Corpane Industries
10100 Bluegrass Parkway
Louisville, KY 40299
502-491-4433

Crest Ultrasonics Corp.
Scotch Road Mercer County Airport
P.O. Box 7266
Trenton, NJ 08628
609-883-4000

Delta Industries
8137 Allport Avenue
Santa Fe Springs, CA 90670
213-945-1067

Detrex Chemical Industries, Inc.
Equipment Division
P.O. Box 501
Detroit, MI 48232
313-358-5800

Finishing Equipment, Inc.
3640 Kennebec Drive
St. Paul, MN 55122
612-452-1860

Phillips Manufacturing Company
7334 North Clark Street
Chicago, IL 60626
312-338-6200

Ramco Equipment Corporation
32 Montgomery Street
Hillside, NJ 07205
201-687-6700

Unique Industries
11544 Sheldon Street
Sun Valley, CA 91352
213-875-3810

Electrical Heating Components

Chromalox Industrial Heating Products
#4 Allegheny Center
Pittsburgh, PA 15212
412-323-3900

Serfilco, Ltd.
1234 Depot Street
Glenview, IL 60025
312-998-9300

Steam Boilers

Cleaver Brooks Division
Aqua Chemical Inc.
Box 421
Milwaukee, WI 53201
414-962-0100

Steam Pressure Regulators

Fisher Controls, Int. Inc.
P.O. Box 190
Marshallton, IA 50158
515-754-3011

Leslie Company
12501 Telecom Drive
Tampa, FL 33637
813-978-1000

Water Chillers

Edwards Engineering Company
101 Alexander Avenue
Pompton Plains, NJ 07444
800-526-5201

Safety Controls

Honeywell Corporation
Industrial Control Division
P.O. Box 916
Valley Forge, PA 19482
800-343-0228

Spirax-Sarco Company
P.O. Box 199
1951-26th Street South
Allentown, PA 18105
215-797-5830

Insulation

Owens-Corning Fiberglass Corp.
Fiberglass Tower
Toledo, OH 43659
419-248-7066

Carbon Absorption Equipment

Ceilcote Company
140 Sheldon Road
Berea, OH 44017
216-243-0700

DCI International
1229 Country Club Road
Indianapolis, IN 46234
317-271-4001

Hoyt Manufacturing Corporation
251 Forge Road
Westport, MA 02790
617-636-8811

Vic Manufacturing Company
1620 Central Avenue NE
Minneapolis, MN 55413
612-781-6601

Also the following
Vapor Degreaser Manufacturers:

Baron-Blakeslee, Inc.
Detrex Chemical Industries
Phillips Manufacturing Company

4 Degreaser and Still Operation

Start-Up

1. Turn on condensing water. Check discharge line to insure proper flow.
2. Start air exhaust equipment.
3. Actuate all safety control thermostats, i.e., vapor control thermostat above condensing zone, heating element control thermostat, boiling sump control thermostat.
4. Adjust solvent levels in all compartments as necessary by adding makeup solvent from drums or storage tanks.
5. Turn on heat supply; adjust settings as necessary.
6. Allow heat to vaporize solvent in boiling compartment(s).
7. Once the vapor level reaches the condensing coils, check to insure flow of condensed solvent through the water separator and its return to proper degreaser compartment(s).
8. Check all thermometers and gauges for proper operation.
9. Commence vapor degreasing of work.
10. Check condenser water discharge temperature and ajust flow to maintain a temperature between 100–120° F. When M-Clene D is used, the exit water temperature should be maintained below 85° F.

Degreasing

1. Work loads should be sized so they do not exceed designed degreaser capacity. Exceeding capacity can result in poor cleaning as well as increased solvent losses.
2. Work should be positioned in baskets, trays, racks, etc. to minimize solvent drag-out. Such carry-out is most likely to occur from solvent being held-up in recesses or pockets in work being degreased.
3. Maximum recommended vertical rate of entry and withdrawal of work is 11 feet per minute. Higher throughput rates result in excessive vapor fluctuations and increased solvent loss through diffusion with air and/or water vapor.
4. The work should remain in the vapor zone until condensation has stopped. Premature removal from the vapor zone while work is still wet can result in spotting or staining, and increased solvent loss.
5. Work should always be sprayed within the vapor zone to avoid violent vapor fluctuations and subsequent high solvent losses. Solvent spray temperature should be well below that of the vapor to insure adequate vapor condensation following spraying.
6. Excessive water contamination in a vapor degreaser can result in solvent breakdown, spotting of work, and increased solvent consumption. All water and steam lines must be free of leaks and the water separator must be functioning properly. For maximum efficiency, the water separator should be maintained at the coolest possible temperature. Normally, there should be a layer of water over the solvent in the separator, and the water outlet drain should always be left open. Water flow through the condensing coils should be controlled to maintain a water discharge temperature of 100—120° F (below 85° F for M-Clene D).

Shut-Down

1. Stop throughput of work.
2. Turn off heat supply.
3. After vapor level has dropped well below the condensing coils, turn off the condensing water.
4. Turn off air exhaust equipment.
5. Place cover on open-top degreasers to minimize solvent losses.

Degreaser Clean Out

1. Distill solvent in boil chamber over to reservoir sump or to suitable storage containers until the solvent reaches the recommended minimum level or until vapors fail to reach the condensing coils. At no time should the solvent level be allowed to drop lower than 2 inches above the gas tube or electric heating elements.
2. Turn off heat and allow degreaser to cool.
3. Turn off water flow.
4. Pump dirty solvent to a still, drums, or separate storage for dirty solvent.
5. Remove clean-out ports and heating elements.
6. Remove all dirt, sludge, and metal chips from the bottom of each compartment, without entering the degreaser.
7. Scrape foreign material off heating elements and/or interior surfaces of the degreaser. When the degreaser has to be entered to brush down the unit, it must be thoroughly aerated by forced ventilation beforehand. INDIVIDUALS ENTERING THE DEGREASER MUST WEAR A HARNESS AND LIFE LINE, IN ADDITION TO APPROVED RESPIRATORY PROTECTION WITH A POSITIVE SUPPLY OF FRESH AIR. THE FREE END OF THE LIFE LINE MUST BE MANNED BY AN ATTENDANT WHO REMAINS OUTSIDE THE DEGREASER AT ALL TIMES. Special ventilation must be continued during the entire cleaning of the degreaser.
8. Clean out the interior of the water separator as necessary.
9. Check and clean the various thermostatic controls and indicating thermometers.
10. Reassemble all components and replace clean-out ports, replacing gaskets where necessary.
11. Refill the unit with solvent and follow start-up procedure.

If acid has been a problem, the degreaser should be cleaned using 5% solutions of soda ash or trisodium phosphate. Do not use strong alkalis such as caustic soda or potassium hydroxide. All pipes, fittings, valves, water separator, still, storage tank, etc., must be neutralized, in addition to all interior surfaces of the degreaser. Complete removal of all solid residues from the degreaser is vital in order to avoid reoccurrence of the acid condition. Once the unit is neutralized, it should be thoroughly rinsed with water and dried prior to refilling with solvent.

Disposal of Degreaser Wastes

Waste sludges from vapor degreasers are considered to be hazardous wastes and are to be disposed of properly, as mandated by the Resource Conservation and Recovery Act (RCRA). Degreaser operators must fill out RCRA manifests before the wastes can be transported, stored or disposed of by qualified parties.

Solvent Reclamation

OxyChem degreasing solvents may be reclaimed, either in the degreaser or in a separate distillation unit with virtually no loss of inhibitor effectiveness in the reclaimed material.

Where contamination levels are relatively light, solvent reclamation may be conducted in the degreaser boil sump. Solvent condensate may be directed to solvent reservoir tanks or to drum storage. Solvent levels should drop no lower than 2 inches above the heating surface in gas and electric heated stills. In general, reclamation in the degreaser is less efficient than reclamation in a separate still due to its design characteristics.

Normally, a simple one-plate still, such as supplied by most vapor degreasing equipment manufacturers, will do a satisfactory job of reclaiming chlorinated solvents. Such units may be operated on a batch basis or can be coupled directly to the degreaser and operated continuously. With the latter arrangement, contaminated solvent is pumped directly to the still from the degreaser. Solvent level in the still is maintained by an automatic level control which actuates a solvent transfer pump. This affords maximum cleaning efficiency in the degreaser while minimizing shut-down time to clean the unit and refill with fresh solvent. Many solvent recovery stills use live steam injection to maximize efficiency. This procedure works when reclaiming Triclene D or Perclene D. But live steam should not be used to reclaim One-One-One-Trichloroethane.

Degreaser Maintenance

Adequate degreaser maintenance is essential to a safe, economical, efficient cleaning operation. A vapor degreaser is constantly accumulating soils from the work being degreased. So the degreaser must be periodically cleaned out. Clean-out frequency depends primarily on the work volume, the nature and quantity of soil and the cleanliness required. Soils allowed to accumulate collect around the heating coils, thereby reducing heat transfer efficiency. Certain soils (such as acidic cutting oils or aluminum or zinc fines) can lead to decomposition of the solvent if allowed to accumulate in the sump. Finally, as oil concentration in the boil sump increases, boiling temperature of the solvent-oil mixture also increases. Eventually cleaning efficiency may be impaired because of insufficient vapor generation.

It is impossible to generalize about clean-out frequency. For each specific situation, this can be determined by one or more of the following tests:

1. *Solvent boiling point*
2. *Solvent specific gravity*
3. *Solvent acid acceptance and/or pH*

Oil contamination in a vapor degreaser raises the solvent boiling point while lowering the specific gravity. The actual contamination level can be estimated as shown in the following table:

As a general rule, Perclene D, Triclene D and One-One-One-Trichloroethane degreasers should be cleaned out when the soluble oil contamination reaches 25 percent by volume. An M-Clene D degreaser should be cleaned at 40 percent contamination.

Likewise, when the pH of the degreasing solvent drops below 5.5 or the acid acceptance drops lower than 0.01% for Perclene D, 0.03% for Triclene D or M-Clene D or 0.06% for One-One-One-Trichloroethane, the degreaser should be cleaned. Acid acceptance and pH values of OxyChem's chlorinated solvents are well above these values.

Solvent Boiling Point (°F)

Volume Percent Oil	Perclene D	Triclene D	One-One-One Trichloroethane	M-Clene D
0	250	188	165	104
10	252	190	168	106
20	254	192	170	107
25	256	193	172	108
30	258	195	174	109
40	—	—	—	110

Solvent Specific Gravity @ 25/25

Volume Percent Oil	Perclene D	Triclene D	One-One-One Trichloroethane	M-Clene D
0	1.64	1.46	1.32	1.32
10	1.55	1.41	1.26	1.27
20	1.47	1.35	1.23	1.22
25	1.44	1.33	1.21	1.20
30	1.40	1.29	1.18	1.19
40	—	—	—	1.18

5 Reasonably Available Control Technology Guidelines

The Reasonably Available Control Technology (RACT) are guidelines set up by the United States Environmental Protection Agency (EPA) for the purpose of controlling solvent emissions. Many states are adapting the guidelines in their State Implementation Plans in an effort to reduce photochemical smog formation.

The EPA approach is that emissions can be reduced by installing emission control equipment on the degreaser and by insisting that operating personnel use proper techniques.

Emission Control Equipment for Open Top Degreasers

1. The first and foremost requirement is a cover that can be opened or closed easily without disturbing the vapor zone. In some states this must be a powered cover for machines over 10.8 $ft.^2$ in open top area. This is probably the single most effective control device for the money.
2. Safety switches — A switch and thermostat are required that will shut off the sump heat if the condenser coolant is either not flowing or is too warm. A safety switch which will shut off the spray if the vapor line drops more than four inches is also required.
3. The machine must be equipped with one of the following control devices:
    a. Extended freeboard which will provide a ratio of 0.75.
    b. A refrigerated chiller
    c. Carbon adsorber system
    d. Other control systems not defined if they can be shown they are of equal efficiency.

    Another alternative would be an enclosed design whereby the cover door opens only when the dry parts are actually entering or leaving the degreaser.
4. The last control equipment requirement is a permanent label which clearly summarizes the operating procedures.

Operating Requirements for Open Top Degreaser

1. Keep cover closed except when processing work load through the degreaser.
2. Minimize solvent carry out by:
    a. Rack parts for full drainage
    b. Control vertical hoist speed below 11 ft/min
    c. Keep the work in the vapor zone for at least 30 seconds or until condensation ceases
    d. Tip out pools of solvent from work before removing from degreaser
    e. Allow parts to dry within the degreaser
3. Do not degrease porous material such as cloth, rope, wood or leather.
4. Vapor collapse should be minimized when work load enters the degreaser.
5. Work load should not occupy more than 50% of degreaser's open top area.
6. Never spray above vapor line.
7. Repair solvent leaks immediately or shut down the degreaser.
8. Do not dispose of waste solvent such that greater than 20% will evaporate.
   Store waste solvent in loosely closed containers.
9. Exhaust ventilation should not exceed 65 CFM per ft^2 of open top area unless necessary to meet OSHA requirements. Fans should not be placed near the degreasing opening.
10. Water should not be visually detectable in solvent exiting water separator.

    Due to the complicated and ever-changing nature of environmental regulations, Occidental Chemical Corporation suggests that you confirm the status of these regulations in your geographic area by contacting either a local EPA office or your local OxyChem Sales Office.

6 Trouble Shooting

Corrosion in Degreaser

PROBABLE CAUSE	REMEDY
Wrong solvent	Only properly stabilized vapor degreasing grades of chlorinated solvents should be used. For proper guidance on the correct solvent for various applications, contact Occidental Chemical Technical Service.
Water separator not functioning properly	Periodically check water separator to be sure it is clean and not plugged. Keep drain valve open so separated water may drain out. Also make certain design is correct for the solvent being used.
Addition of acidic products to degreaser	Where work being degreased contains acidic cutting oils or other acidic products, acid acceptance and pH determinations should be made frequently.
Excessive heater surface temperature	Inspect temperature controls frequently. Replace defective heating elements. Solvent in the boil sump should always be at least 2 inches above the heating surface.
Lack of degreaser quality control	Daily additions of virgin make-up solvent should be made to maintain adequate acid acceptance levels.
Cross-contamination	Never use a vapor degreasing solvent that has been contaminated with another solvent. As little as 0.1% of 1-1-1 trichloroethane mixed into another solvent can cause an acid condition.

Slow Heat-Up

PROBABLE CAUSE	REMEDY
Prolonged presence of metal fines or parts	Reactive metals, such as zinc or aluminum, can cause problems if left in the degreaser for a long time. Make sure these parts are collected on a regular basis. Placing a screen over the heating coils is a good idea.
High level of solvent contamination	Degreaser should be cleaned out when the boil sump contains 25—30% oil by volume (40% for M-Clene D).
Low steam pressure and or insufficient steam coil area	Recommended steam pressures are 3—15 psig for One-One-One-Trichloroethane, 6-15 psig for Triclene D, 55—75 psig for Perclene D and 0—15 psig for M-Clene D. Operating steam pressure depends upon steam coil area.
Heating elements burned out	Make sure all heating elements are functioning properly by noting presence or absence of convection currents over the top of each element during start-up.
Improper air-gas mixture	Regulate mixture so that flame from burner is blue with white tip and neither floats nor wavers.
Dirt or sludge on heating elements	Scrape off all residues on heating elements. Clean inside of immersion gas tubes.
Safety thermostats shutting down the degreaser	Recommended boil sump and freeboard safety thermostat settings are 265°F and 185°F and Perclene D, 200°F and 160°F for Triclene D, 180°F and 135°F for One-One-One-Trichloroethane, and 110°F and 95°F for M-Clene D.

7 Safety Precautions

Flammability

All vapor degreasing chlorinated solvents exhibit no flash or fire point and present no fire hazard under normal conditions. However, high concentrations of methylene chloride, one-one-one-trichloroethane, and trichloroethylene vapor may form weakly combustible mixtures in the present of oxygen (air). For this reason, welding arcs or flames or other energy sources should not be used around any vessel holding these chlorinated solvents, until all solvent vapors are completely eliminated.

Toxicity

Exposure to high levels of chlorinated solvents can be harmful. The Occupational Safety and Health Act has established Time Weighted Average (TWA) exposure limits for chlorinated solvents. The Time Weighted Average represents the average concentration to which nearly all workers may be exposed, 8 hours per day, five days a week, without adverse effect.

Recognition of potential hazards involved in the use of these solvents, coupled with the use of appropriate safety measures, is essential in maintaining safe operations.

See the RECOMMENDED EXPOSURE STANDARDS insert in the back pocket of this publications.

Additional and up-to-date toxicity information is available from Material Safety Data Sheets for each solvent.

Reactivity

Chlorinated solvents should not come in contact with open flames, electric arcs, alkali metals, pure oxygen and oxidizing materials. Do not use strong alkalies with trichloroethylene, chloroform and one-one-one trichloroethane.

Uninhibited, or lightly inhibited trichloroethylene, one-one-one-trichloroethane and methylene chloride can react with aluminum or zinc or their alloys under certain conditions. Aluminum should not be used as a material of construction for pumps, tanks, pipelines, valves, spray equipment and other handling equipment used for chlorinated solvents or blends containing chlorinated solvents. Short term contact with aluminum, such as vapor degreasing and cold cleaning will not present a problem as long as the proper grade of solvent is used and the stabilizer is maintained at the proper level.

Safety Practices

An operation using chlorinated solvents can ensure minimum employee exposure by using a properly designed machine and by insisting that employees observe the following safety practices:

1. Chlorinated solvent containers should be properly identified and should have an appropriate warning label.
2. Protective clothing and equipment should be worn when direct contact with liquid solvent is unavoidable. Use of such equipment is not intended as a substitute for proper operation or maintenance practices.

   Gloves and aprons made from polyvinyl alcohol, or Viton* as well as splash-proof goggles should be provided for degreaser operators.
3. Do not use chlorinated solvents in open containers unless adequate ventilation is provided.
4. **Avoid Prolonged or Repeated Exposure to Chlorinated Solvent Vapors.**
5. Do not take chlorinated solvents internally.
6. Avoid spilling or splashing chlorinated solvent. Where spillage has occurred, clean up immediately and dispose of solvent according to section IX on the MSDS.
7. Chlorinated solvents should be protected from the direct rays of the sun. Ultraviolet light can accelerate solvent oxidation.
8. Chlorinated solvent vapor should not be exposed to glowing metal surfaces and open flames, such as electric heaters, welding arcs, acetylene torches and high pressure steam lines, since thermal decomposition can occur.
9. Disposal of chlorinated solvent residues should be in keeping with federal, state and local regulations.

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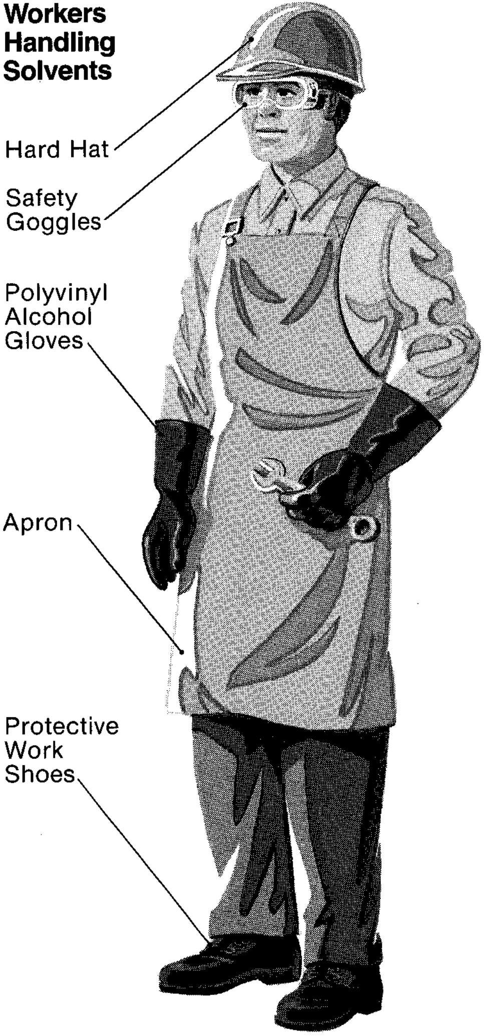
*Registered Trademark of E.I. duPont de Nemours Company, Inc.

Typical Protective Apparel for Workers Handling Solvents



Tank Cleaning

Before entering a solvent storage tank or vapor degreaser for cleaning or inspection, all solvent should be removed and the tank steamed or filled with water, drained, ventilated and checked for absence of solvent vapors. Anyone entering such a tank should wear a harness and life line in addition to approved respiratory equipment. Forced ventilation should be applied as long as anyone is in the tank, and a second person should be present at all times outside the tank. In tank cleaning, strong alkalies such as caustic soda (sodium hydroxide) or caustic potash (potassium hydroxide) should not be used. They react with certain chlorinated solvents, notably trichloroethylene and one-one-one-trichloroethane, to form explosive mixtures.

Weak alkalies, such as sodium carbonate (soda ash) or trisodium phosphate may be used safely as cleaning or neutralizing agents. Make sure the tank or degreaser is thoroughly dry before it is refilled.

Spills

All spills of chlorinated solvents should be cleaned up immediately to reduce the risk of excessive inhalation by workers. Follow section IX on the appropriate MSDS. OxyChem's HAZORB® universal sorbent is ideally suited for the control and pick-up of chlorinated solvents. Supplied in pillow form, HAZORB will absorb a minimum of one gallon of solvent per pillow. The nearest OxyChem sales office can supply more information on this product.

First Aid and Precautions

See the WARNING LABEL INFORMATION PAGE for each solvent MSDS Sheet for information on HAZARDS, PRECAUTIONARY STATEMENTS and FIRST AID.

8 Solvent Quality Control Procedures

pH

This method is used to determine the pH of Perclene D, Triclene D, One-One-One-Trichloroethane and M-Clene D.

The pH of the solvents will vary as the water to solvent extraction ratio is varied. Therefore, the extraction ratio should be noted with the reported pH. In this procedure, the extraction ratio is 1:1, solvent to water.

Reagents and Special Apparatus

pH Meter

Graduated Cylinder, 100 ml

Separatory funnel, 250 ml

Beaker, 100 ml

Neutral water—distilled water which has been neutralized to pH of 7.0

Procedure

Extraction:

1. Using a clean dry 100 ml graduated cylinder, transfer 100 ml of the sample into a clean dry 250 ml separatory funnel.
2. Measure 100 ml of neutral distilled water into the same 100 ml graduated cylinder and transfer to the separatory funnel containing the sample.
3. Shake vigorously for *one full minute.*
4. Allow the water and solvent to separate and draw off the solvent layer into the 100 ml graduated cylinder previously used.
5. Drain water layer into a 100 ml beaker.

Using pH Meter:

1. Rinse electrodes and standardize instrument with 7.0 and 10.0 buffer solutions, using 50 ml beakers. (Also, check temperature compensation of the pH meter.)
2. Rinse electrodes with distilled water, dry with a soft tissue, and determine the pH of the water extract.

Acid Acceptance

All four Occidental Chemical vapor degreasing solvents are stabilized against acid formation and solvent breakdown by the addition of small amounts of neutral stabilizers which act as acid acceptors. By adding a known amount of standard hydrochlorination reagent, the amount of stabilizer present can be determined.

Reagents and Apparatus

All reagents must be reagent grade, ACS specification or equivalent.

Sodium hydroxide solution, 0.1 N.

Hydrochlorination reagent. Mix thoroughly 4.4 ml of concentrated (37%) hydrochloric acid with 500 ml of anhydrous isopropanol. This solution is approximately 0.1 N hydrochloric acid.

Bromphenol blue indicator, 0.04% by wt.

Pipet, 25 ml & 10 ml

Erlenmeyer flask, glass stoppered, 125 ml

Buret, 50 ml, calibrated to 0.1 ml

Procedure

1. Pipet 10 ml of the solvent sample into a 125 ml glass stoppered Erlenmeyer flask.
2. Pipet 25 ml of the hydrochlorination reagent and 25 ml of isopropanol into the flask.
3. Stopper and shake thoroughly.
4. Allow to stand for 10 minutes, then shake a second time.
5. Add 5 drops of bromphenol blue indicator.
6. Titrate to a light purple endpoint using 0.1 N sodium hydroxide.
7. Titrate a blank containing only 25 ml of the hydrochlorination reagent plus 25 ml isopropanol.

Calculations

Report acid acceptance as weight percent sodium hydroxide.

$$\% \text{ Acid Acceptance} = \frac{(A - B)(0.04)(100)(N)}{(S)(\text{Sp. Gr.})}$$

A = NaOH required for blank titration.

B = ml NaOH required for sample titration.

N = Normality of sodium hydroxide solution.

S = Sample volume, in milliliters.

Sp. Gr. = Uncorrected specific gravity of sample.

Aluminum Scratch Test

This method is used to determine the effectiveness of the stabilizer system in One-One-One-Trichloroethane for preventing solvent breakdown in the presence of aluminum or aluminum alloys. This test is *only* required for One-One-One-Trichloroethane.

Procedure

1. Place a cleaned strip of AA1100 aluminum alloy in a sample of used or recovered One-One-One-Trichloroethane.
2. With a sharp-edged instrument, scratch the aluminum strip beneath the surface of the liquid. Do not expose the aluminum strip to the atmosphere.
3. Note the presence of any gas bubbles or bleeding (dark red color) emanating from the scratch mark.
4. If any reaction is observed, the solvent is insufficiently stabilized and should not be used in a vapor degreasing operation. Properly stabilized One-One-One-Trichloroethane does not give a positive scratch test.
5. The presence of free water invalidates this test.

Specific Gravity

Specific Gravity is the ratio of the weight of a substance to the weight of an equal volume of water at a given temperature. The Specific Gravity is usually reported at 60°/60°F or 25°/25°C but may be converted to any temperature by calculation. A temperature correction must be applied if the temperature at which the measurement is made differs appreciably from the temperature at which the precision hydrometer was calibrated.

Apparatus

Precision Hydrometer, 325 mm, Specific Gravity range:

- 1.300—1.370, subdivision of 0.005 (One-One-One-Trichloroethane and M-Clene D).
- 1.420—1.490, Subdivision of 0.005 (Triclene D)
- 1.600—1.670, Subdivision of 0.005 (Perclene D)

Cylinder, Hydrometer, 1½ x 13⅜".

Thermometer, −2°F to 230°F.

Procedure

1. Transfer the sample into the hydrometer cylinder to within 2—3 inches of the top.
2. Place the hydrometer cylinder in a water bath having a temperature of 67—87°F.
3. Insert hydrometer and thermometer into hydrometer cylinder and stir carefully.
4. Allow sufficient time for sample to reach equilibrium temperature with water bath.
5. Record sample temperature to nearest 0.5°F and hydrometer reading to nearest 0.0001 division.
6. Obtain temperature correction from following table and calculate Specific Gravity.

Temperature Correction for Specific Gravity to 60°F/60°F

TEMPERATURE	CORRECTION			
	M-CLENE D	ONE-ONE-ONE TRICHLOROETHANE	TRICLENE D	PERCLENE D
60	.0000	0.0000	0.0000	.0000
65	.0050	0.0043	0.0046	.0044
70	.0100	0.0085	0.0091	.0088
71	.0110	0.0094	0.0100	.0096
72	.0120	0.0102	0.0109	.0105
73	.0130	0.0111	0.0118	.0114
74	.0140	0.0119	0.0127	.0123
75	.0150	0.0128	0.0137	.0131
76	.0160	0.0136	0.0146	.0140
77	.0170	0.0145	0.0155	.0149
78	.0180	0.0153	0.0164	.0158
79	.0190	0.0162	0.0173	.0166
80	.0200	0.0170	0.0182	.0175
81	.0210	0.0179	0.0191	.0184
82	.0220	0.0187	0.0200	.0193
83	.0230	0.0196	0.0209	.0201
84	.0240	0.0204	0.0218	.0210
85	.0250	0.0213	0.0228	.0219
86	.0260	0.0221	0.0237	.0228
87	.0270	0.0230	0.0246	.0235
90	.0300	0.0255	0.0273	.0245
95	—	0.0298	0.0319	.0254

Calculations: Sp. Gr. @ 60°F/60°F (15.6°C/15.6°C) = Uncorrected Sp. Gr. + Temperature Correction

9 Bulk Storage of Chlorinated Solvents

Costly drum handling can be eliminated by bulk storage. In addition, the price of solvent on a bulk basis is less than in drums.

The bulk storage tank may be located near the degreaser or outdoors, either at ground level or underground. The tank should be large enough to supply the requirements for at least one month. Minimum tank size also depends upon upon the type of deliveries available. Most Occidental Chemical solvent distributors have equipment to supply from 200 to 3000 gallon bulk quantities. If the usage is less than 200 gallons per month, a good drum pump should be considered rather than bulk storage.

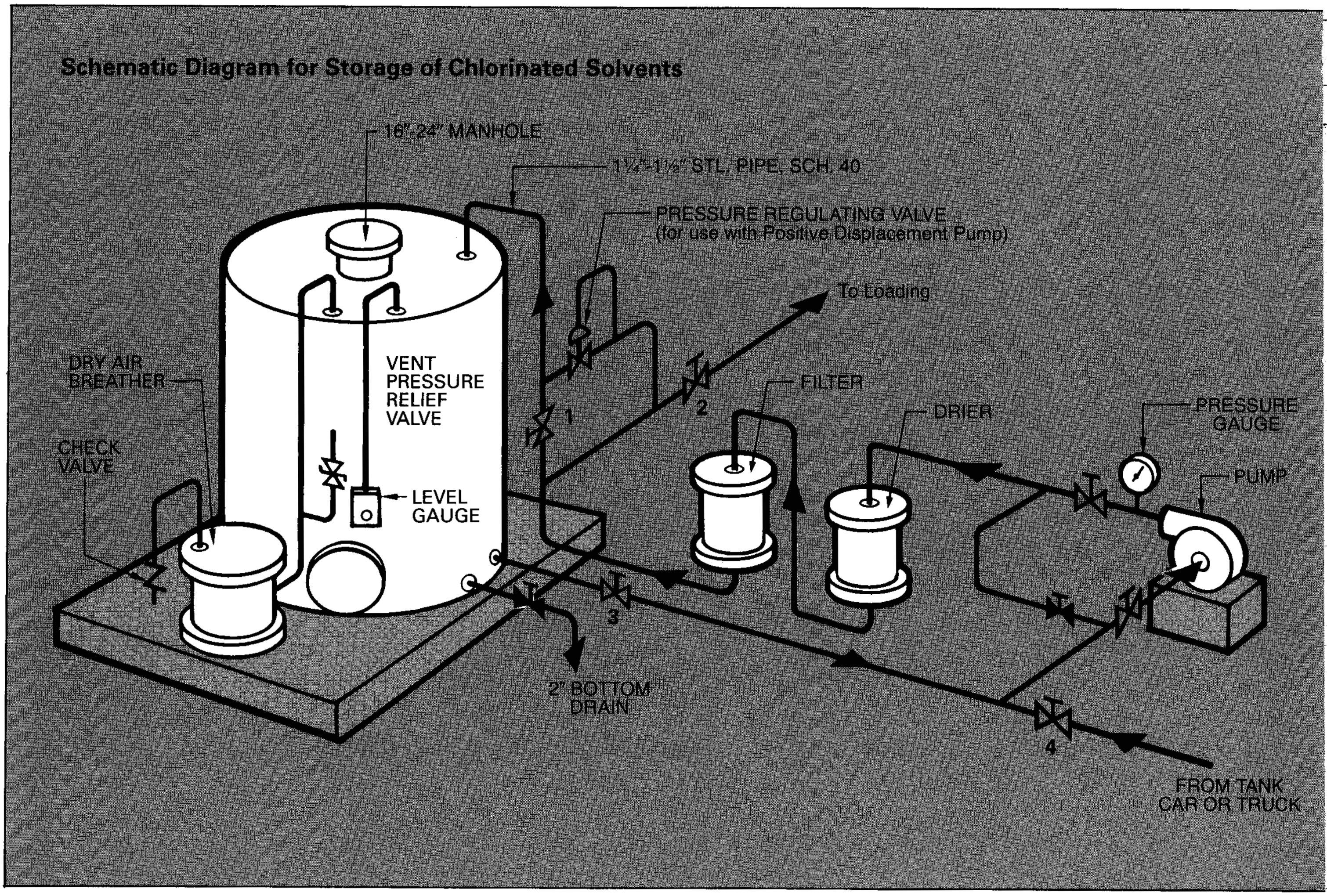
To accept full transport truck deliveries (3500–4000 gal.) the storage tank should have a capacity of 6000 gallons. For rail car deliveries (8000 gallon minimum) a 15,000 gallon tank should be installed.

Unloading and storage equipment for OxyChem's chlorinated solvents is normally constructed of mild steel.

The following diagram illustrates the components of a typical storage system. The inline filter and dryer are optional and are seldom seen on less expensive small bulk installations. The pressure and vacuum relief valve, safety seal and vent dryer are recommended for all systems. Note that the filling point is on the bottom of the storage tank. This, or a submerged fill pipe from the top of the tank is required by EPA legislation in many areas.

While the typical bulk storage system shown can be used for M-Clene D, a pressure vessel (12 psig design) equipped with a pressure relief valve at 8 psig will conserve solvent. If the vapor degreaser is in operation 24 hours per day, solvent can also be conserved by ducting the pressure relief vent back into the vapor zone. In this way, losses can be minimized without the need for a pressure vessel.

Schematic Diagram for Storage of Chlorinated Solvents



Unloading from Delivery Tank

1. Open Valves 1 and 4
2. Close Valves 2 and 3
3. Energize Pump

Loading Containers from Storage Tank

1. Close Valves 1 and 4
2. Open Valves 2 and 3
3. Energize Pump

Note: On both Unloading and Loading
All Solvent passes through the Drier and Filter
assuring maximum Dryness and Purity

Technical Service

Since conditions and problems vary with each installation, OxyChem's Technical Service Staff may be consulted for assistance concerning equipment and procedures for handling and storage.

Metallic Hose

Dana/Everflex
Artell Road
P.O. Box 370
Ludlow, MA 01056
413-589-9061

Flexonics Inc.
300 E. Devon Avenue
Bartlett, IL 60103
312-837-1811

Unions

Ladish Company
5481 S. Packard Avenue
Cudahy, WI 53110
414-747-2611

Latrobe Foundry Machine and Supply
P.O. Box 431
Latrobe, PA 15650
412-537-3341

Valves

Crane Company
800 3rd Avenue
King of Prussia, PA
215-962-0366

The Durion Company
1978 Foreman Drive
Cookville, TN 38501
615-432-4021

Jamesbury Corporation
640 Lincoln Street
Worcester, MA 01605
617-852-0200

Gaskets and Packing

Anchor Packing
408-G Gallimore—Dairy Road
Greensboro, NC 27409
919-668-7955

Garlock Company
1666 Division Street
Palmyra, NY 14522
315-597-4811

Pumps

The Gorman Rupp Company
305 Bowman Street
Mansfield, OH 44901
419-755-1011

Goulds Pumps Inc.
P.O. Box 330
Seneca Falls, NY 13148
315-568-2811

ITT Marlow Pumps
P.O. Box 200
Midland Park, NJ 07432
203-444-6900

Filters

Cuno Industrial Filter Products
400 Research Parkway
Meriden, CT 06450
201-237-5541

Filterite Corporation
2033 Greenspring Drive
Timonium, MD 21093
301-252-0800

Resin Drier Systems (Solvent and Dry Air)

C.M. Kemp Manufacturing Company
7280 Baltimore-Annapolis Boulevard
Glen Burnie, MD 21061
301-761-5100

Lectrodryer
P.O. Box 2500
Richmond, KY 40475
606-624-2091

Chemical Drier Systems (Solvent and Dry Air)

W.A. Hammond Drierite Company
138 Dayton Avenue
Xenia, OH 45385
513-376-2927

Drier Chemicals

Aluminum Company of America
Separation Technology
181 Thorn Hill Road
Warrendale, PA 15086
412-772-0086

Kaiser Chemical Company
P.O. Box 1071
Baton Rouge, LA 70821
800-524-2586

W.A. Hammond Drierite Company
138 Dayton Avenue
Xenia, OH 45385
513-376-2927

W.R. Grace and Company
P.O. Box 2117
Baltimore, MD 21203
301-659-9000

Meters

Liquid Controls Corp.
Wacker Park
North Chicago, IL 60064
312-689-2400

Micro Motion Inc.
7070 Winchester Circle
Boulder, CO 80301
303-530-8400

Neptune Measurement Company
P.O. Box 792
Greenwood, SC 29648
803-223-1212

Hose

Crane Resistoflex
Greenlee Road off Highway 70 West
Marion, NC 28752
704-724-9524

Goodall Rubber Company
572 Whitehaven Road
Trenton, NJ 08619
609-587-4000

Gauges

Meriam Instrument Company
10920 Madison Avenue
Cleveland, OH 44102
216-281-1100

Uehling Instrument Company
P.O. Box 2157
Paterson, NJ 07509
201-742-8710

Vacuum-Pressure Relief Valves

Farris Engineering Corporation
400 Commercial Avenue
Palisades Park, NJ 07650
201-944-6300
(Pressure Relief Valves)

The Johnson Corporation
805 Wood Street
Three Rivers, MI 49093
616-278-1715
(Vacuum Relief Valves)

J.E. Lonegran Company
10050 Sandmeyer Lane
Philidelphia, PA 19116
215-677-1710
(Pressure-Vacuuum Relief Valve)

Oceco Inc.
P.O. Box 159
Tiffin, OH 44883
419-447-0916
(Pressure-Vacuum Relief Valves)

The Protecto Seal Company
225 Foster Avenue
Bensenville, IL 60106
312-595-0800
(Pressure-Vacuum Relief Valves)

Tanks

Gaston County Fabrication
P.O. Box 308
Stanley, NC 28164
704-827-6751
(Stainless Steel)

Kennedy Tank and Manufacturing
833 E. Sumner Avenue
Indianapolis, IN 46227
317-287-1311

Modern Welding Company
2880 New Hartford Road
Owensboro, KY 42301
502-685-4404

Peabody Tec Tank
P.O. Box 996
Parsons, KS 67357
316-421-0200

Aprons, Masks & Respirators

American Optical Company
Safety Products Division
Dept. 4041
P.O. Box 197
14 Mechanic Street
Southbridge, MA 01550
617-765-9711

Mine Safety Appliance Company
P.O. Box 426
Pittsburgh, PA 15230
412-967-3000

Gloves

Edmont
Div of Becton, Dickenson & Company
Coshocton, OH 43812
614-622-4311

L.R.C.—Surety Products Inc.
Route 46 West
P.O. Box 415
Little Falls, NJ 07424
201-256-4100

Magic Glove Manufacturing Company
2060 North Kolmar Street
Chicago, IL 60639
312-384-2070

Norton Safety Equipment Company
2000 Plainsfield Pike
Cranston, RI 02921
401-943-4400

Notes

Occidental Chemical Corporation

SALES OFFICES

SOUTHEAST REGION

2500 Windy Ridge Parkway
Suite 1225
Marietta, Georgia 30067
(800) 241-7779
(404) 952-3700

MIDWEST REGION

1260 Iroquois Drive
Bldg. 400
Naperville, Illinois 60540
(800) 323-7228
(312) 357-4970

NORTH CENTRAL REGION

34555 Chagrin Boulevard
Moreland Hills, Ohio 44022
(800) 321-1238
(216) 247-3655

SOUTHWEST REGION

363 North Belt
Suite 1600
Houston, Texas 77060
(800) 231-2430
(713) 931-0485

WESTERN REGION

1450 Fashion Island Boulevard
Suite 650
San Mateo, California 94404
(800) 334-3400
(415) 572-2705

NORTHEAST REGION

379 Thornall St.
Edison, New Jersey
(800) 666-9900
(201) 906-2200

EAST REGION

One Greentree Center
Suite 302
Route 73
Marlton, New Jersey 08053
(800) 342-6900
(609) 983-9650

CUSTOMER SERVICE CENTER

Occidental Tower
5005 LBJ Freeway
Dallas, Texas 75244
(214) 404-3300
(800) 752-5151

DEVELOPMENT CENTER

Occidental Chemical Corporation
Development Center
Building V-81
53rd and Buffalo Avenue
P.O. Box 344
Niagara Falls, New York 14302
(716) 278-7201/7202

HEADQUARTERS

Electrochemicals Division
Occidental Tower
5005 LBJ Freeway
Dallas, Texas 75244
(214) 404-3300

RECOMMENDED EXPOSURE STANDARDS

Industrial Health Standards	**Methylene Chloride**	**Perchloro-ethylene**	**1,1,1-Tri-chloroethane**	**Trichloro-ethylene**
ACGIH[a]—TLV's				
TLV[b]—TWA (ppm)	50	50	350	50
TLV—STEL[c] (Short-term exposure limit) (ppm)	----	200	450	200
OSHA—Permissible Exposure Limits				
PEL—TWA[d] (ppm)	500	100[g]	350	100[g]
Acceptable ceiling[e] Concentration (ppm)	1000	200	----	200
Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift[f] (ppm)	2000	300	----	300

Note: Refer to current OSHA Occupational Exposure Standards (29 CFR, Part 1910.1000)

a ACGIH—American Conference of Governmental Industrial Hygienists, "Threshold Limit Values...1988-89," 6500 Glenway Avenue, Cincinnati, OH 45411.

b Threshold Limit Value—Refers to a time-weighted concentration for a normal 8-hour workday and a 40-hour workweek. Current OSHA standards should be reviewed.

c STEL—15-minute time-weighted average which should not be exceeded, even though the eight-hour average is within the TLV. STEL exposures should not exceed 15 minutes and should not be repeated more than four times a day.

d Eight-hour time-weighted average—an employee's exposure to any material listed in OSHA Table Z-2 in any 8-hour work shift of a 40-hour workweek shall not exceed the 8-hour time-weighted average limit for that material in the table.

e.f An employee's exposure to material listed in OSHA Table Z-2 shall not exceed at any time during an 8-hour shift the acceptable ceiling concentration limit given for the material in the table, except for a time period, and up to a concentration not exceeding the maximum duration and concentration allowed in the column under "Acceptable Maximum Peak Above the Acceptable Ceiling Concentration for an Eight-Hour Shift."

g Proposal to amend the existing standards published.

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Occidental Chemical Corporation

Electrochemicals Division
Occidental Tower
5005 LBJ Freeway
Dallas, Texas 75244

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Vapor Degreasing Handbook

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